# GENOTYPE AND PLANTING DATE EFFECTS ON PHENOLOGY, GROWTH AND YIELD OF WHITE MAIZE

SHAHRINA AKHTAR

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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# GENOTYPE AND PLANTING DATEEFFECTS ON PHENOLOGY, GROWTH AND YIELD OF WHITE MAIZE

**By**

**SHAHRINA AKHTAR**

**REGISTRATION NO. 13-05803**

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**APPROVED BY:**

**Prof. Dr. Md. Jafar Ullah**
Chairman
Advisory Committee

**Prof. Dr. Md Kamal Uddin Ahamed**
Member
Advisory Committee

**Prof. Dr. Abdul Hamid**
Member
Advisory Committee

**Prof. Dr. Md. Shahidul Islam**
Member
Advisory Committee

**DEDICATED**

**TO MY**

**FAMILY AND**

**SUPERVISOR**

# *CERTIFICATE*

This is to certify that thesis entitled "**PLANTING DATE AND VARIETY EFFECTS ON PHENOLOGY, GROWTH AND YIELD OF WHITE MAIZE** "submitted to the faculty of agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** in AGRONOMY embodies the result of a piece of *bona fide* research work carried out by **SHAHRINA AKHTAR**, Registration No. REGISTRATION NO. 13-05803under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of the investigation has been duly acknowledged by her.

Dated
Dhaka. Bangladesh

**(Prof. Dr. Md. Jafar Ullah)**
Supervisor
Advisory Committee

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# GENOTYPE AND PLANTING DATE EFFECTS ON PHENOLOGY, GROWTH AND YIELD OF WHITE MAIZE

## ABSTRACT

Three experiments were conducted at the Sher-e-Bangla Agricultural University in Rabi and Kharif-I seasons of 2016-2017, 2017-2018 and 2017to study the effects of planting date on the phenology, growth and yield of four genotypes of white maize viz., PSC 121, Yangnuo-30, Changnau-6 and Youngnau-7. The planting dates were, November 25, December 10 and December 25 in Rabi and May 29, June 21 and July 7 in Kharif-I. A delay in planting delayed the time required for seedling emergence and to reach the 6-leaf collar, tasseling, silking and maturity stages, and reduced yield of the maize genotypes in both seasons. The recorded maximum time for seedling emergence after planting was 9.67 d for Yungnuo-30 in Kharif-I, 2017 and 5 d for PSC-121 in Rabi 2017 season when the planting time was delayed by 30d. The genotype PSC-121 took 43.67 d to reach the 6-leaf collar stage in Rabi 2017 season when plantingwas done on December 26, i.e., delayed by 30 d from November 25 where as Yangnuo-7 took only 30 d with the optimum planting date of November 25. In respect of the time to reach the tasseling stage, PSC-121 needed 69.33 d in Rabi 2016 when planting was delayed, but Yangnuo-7 needed a shorter time to reach the tasseling stages. With delayed planting, PSC-121 needed a long period of 81.33 d to reach the silking stage. Likewise, delayed planting substantially delayed maturity. The genotype PSC-121 took the maximum time, 141.33 d, to mature in the Rabi season due to delayed planting, where as the time needed for maturity was minimum, 111 d (Yangnuo-7) when planting was done at the optimum time, i.e., November 25. The genotype PSC-121, when planted at the optimum time, had the highest leaf area, greater than 0.80 $m^2$ $plant^{-1}$in the first Rabi season. However, the genotype-planting date interaction effect on LAI was not consistent. The crop growth rate (CGR) was the highest, 23.32, between 90 days after planting (DAS) and maturity, for November 25 sown PSC121. The same combination (PSC-121 x November 25 planting) showed the highest relative growth rate (RGR) of 0.06 and the highest net assimilation rate (NAR) of 0.003 at 45-60 DAS. The November 25-planting-PSC-121 combination was also found to be superior in terms of stover production (113 and 124 g $plant^{-1}$ in Rabi and kharif, respectively) and ear weight (156, 108 and 154 g $plant^{-1}$, respectively, in first Rabi, kharif and second Rabi). Planting at the optimum time in Rabi (November 25) gave the highest dry matter $plant^{-1}$ (207-278g $plant^{-1}$) in PSC-121. The November 25 planting x PSC-121 combination gave the best results in terms of the yield contributing characters, 100 seed weight (32g), grain number $plant^{-1}$ (249-322) and grain weight $plant^{-1}$(95-160g). Consequently, the highest seed yield was obtained with November 25 sown PSC-121 (9.982-10.770 t $ha^{-1}$). Planting date was of critical importance in maize yield. For example, the highest yield of 11.46 t $ha^{-1}$ (PSC-121) in the Rabi season was achieved when planting was done on November 25, and in general, the earlier the planting the higher was the yield irrespective of genotype. The total growing degree days (GDD) was less in PSC-121 (1747.05 and 1727.50) than that in Yangnuo-7 (1915.20 and 1905.60) with the first date of planting. There was a negative correlation between temperature and yield. On an average, the seed yield in the Rabi season was 9.852 $tha^{-1}$, while in the Kharif season it was 6.070 $tha^{-1}$. Thus, there was a 38% lower yield in the warm Kharif season than that in the cool Rabi season. Overall, planting PSC-121 early on in the Rabi season would be the appropriate practice in the cultivation of white maize in Bangladesh. However, these results need to be fine-tuned through further experimentation in different maize growing areas of the country.

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# LIST OF ABBREVIATIONS AND ACRONYMS

| **Full word** | **Abbreviation** |
|---|---|
| Analysis of Variance | ANOVA |
| And others | *et al.* |
| Crop growth Rate | CGR |
| Figure | Fig. |
| Gram | g |
| id est (means That is ) | i.e. |
| Kilogram | Kg |
| Leaf area index | LAI |
| Least Significant Difference | LSD |
| Namely | Viz. |
| Percentage | % |
| Randomized Complete Block Design | RCBD |
| Relative growth rate | RGR |
| Relative Humidity | RH |
| Species (plural number) | spp. |
| Sunshine Hours | SH |
| Temperature | Temp°C |
| Ton per Hactare | t/ha |
| Variety | var. |

# INTRODUCTION

# CHAPTER I

## Introduction

Maize, an annual determinate crop having a $C_4$ carbon fixation pathway (Imran *et al*., 2016), is one of the principal staple food crops grown worldwide. It ranks first worldwide in respective of productivity and compared with $C_3$ crops is quite adaptable to high temperature and dry environments (Shima *et al*., 2017). Owing to its high production potential and adaptability to a wide range of environments maize is known as the 'Queen of Cereals' (Choudhari and Channappagouda, 2015). Maize can be grown throughout the year, the financial returns from Rabi season maize being 2-3 times more than those from wheat or rice (Moniruzzaman *et al*., 2009).

In Bangladesh, at present, maize covers an area of about 0.304 M ha with a production of over 2 M t per year which is almost exclusively used as livestock feed (Ullah *et al*., 2017). The area and production of maize have been increasing rapidly in the country (BBS, 2015) over the last two decades. It provides food, feed, fodder and serves as a sources of basic raw material for a number of industrial products *viz*., starch, protein, oil, alcoholic beverages, food sweeteners, cosmetics, more recently as bio-fuel, etc. No other cereal is being used in as many ways as maize. The maize grain has a high nutritive value as it contains about 72% starch, 10% protein, 4.8% oil, 5.8% fiber and 3% sugar (Rafiq *et al*., 2010).

Maize can be grown throughout the year on well drained soil in Bangladesh. However, it occasionally faces extreme climatic conditions and biotic/abiotic pressures (Chaudhry, 1994) andsuch stresses are being aggravated by climate change. Dramatic impacts on maize yield and food security are expected under future climate regimes (Shima *et al*., 2017) especially higher growing-season's temperatures will reduce maize yield in diverse regions of the world and exacerbate food insecurity (Deryng *et al.,* 2014). Cereal crops including maize are the most important food source for human consumption (FAO 2014) and as global population increases, crop production must be increased (Alexandratos and Bruinsma, 2012).

Many authors have reported the effect of planting date on maize along with research with cultivar selection, plant density, amount and timing of fertilizers, etc. for growing a maize crop (Tsimba *et al*., 2013a). Proper planting date for crops becomes even more challenging because of the climatic change adversaries (IPCC, 2013; Streck *et al*., 2012). In this context, planting date assumes immense importance to ensure that the crop avoids negative climatic conditions (Waha *et al*., 2013; Khan *et al.,* 2011). Furthermore, producers can reduce the negative impact of possible climatic change by adapting the planting date to the new climatic scenarios choosing an appropriate varieties (Waha *et al*., 2013).

A significant decrease in maize yield with delayed planting was reported (Anapalli *et al.,* 2005; Martin and Williams, 2008). It was found that the number of days between emergence and $R_1$ varied with the time of planting without changing the thermal sum in the growing period. This fact is explained because corn requires an accumulation of degree days to complete the development stages and only then can move on to another stage (Tsimba *et al.,* 2013b). Wilson and Robson, (1996) noted that the time to flowering and the duration of growth were strongly influenced by climatic adaptation which affected yield of crop plants. Delayed planting in kharif and

Rabiseasons reduced days to tasseling, silking and duration of crop and also the grain yield (Lenka, 1998). Berzsenyi *et al*. (1998) found that a delay in planting reduced the number of days from planting to seedling emergence from 6 to 5 days. Silking and seed black layer formation occurred significantly in fewer growing degree days (GDD) as planting was delayed from early May to early June (Nielsen *et al.*, 2002).

Identification of suitable high-yielding varieties (HYV) along with planting at the optimum time to grow are two of the key factor for future farming (Liaqat *et al*., 2018a; Ramankutty, 2002).The phenology of a crop, which comprises the relationship between various physical factors of the environment and seasonal changes in growth and development during its life cycle (Varma *et al*., 2014), determines its adaptation to a region, its ability to mature and set grain within a growing season, and the synchrony of key developmental phases with ambient environmental conditions critical for productivity (Kumudini *et al*., 2014). Crop phenology is one of the most important aspects of crop yield determination (Carcova and Oteguai, 2001). Warmer growing season temperatures can directly reduce yields through affecting crop growth and the development of grain (Harrison *et al*., 2011**)**. The effect of temperature in reducing the length of the growth cycle, especially the grain filling phase, is the most important factor in explaining reduced yields at higher temperatures (White and Reynolds, 2003).

In general, higher temperatures, within a certain limit, tend to accelerate the rate of development while lower temperatures tend to delay development (Payero, 2017). Every phase of development requires a minimum accumulation of temperature before that stage can be complete and the plant can move to the next stage. The GDD requirement of maize cultivars showed variation with planting dates depending upon temperature during each growth phase and also the cultivar (Singh *et al.*, 1990). It is used to determine for selecting crop varieties for specific area with specific climatic variables. It is an easy way to fix the selection criteria for a certain locality. For example, if a variety needs $105^0$ degree days (°d) thermal time (over the base temperature) for its planting to maturity, 85°d for vegetative and 200°d from tasseling to maturity, any gap (time between two crops) having thermal time facility over the base 105°d in the existing cropping system may be filled with the crop which needs the thermal time 105°d.

In Bangladesh conditions, maize planted in late Rabi suffers heat stress during flowering and early grain filling stages which may affect these developmental stages. Sometimes drought coupled with heat shock may also affect the crop. High temperature or heat stress at this stage may affect flowering and grain filling ultimately reducing yield. Numerous previous studies have studied the optimization of the planting date and investigated the effect of different planting dates on spring or summer maize (Yan *et al.*, 2017; Binder *et al.*, 2008; Tao *et al.*, 2016; Zhou *et al*., 2017; Yan *et al.*, 2018; Zhang *et al.*, 2018). However, there is still a lack of research on planting date and variety effectson phenology and yield of maize under changing temperature in Bangladesh conditions. In addition, most research defines the planting date by the day of the year, which has a large photo thermal resource variation in each year. Growing degree-days (GDD), has greatly improved the accuracy of the description and prediction of crop phenological events compare with other approaches (Zhang, *et al.*, 2019). Hence there is a need to screen maize germplasm with adaptive potential to perform well under high heat regimes as well as under optimal conditions. It is also necessary to identify the morphological and physiological traits conferring resistance to heat stress and incorporating these traits in well adapted maize genotypes to come up with promising materials for the development of varieties. The present study was thus conducted with the following objectives:

I. To identify the best white maize varieties for growing in Bangladesh;
II. To determine the optimum planting date of white maize varieties in Bangladesh;
III. To study the interactions between white maize variety and planting date in Bangladesh conditions; and
IV. To examine the relationship of the white maize variety with environmental parameters, especially with temperature in relation to GDD.

# REVIEW OF LITERATURE

## CHAPTER II

# REVIEW OF LITERATURE

Optimum planting date along with suitable maize cultivar for an area guarantees higher yield. To study maize performance for different planting dates with multiple varieties in Bangladesh climate, different researches of the world were reviewed. Data revealed that planting dates significantly affected crop phenology (days to emergence, teaselling, silking, and maturity), crop growth (leaf area, leaf area index, plant height and ear height), yield contributing traits (rows per ear, grains per ear, ears per plant, shelling percentage, and thousand grains weight) which ultimately affects both biomass and grain yield.

In this chapter approach has been made to review the relevant research information of maize cultivation taking consideration of both the world and Bangladesh aspects. Literature on the influence of planting date and hybridon phenology, growth and yield of maize especially in the short duration late planting varieties have been given importance while reviewing. The research work by several workers for planting date and hybrideffect on phenology, growth and yield of maize related investigation is reviewed and presented under suitable heads.

### 2.1. Varietal effect on maize

Two important components of maize cropping systems are plant hybrid and planting date. Proper selection of these components can help in improving maize yields (Prasad *et al.,* 2018). Kharazmshahi *et al*., (2015) reported that the most important effective factors on grain yield are application of optimal maize varieties and suitable planting dates. Planting dates and varieties selection are the major factors affecting maize production in addition to soil fertility, temperature regimes and irrigation (Khan*et al.,* 2011). Each hybrid has an optimum planting date, and the greater the deviation from this optimum (early or late planting), the greater the yield loss (Sárvári and Futó, 2000; Berzsenyi and Lap, 2001) and may negatively influence the growth duration and the yield (Sárvári & Futó, 2000). Crop cultivars show distinctive variation in response pattern among them related to planting date (Shrestha *et al*., 2018). Furthermore, maize varieties respond differently to planting dates (Darby and Lauer, 2002). The research works at that time are focused more on breeding aspects rather than crop management (Xue *et al.,* 2002).

The optimum planting time of maize varies with geographical location, weather condition and varieties (Shrestha *et al.,* 2018). Newly improved varieties usually need to be examining at several planting dates or locations and for many years before being counseled for a given location. The basic environmental effects and genotype environment interaction have been introduced as the most important sources of alteration for the measured yield of crops (Dehghani *et al.,* 2006; Yan *et al.,* 2007; Sabaghnia *et al.,* 2008).In India Sadek *et al., (*1994) and Zaki *et al., (*1999) reported that maize cultivars differed in yield and its components in the same region.

Applying the optimum planting date for maize cultivars has a positive effect on a grain yield and physiological index in maize reported by Kharazmshahi *et al*., (2015). The study revealed that both planting date and cultivar had significant effect on grain yield in applied sweet maize varieties under the field conditions. Similar results have been obtained where graining dates and varieties significantly influenced on 1000 kernel weight (Rahman *et al.,* 2001; Nielson *et al.,* 2002). The early optimum planting date produced maximum number of ears plant$^{-1}$ than late planting. Short season varieties can be planted early without damaging effects on their maximum yield potential and can also be minimize the risk of obtaining immature ears and grains or sustaining early frost damage (Hicks *et al*., 1993). But, in case of maize cultivars, both long durational cultivars had higher harvest index than short durational cultivar. It was due to longer grain fill duration, higher leaf area index, higher leaf area duration (Shrestha *et al.*, 2016).

High yielding varieties are of primary importance for potential yield. Yield can be increased to a greater extent provided high yielding varieties are identified and planted at proper time (Khan *et al.,* 2009; and Arif *et al.,* 2001). Khan *et al*., (2004) reported significant effects of varieties on days to tasseling and grain yield of corn. Varietals differences in growth characteristics of maize have been reported by Ayub *et al., (*1998) and Ramankutty *et al., (*2002). Shrestha *et al., (*2018) reported that longer maturity maize varieties were more sensitive to late planting date than the short maturity varieties. The reason for differential response to maize planting dates could be attributed to variation in the maturity periods. Sangoi, (1993) found hybrid maize planted during earlier planting date elongated growth period of more than 2 weeks than planted in delayed date

Genetically different varieties significantly differed in their grain yield performance in corn was also reported by Khan *et al.,* (2009). Mahmud and Rahuma (2018) stated that there were significant differences between the studied single crosses and the three way crosses and within each cross type, where crosses with white grains were significantly higher in grain yield and yield components than those of yellow grains. Griesh and Yakout, (2001) reported the same trend of results. Grzesiak, (2001) reported remarkable genotypic variability among various corn varieties for variant characteristics. Ihsan *et al.*, (2005) also demonstrated considerable genetic differences for morphological variables for corn genotypes. This mutability is a clue to crop improvement (Welsh, 1981).Khan *et al., (*2004), Khan *et al.,* (1999) and Aziz *et al.,* (1992) reported that genetically different varieties significantly differed in their grain yield performance in corn. The grain yields of varieties with longer growing periods were significantly higher than those with shorter growing periods (Nagy 2009). Shorter cultivar had greater assimilated allocation to the grain than the taller cultivars (Benga *et al.,* 2000). From several researches, it has also been reported that varieties can give 20-50% more grain yield than the inbred hybrid (Shrestha *et al.,* 2016).

The three hybrid sweet corn varieties*viz*. Hibrix 39, Madhu 5 and Sugar 75 and four planting dates *viz*. 15th December, 15th January 30th January was studied by Dekhane *et al.,* (2017). All quantity traits were promising when the planting was carried out on 15th December. Further delay of the planting had negative effects on the performance of quantity of sweet corn varieties. Hybrid sweet corn var. Sugar 75 was recorded promising hybrid which gave higher grain yield of 2381 kg ha$^{-1}$. Grain yield maize was reduced when planting date was delayed to the end of October (Mc Cormick, 1974). Delaying planting date to mid-December reduced the individual 1000 kernel weight (Cirilo and Andrade, 1996), where indicated that maize varieties differed in their growth characters in Gainesville Florida (El-Koomy, 2005; Gardner *et al.,* 1990). It has been shown that July 15 as an optimal planting date for maize in Peshawar (Ahmad *et al.,* 2001).Nonetheless, a good hybrid selection of maize either hybrid or OPV (open pollinated variety) can minimize yield losses but cannot substitute yield reduction by subsequent delay in planting made after July 15 in the region by any other means (Liaqat *et al.,* 2018). Buriro *et al.,* (2015) reported that the effect of three planting dates 25th October, 10$^{th}$ November and 25th November on three hybrid maize varieties (Pioneer 1543, Syngenta 4841 and Monsanto DK-6142), it was concluded from the finding of present research work that all quantity and quality traits were promising in Pioneer 1543 when the planting was completed up to 25th October. Further delay of the planting had negative effects on the performance of quantity and quality of maize. Afshar Manesh, (2004) compared the summer planting of delay mature hybrid cultivars and found the highest grain yield for the cultivars 720 and Karaj 700. The highest grain yield was obtained from Aveline corn cultivar in late planting date in both years because of having high thousand grain weight reported by Koca and Canavar, (2014). Ali *et al., (*2018) observed that delay in planting decrease biological yield through May, while further delay showed an increase of biological yield in maize. The period from November to February is the best time for the highest dry matter production of maize in the Khartoum area in Iran (Kharazmshahi *et al.,* 2015). Jasemi *et al*., (2013) who found harvest index was higher for plant sown on 22nd May than 13th July.

In spite of this, adaptation measures such as cultivar shifts and management improvements could reduce the negative effects of warming climate on crop production (Liu *et al.,* 2010; Olesen *et al.,* 2011; Wang *et al.,* 2012). For example, the adoption of cultivars with longer growth periods could increase yield under climate change due to higher heat accumulation (Wang *et al.,* 2012; Liu *et al.,* 2013; Xiao and Tao, 2014). Crop phenological processes are driven by the combined effects of climate variability and agronomic factors such as cultivar shifts and management practices, which are to some extent controlled by man (Liu *et al.,* 2010; Xiao and Tao, 2014). Depending on climate characteristics and the need for avoiding local agro-meteorological disasters, hybridshifts can shorten or lengthen growing season duration (Estrella *et al.,* 2007; Torrion *et al.,* 2011; Tao *et al.,* 2013; Zhang *et al.,*2013; He *et al.,* 2015). However, the hybrid and improved cultivars of any crops are more sensitive to the environment of climatic variability than the local genotypes, and yield reduction is more on them (Amgain, 2011; Lamsal and Amgain, 2010; Bhusal *et al.,* 2009).

Environmental impact on agro-climatic indices such as heat use efficiencies and phenothermal index were studied to find there significant role in varietal selection (Shrestha *et al.,* 2016). During both the winter and spring planting, 'Arun-2' has given more stable yield and heat use efficiency for the early and late (September 1 to November 1, and February 24 to March 4) plantings (Amgain, 2011). Research has shown a yield penalty from planting early varieties if season length was sufficient for later maturing varieties (Sorensen *et al.,* 2000). Early maturing varieties usually fail to fully utilize available solar radiation for the period when temperatures are suitable for growth and therefore will not realise the full yield potential of the growing season and the inputs provided by the grower (Lauer, 1998). However, Wang *et al., (*2016) reported that the lengths of the vegetative and vegetative and reproductive phases became shorter under the combined effects of changing temperature, agronomic management practices and cultivars. This was not consistent with the results of previous studies (Olesen and Bindi, 2002; Lv *et al.,* 2013). To avoid high temperature and drought during post anthesis period, farmers like to cultivate short durational varieties. Farmer expects short durational hybridto escape drought period and provide higher yield and net returns. However, they are still in dilemma, which varieties will provide greater yield under prevailing environment (Shrestha *et al.,* 2016).Tao *et al.,*

(2014) reported that the duration of the maize growing season was prolonged during the past three decades in response to the combined effects of temperature, agronomic management practices and cultivars.

A field experiment was conducted by Dahmardeh, (2012) to analyze the relationship between growing degree days, yield and yield components of maize cultivars. Five maize cultivars (SC 108, SC 301, SC 604, SC 704 and TVG) were sown on four different dates during summer. Maize cultivars exhibited significant differences on yield, weight of 100 grains, biological yield and harvest index. Each maize hybrid has an optimum planting date and any deviation from optimal planting date may negatively influence the growth duration and the yield (Sárvári and Futó, 2000). However, the number of growing degree days (GDD) needed for maize varieties to reach various developmental stages is fairly uniform across environments (Hoegemeyer, 2013).

Other non-climatic factors, including varietal differences, can also play an important role in determining crop phenology (Wu *et al.,* 2019). In addition, field experiment conducted by Wang *et al.*, (2016) showed that cultivars prolonged the growth duration of summer maize. Therefore, these results indicated that farming practices and cultivars have had a relatively strong effect on summer maize phenology by prolonging the maize growing season, which was consistent with Tao *et al., (*2014). Maize SC701 cultivar is one of the commonly southern African grown varieties. The cultivar’s desired traits were its large ear size, long shelf life high yield and moderate drought tolerance (ARC, 2014). It is a late maturing cultivar which requires an average of 1028 GDD from emergence (VE) to physiological maturity ($R_6$) and an average of 6.4 mm/day of water from 12 leaf stage to full dent stage (Darby and Lauer, 2002). Banotra *et al., (*2017) reported that Cultivar Gold star took minimum 91.55 days to reach harvest maturity stage which were significantly less from Sugar-75 and Misthi with 93.10 days and 94.24 respectively, which in turn also differed significantly from one another. This might be due to the reason that different crop cultivars take their normal time to develop different vegetative and reproductive structure and attain maturity. These results were akin to that of Otegui *et al*., (1995).

### 2.1.1Vegetative Growth of maize

A field experiment was conducted by Banotra *et al*., (2017) during summer season to study the effect of different cultivars and planting times of sweet corn at Jammu in India. The treatments include three sweet corn cultivars (Misthi, Sugar-75 and Gold star) and six planting times (29 March, 15 April, 30 April, 15 May, 30 May and 19 June). Significant effect of planting times was noticed on days to emergence of sweet corn. March 29 planted crop took significantly higher days (5.77 days) to emerge as compared to other planting times. It was followed by the crop planted on 30 of May which took statistically similar days to emergence (5.22 days) with that of crop sown on April 15 with 5.00 days and this in turn was found statistically at par with the crop sown on 30th of April which took 4.66 days. The June 19 sown crop took significantly less (4.44days) but statistically similar days to emergence as recorded with the crops sown on May15 with 4.33 days and 30 of April. Kara, (2011) reported that planting dates had a significant effect on harvest period, emergence rate, fresh ear yield and yield characteristics. Compared with the corn, planting dates from April to June the corn sowed in the earlier had longer total growth period. The highest emergence rate (93.3 and 91.7%, respectively) was determined from June 1 in both years.

### 2.1.2 Reproductive growth of maize

Khan *et al., (*2011) reported that days to silking were significantly affected by planting date. Sweet corn planted on 17th March took more days to silking (72.2). Delay in planting decreased days to silking and minimum days (56.73) were noted for 26th July planted crop. This decrease in days to silking may be due to increase in mean temperature with delay in planting date. Significant effects of planting date and landraces on days to silking in corn are reported Khan *et al*., (2009) and Shafi *et al*., *(*2006). This is in agreement with Mederski and Jones (1963), who reported a decrease in the number of days from planting to silking as soil temperature increases. Shrestha *et al*., (2016) observed that April 7th showed higher days to knee height stage (31.42), anthesis (53.75), silking (58.08) and grain fill duration (51.25) than other planting dates. The reason for its higher days to different phonological stages were due to relatively cooler temperature. Banotra *et al*., (2017) found a significant difference in silking due to varietals effect. The cultivar Misthi took maximum days (60.71 days) followed by cultivar Sugar-75 (60.32 days) and Gold star (60.21 days) to attain 50 per cent silking in decreasing order of number of days, respectively. This variation in the number of days taken to silking was due to genetic variation of the different sweet corn cultivars observed by Khan *et al*., (2009).

Khan *et al., (*2011) reported that days to tasseling were significantly affected by planting date. Sweet corn planted on 17th March took more days to tasseling (63). Days to tasseling decreased with delay in planting and minimum days (51.4) were noted for 26th July planted crop. Since, tassel initiation is correlated with maturity of genotype and late maturing genotype will take more days to tasseling (Lejeune and Bernier, 1996) and vise versa. Banotra *et al*.(2017) found 29 March sown crop took maximum days (56.31 days) to acquire 50 per cent tasselling and this was statistically at par in days taken by the crop with April 15 (55.62 days) and April 30 (55.45 days) sown crops to get to this stage.

Photoperiod and temperature can influence the timing of development events in maize (Aitken, 1977; Allison and Daynard, 1979) and influence days to tasseling in maize with appreciable genetic differences in relative sensitivity to these factors (Ellis *et al.,* 1992). These results are also supported by Khan *et al., (*2009), Khan *et al*., (2004), Shaw (1988), and Daughtry *et al., (*1984) who reported dependence of tasseling duration on temperature and variety. Maize hybridazam belongs to medium maturity group (Khan *et al.,* 2004) hence it took significantly less days to tasseling. Days to tasseling decreased with delay in planting from March to July. Prasad *et al., (*2017) reported that days taken to 50% tasseling were delayed with delay in planting by 20 days from normal planting date as compared to 10 days advance, normal and 10 days delayed planting and the later three being at par. Kharazmshahi *et al., (*2015) conducted a study with planting date in two levels (15 and 30 May) and they found significant difference of planting date and sweet maize varieties on number of days to emergence tassel, number of days to anthesis, number of days to emergence spikelet, per plant.

Ali *et al., (*2018) conducted an experiment at Peshawar (Pakistan) in which ten selected varieties (Iqbal, Azam, Jalal, Babar, SB-989, SB-909, SB-292, CS-200, CS-220, and W- 888) were sown at six different planting date (10 June, 21 June, 1 July, 11 July, 22 July) and concluded that Early planting and tested hybrid W-888 performed better with respect to maximum days to tasseling (57), days to silking (62), tasseling and silking interval (7). It was also revealed that late planting of maize caused reduction in these attributes. Prasad *et al., (*2017) studied four planting dates of maize (15th June, 25th June, 5th July and 15th July) on five maize (*Zea mays* L.) varieties of different maturity group [HQPM-1 (long), HM-4 (medium), HM-5 (long), HM-6 (early) and HM-7 (extra early)] and revealed that days to 50 % tasseling, 50% silking and maturity were delayed in last date of planting. HM-7 and HM-6 took lower number of days to attain 50% tasseling, 50% silking and maturity stage. HQPM-1 and HM-5 being at par took higher number of days to 50% tasseling, 50% silking and maturity as compared to HM-4. Khan *et al*., (2011) conducted a study where a maize hybrid Azam were planted on 5 dates i.e. 17 March, 30 April, 17 May, 21 June, and 26 July. Days to tasseling, silking, were significantly affected by planting dates. Days to tasseling and silking enhanced as the planting was delayed.

Banotra *et al*., (2017) studied six planting dates (29 March, 15 April, 30 April, 15 May, 30 May and 19 June) on three sweet corn cultivars (Misthi, Sugar-75 and Gold star) and revealed that maximum of 94.67 days taken by the crop to reach harvest maturity were recorded with March 29 sown crop which was statistically at par with April 15 and April 30 sown crops with 94.57 days and 94.26 days, respectively. Sweet corn crop planted on June 19 planting minimum days to reach these stages. Among the different varieties, cultivar Misthi has been adjudged as the best cultivar and the period from 29 March to 30 April as the optimum planting window with 15 April as appropriate planting date for judicious utilization of applied resources for optimization of yields under sub-tropical Jammu, India.

Khan *et al., (*2011) reported that days to maturity decreased when planting was delayed from March to June, however further delay in planting increased number of days to maturity. These results are supported by Khan *et al*., (2009) and Zaki *et al*., (1994) who reported decrease in days to maturity with delaying of planting from April to July. As planting date was delayed, growth occurred under greater temperatures, with associated reductions in duration of growing cycles (Otegui *et al.,* 1995). Zaki *et al., (*1994) also reported decrease in number of days to maturity when planting date was enhanced from April to June. While further delay in planting to August, they noted an increase in number of days to maturity. Whereas weather condition particularly cloudy days and intensive rains might have forced the plants to enter into reproductive phase early thus resulting in shorter growth period and the plant do not get enough time for complete maturity during delayed planting (Azadbakht *et al.,* 2012; Ramachandrudu *et al.,* 2013). Intensively studies have been carried out on the effect of harvesting stages on maize yield and agreed that the optimal time to harvest maize is when close to its physiological maturity (Henning *et al.,* 2011; Junior *et al.,* 2014). Planting dates and maturity stages at harvest have strong effect on grain yield (Adelabu and Modi, 2017).

A field experiment was conducted by Verma *et al., (*2012) during rabiseason to study the effect of planting dates and integrated nutrient management on growth, yield and quality of winter maize. The significantly more number of days to maturity was observed in 25 Oct planting followed by 15 Oct and 5 Nov dates of planting and the average number of days to maturity were also more in 25 Oct planting as compared to other dates of planting, also supported by Andrew *et al.(*2006). A study was undertaken by Shah *et al., (*2012) to investigated yield and yield contributing traits response of maize with recent climate change by planting maize early too late.Planting was done from June 8 to July 24, with ten days intervals. Mazie (cv. Azam) was planted and raised under the uniform recommended cultural practices. Data regarding days to emergence, tasseling and maturity showed a consecutive decrease when planting was delayed form June 08 onwards. However, the crop life cycle (i.e. vegetative and reproductive durations) initially remained uniform but expanded for late planting dates (July).

### 2.1.3 Phenology

Crop phenology is an important area in Agricultural Meteorology. Phenology is the study of development, which refers to ontogenetic processes at different levels of organization that a crop goes through during its life cycle, and extends from cell differentiation, organ initiation (organogenesis) and appearance (morphogenesis), to crop senescence (Streck *et al.,* 2012). Characterizing and understanding crop phenology is crucial for field crop management practices such as fertilization, pests control and irrigation scheduling (Streck *et al.,* 2008; Bergamaschi and Matzenauer, 2009).

The phenology of corn has been described as the appearance of leaves or leaf collars during the vegetative stage and accumulation of material in the grain during the reproductive stage. The developmental stages of corn has been recently described by Abendroth *et al., (*2011) and similar guidelines are used to quantify the phenological stage of corn during the growth cycle (Hatfield and Dold, 2018). Phenology is the study of the timing of recurring biological events, as affected by biotic and abiotic factors (Ma *et al.,* 2012). Phenological stages, such as jointing and anthesis, represent critical physiological processes in crops and are strongly influenced by climate (Lu *et al.,* 2014). Phenological studies made major contributions to the conclusion in the IPCC’s Fourth Assessment Report (Parry *et al.,* 2007) that “there is very high confidence, based on more evidence from a wider range of species” (Arnold *et al.,* 2014).

In order to minimized negative effect of some abiotic and biotic stress on plant, planting date can play a major role in determining the grain yield, quality, grain germination and understanding whole phenological stages in many regions (Koca and Canavar, 2014). Shunway *et al., (*1992) explained that delay in planting reduces quality performance and performance components of maize. Early and intermediate plantings tend to best utilize solar radiation for grain production (Otegui *et al.,* 1995). The planting date of maize not only effects grain germination, but the whole phenological stages will be impressed by planting time as reported by Mokhtarpour *et al., (*2013). Planting date is one of the most important aspects of management in agricultural system, which can affect yield through influencing emergence date, plant density, normal growth, pollination and maturity date (Panahi *et al.*, 2010).

The developmental cycle of maize is divided into two major phases: vegetative (from emergence to silking) and reproductive (from silking to physiological maturity) phases (Ritchie *et al.,* 1997). During the reproductive phase, the potential number and size of kernels is defined at silking and grain filling takes place until physiological maturity, when final crop yield is defined (Streck *et al.*, 2012). Two weeks before and after silking is a critical period in maize, so that any stress (biotic and abiotic) during this period affects yield drastically (Ritchie *et al.,* 1997; Bergamaschi and Matzenauer, 2009).

Consequently, climate change impacts on crop phenology have been of much concern, especially during the last two decades (Wu *et al.*, 2019). In recent decades, the response of crop phenology to historical climate change has been extensively investigated in many regions and climates around the world (Estrella *et al.,* 2007; García-Mozo *et al.,* 2010; Siebert and Ewert, 2012; Sadras and Moran, 2013). Reports have shown that phenology has potentially changed as a consequence of climate change for many crops, but the changes appear to be crop and location dependent. Recently, interest in spatiotemporal changes of crop phenology has increased. Several studies have reported phenological changes in response to climate factors (Shimono *et al.,* 2011; Croitoru *et al.,* 2012; Arnold *et al.,* 2014; Lu *et al.,* 2014; John *et al.,* 2014). These studies provide strong evidence that the dates of crop phenology phases shift markedly in response to ongoing climate change, recognizing the complex effects of agronomic factors such as agronomic management practices and cultivar (Li *et al.,* 2014; Tao *et al.,* 2014). The most critical variable in phenological development is temperature and each plant has a specific range of temperatures for growth as defined as the upper and lower limit (threshold) and an optimum (Hatfield*et al.,* 2011). For corn during the vegetative stage this has been identified as 8 to 38ºC with an optimum of 34ºC (Badu-Apraku 1983; Kiniry and Bonhomme, 1991) while the range for the reproductive stage is 8–30ºC (Muchow, 1990).

There is now a general consensus in the scientific community regarding warming climatic conditions in recent decades (IPCC, 2013), which is considered to significantly influence phenological development and productivity of crops (Tao *et al.,* 2006; Craufurd and Wheeler, 2009; Lobell *et al.,* 2011; Maddonni, 2012). Moreover, phenological changes are vital indicators of changes in climate and environmental conditions (Orlandi *et al.,* 2005; Xiao *et al.,* 2013a). Obvious reductions in the length of crop growth seasons due to warming climate are extensively documented in several studies (Estrella *et al.*, 2009; Tao and Zhang, 2010; Zhang *et al.,* 2013; Xiao *et al.,* 2013a,b). Other studies have noted that climate change accelerates crop growth processes, with direct negative impact on crop yield (Liu *et al.,* 2013; Xiao and Tao, 2014). Crop phenology has been affected by modifications made to agronomic practices in response to climate change. Adjusting crop planting and harvesting dates and introducing new crop cultivars with longer growing seasons have been recommended as adaptations to climate change (Jørgen and Marco, 2002; Waha *et al.,* 2013; Moradi *et al.*, 2013). Many studies have shown that shifts in plant phenology were correlated with increasing temperature (Schleip *et al*., 2009; Yujie *et al.,* 2017).

### 2.1.4 Physiological maturity

Late planting of maize caused elongation of silking to physiological maturity period due to adverse effect of low temperature on pace of maturity period as well as proper grain black layer filling was also affected (Tollenaar and Bruulsema, 1998). Daynard, (1972) observed that time interval requirement of thermal condition during planting to mid–silking stage in maize crop was lengthen whereas requirement of thermal exposure interval by mid–silking to grain black layer formation stage was shorten as a result of late grain planting. Therefore, due to reduced daily incident radiation, cumulative intercepted PAR was reduced during silking to physiological maturity in case of late planting was observed (Tollenaar and Aguilera, 1992). Whereas, late planting of maize caused reduction of Radiation Use Efficiency (RUE) in later growth stage but increased during earlier growth stage (Shrestha *et al.*, 2018).

Azizian and Sepaskhah (2014) conducted a split-split-plot design with three replications in two years of 2009 and 2010 was conducted to investigate the effect of different levels of irrigation water (main plot), salinity of irrigation water (sub-plot) and nitrogen fertilizer rate (sub-subplot) on maize growth rate and gas exchange. Irrigation treatments were $I_1$ (1.0 crop evapotranspiration (ETc)+0.25ETc as leaching), $I_2$ (0.75I1) and $I_3$ (0.5I1) applied at 7-day intervals. The salinity treatments of irrigation were 0.6 (fresh water), 2.0 and 4.0 dS m-$^1$. There were also three nitrogen (N) treatments including 0, 150 and 300 kg N ha-$^1$. Results showed that vegetative growth stage of maize in salinity stress lasted 5% more than that in water stress. The most sensitive trait under water, salinity and nitrogen stress was grain yield (GY). The optimum treatment for maize production is full fresh water application by 150 kg N ha-$^1$. Results also showed that crop growth rate (CGR) was statistically higher in $I_1$ and

$I_2$ as 58 and 34% relative to $I_3$ treatment, respectively. Furthermore, CGR was statistically lower in $S_2$ and $S_3$ as 10 and 18% relative to $S_1$, respectively. Besides, N application significantly increased CGR by an average of 15% as compared with no N rate. The net assimilation rate (NAR) reached its maximum value in $I_2$, $S_2$ and $N_2$ relative to other treatments indicating that NAR did not necessarily occurred at maximum LAI conditions. In general, maize had statistically greater NAR in pollination and filling stages relative to other growth stages.

Delayed planting decreased the number of days to reach various phenological stages of sweet corn. This can be attributed to the fact that lower temperature and accumulation of more heat units with early planting resulted in delayed germination and emergence and more number of days to reach silking, tasseling and harvesting. The results are in conformity with Kim *et al*., (1999), Khan *et al*., (2002) and Williams (2008). Shrestha *et al*., (2018) reported that delayed planting dates affect traits namely anthesis silking interval, photosynthesis, physiological maturity and dry matter production due to reduction in cumulative interception of photosynthetically active radiation (PAR).Cirilo and Andrade, (1994) found that late planting of crop decreased its growth and development because less amount of solar radiation was captured by crop during emergence to silking stage. Maresma *et al*., (2019) observed that early planting date increased the number of days from planting to plant emergence. Late planting date reduced the number of days to plant maturity, and had higher forage yields, higher grain humidity, and taller plants.

### 2.1.5 Yield and yield attributes

Considerable yield decline as a result of planting too early or too late has been reported in maize (Meza *et al.,* 2008). Maize yield response to planting date is very similar in different years and locations attributing yield benefits to early planting (Good *et al.,* 2015; Nafziger, 2008). Maize yield response to planting date is very similar in different years and locations attributing yield benefits to early planting (Good *et al.,* 2015; Nafziger, 2008). Proper selection of planting date can optimize maize yield. It had been reported that maize grain yield was reduced due to delay in planting date (Law-Ogbomo and Remison, (2009). Mascagni and Boquet (1996) studied the effect of planting dates on performance of maize and concluded that delay in planting reduced yield of maize. Other studies have found that the delay in planting date negatively influenced the sweet corn production (Martin and Williams, 2008; Khan *et al.,* 2011). Killi and Altanbay (2005) observed that grain weight was significantly affected by the planting dates.

Yield reductions due to early or late planting are well documented in the literature (Johnson and Mulvaney, 1980; Sorensen *et al.,* 2000). Mid-early planting gives higher grain yield as compare to early or late planting. These results are in line with (Sanghera *et al.,* 2011) who reported that Average yield was lower and smaller when maize had been sown both earlier and later (Hall *et al.,* 2016; Cirilo and Andrade, 1994). Forage yield increased when delaying the planting date, similarly to the results reported by Bunting (1968), Dillon and Gwin (1976), and Fairey (1983). Late planting of maize manifested significant reduction in grain yield (Aziz *et al.,* (2007).

Grain yield increased from March planting to April planting then considerably decreased in May planting and again increased in June planting to reach maximum in July planting. Planting date and landraces showed significant effects on final grain yield of sweet corn (Khan *et al.,* 2009). Herbek *et al.,* (1986) and Zaki *et al.,* (1994) reported decrease in grain yield when planting delayed from April to May and then increased in June planting. The planting dates 2 (21 June 2016) gives higher because the maize yield usually depends on photoperiod. Reported that delay in planting decrease biological yield through May, while further delay showed an increase of biological yield in maize. Mid-early planting gives higher grain yield as compare to early or late planting. These results are in line with (Ramankutty *et al.,* 2002) who reported that average yield was lower and smaller when maize had been sown both earlier and later (Shah *et al.,* 2012; Sharp *et al.,* 2004). Najafinia, (2002) examined maize planting date in Orsoiieh tropical region and found no statistically significant difference in maize yield for planting dates from 3 February to 17 March.

Shrestha *et al., (*2018) conducted a research in Nepal, delayed planting particularly in late October to December, results poor yield due to low temperature induced delayed germination and slow vegetative growth. Similarly, very early planting in late August or early September is not conducive to the maize growth and yields because of negative consequences of higher temperature and rainfall at the initial growth stages (NMRP, 2004; Amgain, 2015). September planting maize has been producing higher yield than the subsequent late plantings. The percentage reduction in yield was high for September versus (vs) October planting than the October vs November planting and the highest for September vs November planting (Amgain, 2015). In spring season, First week of April is optimum planting time for had higher growth rate, higher yield and its attributing characters as it was facilitated by relatively favorable temperature (Shrestha *et al.,* 2016). In South Africa, early planting usually commences around October/November, though optimal planting widow occurs in late spring/early summer (November/December) while planting can be extended to

January (Adelabu and Modi, 2017). The current drastic variability in weather conditions may cause shift in optimal planting date widow, thereby leading to delay in planting date. The number of suitable days can vary greatly from year to year. Ahmad *et al.*, (2001) suggested July 15 as an optimum planting date for maize in Peshawar region.

Liaqat *et al.,* (2018) stated that early planting of maize i.e. mid-June resulted in better yield and yield traits. However delayed planting from optimum time significantly decreased yield. In light of the present study, one can conclude that planting of maize in June returns higher production with better traits. Additionally, maize hybrid SB-92K97 and SB-909 are relatively better option to plant in the region. The study suggested that maize has to be planted as early as possible (i.e. in June) right after the wheat and/or be seem harvesting. Thereafter, any unavoidable delay in planting date will decrease grain production by adverse effects on yield traits. It has been shown that July 15 as an optimal planting date for maize in Peshawar (Ahmad *et al.,* 2001). Damor *et al.(*2017) stated that the crop sown on 1st November significantly enhanced the growth and grain yield than early planting 15th October and late planting 15th November and 1st December.

Shah *et al., (*2012) reported that both dry matter and grain are economic yield contributors of maize and has shown a significant declining effect by the delay planting. This relationship of dry matter to grain yield for the different showing date treatments was found linear and positively correlated ($R^2$=0.95). The relationship showed about 1.65 g m2 loss in maize production when plantings delayed from June 08 to July 24. Results from the present study agree with findings of Sun *et al*., (2007) and Grenz *et al*., (2005). A study was designed by Gurung *et al.,* (2018) to investigate the effects of planting dates and varieties on the grain yield of maize. The planting date was highly significant on grain production. The highest grain production was 5.1 t $ha^{-1}$in August followed by in February (4.9 t $ha^{-1}$), September (4.6 t/ha) and March (4.4 t $ha^{-1}$) respectively. The lowest grain yield was produced in May (2.4 t $ha^{-1}$). Therefore it was concluded that August planting was best for higher grain production of maize varieties (Rampur Composite, Arun-2 and Gaurav) in terai region of Nepal. Law-Ogbomo and Reinison (2009) studied the biomass production and yield, besides growth parameters under three planting dates (April 7, May 7 and June 7) and four levels of poultry manure and they found the highest grain yield was produced from the April 7 sown plants (3.81t $ha^{-1}$) and was 3.41 and 7.21% higher than in May 7 (3.68t $ha^{-1}$) and June 7 (3.54t $ha^{-1}$), respectively. This observation is conformity with Mendhe *et al.,* (1992) who postulated that grain yield increased with early planting.

Maresma *et al*., (2019) reported that the optimum planting date for grain and biomass were similar in all of the studied years despite of some year-to-year variation. Maize sown in mid-April achieved the highest average grain yields (14.0 Mg ha$^{-1}$), followed by mid-March plantings (13.2 Mg ha$^{-1}$) and the lowest grain yields were achieved with mid-May plantings (12.8 Mg ha$^{-1}$). Banotra *et al*.(2017) observed that the highest grain yield was recorded when planting was done on April 15th with grain yield of 2.395 t ha$^{-1}$ statistically at par with grain yield realized with March 29th (2.315 t ha$^{-1}$) and April 30th plantings (2.234 t ha$^{-1}$). The grain yield recorded with May 15th (1.813 t/ha$^{-1}$) planting was also found statistically comparable to May 30th (1.729 t/ha$^{-1}$) planting dates and significantly lowest yields (0.569 t/ha$^{-1}$) were obtained with June19th planting. The average grain and forage yields achieved were 13.2 and 21.3 Mg ha$^{-1}$; 14.0 and 25.1 Mg ha$^{-1}$; and 12.8 and 27.6 Mg ha$^{-1}$, for crops with early, normal, and late planting date, respectively reported by Maresma *et al.,* (2019). Belay and Patil (2018) found the highest total shoot biomass (187.9q ha$^{-1}$) and grain yield (94.8 q/ha$^{-1}$) were recorded by 11 June compared to 1 June and 1 July. Zafar *et al*., (2011) reported that maize cultivar Azam gave maximum grain yield (4569 kg ha$^{-1}$) followed by landrace SWB sown on 26th July. Maximum harvest index was recorded by Azam when planted on 21st June and 26th July.

Planting date is one of the most important aspects of management in agricultural system, which can affect yield. Delaying planting date ends in decreased in maize grain yields (Panahi *et al.,* 2010). Andrade, (1995) reported that grain weight decreased due to the change in planting dates. The differences in grain weight might be due to the environmental conditions, mostly observed during the plant life cycle. Khan *et al.,* (2002) reported that delaying planting date would lead to a lesser number of grain row in the maize and also a lesser number of grains in the rows. Some researchers pointed out that especially, the effect on planting date and plant density on corn expressed that delay in planting reduces the number of kernels in corn (Cantarero *et al.,* 2000).

Khaksar *et al.,* (2009) reported that early planting along with humidity stress or drought stress can disrupt plant reproductive development stages. These kinds of stresses can result in yield decrement through kernel abortion and production of kernels with lower 1000-grain weight on plants which have been cultivated with delay. Kara, (2011) observed that fresh yield components including ear diameter, ear length, number of kernels per ear and ear weigh were decreased when sweet corn was sown early or delayed. Planting date had significant effect on number of kernels per row, number of kernels per ear, 1000-grain weight (Jasemi *et al.,* 2013).

A study by Turgut and Balci, (2002) has showed that the highest ear yield and its components were obtained when maize was sown on mid of May, early or delayed planting significantly decreased the traits. Mean comparisons showed that the highest grain yield was obtained on 15 May planting date. However, numerically higher number of ears per plant and ear length of rabimaize were recorded by 1st November planting. It might be due to favourable temperature resulting the better growth and development of crop. The results are in close proximity with findings of Singh *et al.,* (1987) and Shaheenazzamn *et al*., (2015). Delaying planting date to mid-December reduced the individual 1000 kernel weight (Cirilo and Andrade, 1996), where indicated that maize varieties differed in their growth characters in Gainesville Florida ($E_l$-Koomy, 2005; Gardner *et al.,* 1990). Banotra *et al., (*2017) reported that the crop sown on April 15, March 29 and April 30 recorded statistically similar but significantly more number of grain rows/ear, number of ears /plant, and number of grains/ear than the crop sown on 15 May and onwards.

Mahmud and Rahuma, (2018) reported that maize planting in mid-May led to produce the maximum number of rows/ ear (14.6), weight of grains/ear (200 g), 100-kernel weight (33.3 g), and shelling percentage (83.7%). Conversely, delayed planting produced the significantly lowest values for all the studied traits. Shrestha 2016 *et al.*(2016) reported that earlier planting date (7th April) produced higher kernel row-1 (28.0), kernel rows ear-1 (12.9) and 1000 grain weight (230 g). Kara, (2011) also observed that the maximum fresh ear yields (14648 and 14568 kg ha$^{-1}$, respectively) were obtained from May l and the highest fresh ear number (64977 and 64916 number ha$^{-1}$, respectively) recorded from May l5 planting date in 2009 and 2010 years. The highest ear diameter (44.8 and 44.9 mm), ear length (18.7 and 18.3 cm, respectively), number of kernels per ear (566 and 552 grain, respectively) and ear weight (225 and 225 g, respectively) were observed from May 1 planting date in 2009 and 2010 years.

Killi and Altanbay (2005) observed that grain weight was significantly affected by the planting dates. The plants planted during the early part of the year (February-April) passed through lower temperature during early phases and completed their life cycle taking longer period, and they had higher grain weight, and the plants planted during the later section of the year, July-August, had higher temperature during the early phases and completed their life cycle rapidly, and therefore had lower grain weight. Variation in maize grain yield is due to the reduction in 1000-grain weight when planting was delayed to the end of October (Gurung *et al.,* 2018).

### 2.1.6 Relations with environmental parameters

Global warming and dimming/brightening could have significant impacts on crops (Salinger, 2005), and maize yield is vulnerable to climate variability and climate change (Tao *et al.,* 2006). However, climate change varies significantly in different regions, thus it is important to evaluate the changes in thermal and solar radiation resources and their interactive impacts on for specific regions. Hu *et al.(*2019) in an investigation found that climate change and its impacts has been experiencing a warming and dimming trend (Hu *et al.,* 2014; Yang *et al.,* 2011), which has significantly affected crop phenology, grain yield, and cropping system (Huang *et al.,* 2018; Mo*et al.,* 2009). Environmental variations related with different planting dates have an altering effect on the growth and development of maize plants (Kharazmshahi *et al.,* 2015). Crop production fluctuates with climate change in the different regions of the world differently (FAO, 2007). Early to late planting affects crop growth and yield adversely due to changes in the climate of the area. However, these changes in the climate affect growth and subsequently the yield differently, depending upon the magnitude of change and developmental stage of the crop (Ali *et al.,* (2018). The optimum planting date of the crops and/or its validation is essential to sustain productivity under the climate change (Asim *et al.,* 2013).

While crop growth might be accelerated by climate warming, the length of the crop growing period has shortened during the last several decades (Olesen and Bindi, 2002; Lv *et al.,* 2013). Wang *et al.,*(2016) indicated that climate warming has accelerated summer maize growth and shortened the length of the growing period in the early stages of maize growth. Although changes in farming practices and cultivar maturity over time may have also prolonged the duration of the maize growth period (Tao *et al.,* 2014). A significant effect on growth and yield of maize has been already observed by changing the climate of crop growth (Gaile, 2012).

To date, compete for maize growers is finding the thin window between cultivation too early and cultivation too late (Nielson *et al.,* 2002). Kharazmshahi *et al.,* (2015) stated that either early cultivation or late cultivation can result in lower yield since the probability exists that unfair climatic conditions can happen after cultivation or during the growing season. However, optimum maize planting date may vary from area to area due to differences in climate and the length of the growing season where the crop is produced (Bruns, and Abbas, 2006).

The recent assessments of climate change impact indicated that some regions are likely to be benefited from an increased in the agriculture productivity while others may suffer in reductions (Lioubimtseva and Henebry, 2009) including green fodder (Akmal *et al*., 2010). Crop production fluctuates with climate change in the different regions of the world differently (Wittmer *et al.*, 2008). Shah *et al.*, (2012) reported that early to late planting affects crop growth and yield adversely due to changes of climate. They also reported that these changes in the climate affect growth and subsequently the yield differently, depending upon the magnitude of change and developmental stage of the crop. The optimum planting date of the crops and/or its validation is essential to sustain productivity under the climate change; particularly the high summer temperature effect on anthesis (Asim *et al.*, 2013). A significant effect on growth and yield of maize has been already observed by changing climate of crop growth (Binder *et al*., 2008; Meza *et al*., 2008).

Maize like many other crops that are cultivated in tropics is influenced by the environmental changes (temperature, rainfall etc.) associated with different planting dates and the wider the deviation from the optimum planting date the greater will be yield loss (Ali *et al.*, 2018). Banotra *et al.,* (2017) concluded that out of management aspects of growing maize crop (Cultivar selection, plant density, amount and timing of fertilizers etc.) planting date is probably the most subject of variation because of the very great differences in weather at planting time between seasons and within the range of climates. But year to year variation in plant establishment, pest and disease incidence make it difficult to predict optimum planting dates for maize crops (Oktem, 2000).

According to the literature, the optimum planting window for maize in the US Corn Belt was determined to be the last week of April (Nafziger, 1994). Within each state, there are different optimum planting window recommendations, depending on location (Sindelar *et al.,* 2010; Abendroth *et al.,* 2017). When maize is planted prior to or later than this optimum window, a yield decline can be observed (Zhou *et al.*, 2016). The optimum timeframe for maize establishment usually refers to the mean weather conditions and does not apply every year. The reality is that year-to-year weather variability and poor soil conditions in the spring forces farmers to frequently plant outside the optimum window (Baum *et al.,* 2018). Very early planting increases the probability of poor planting conditions due to cold, wet soils, resulting in a negative impact on plant emergence (Parker *et al.,* 2016). In another study it was revealed that the optimal planting dates varies across region and differences in planting dates expose crop to different stress factors (Adelabu and Modi, 2017). Existing body of knowledge have shown that maize yield potential reduced with delay in planting beyond the optimum planting window for a given environment (Coulter, 2012; Kgasago, 2006; Nafziger, 2008). Ali *et al.,* (2018) mentioned that maize like many other crops that are cultivated in tropics is influenced by the environmental changes (temperature, rainfall etc.) associated with different planting dates and the wider the deviation from the optimum planting date the greater will be yield loss.

Optimum planting date vary from one environment to another and it is important with respect to regional climate change (Andrade*et al.,* 1996). (Laux *et al*., 2010). Regarding planting date, it is well known that planting date of maize is dependent on the climatic conditions prevailing in the crop growing area (Mahmud and Rahuma, 2018). Weather conditions that are optimal for production of maize are likely to be less predictable in future due to variability in weather conditions and may have resultant effect on the stage of maturity at harvest (Blignaut *et al.,* 2009). Rainfall patterns and other weather conditions associated with different planting dates have a modifying effect on length of the growing season, maize development and harvesting period (Beiragi *et al.,* 2011). Shah *et al.,* (2012) concluded that nonetheless, planting date response depending on weather variability at a given location, also differ to a great deal among the years and locations etc. But one of the most limiting factors in crop growth and to get attainable and optimum yield is moisture stress, which is further aggravated by rising temperature due to climate change; therefore, planting date is important to mitigate climate change (Jasemi*et al.,* 2013).

Temperature is a major environmental agent that determines the rate of plant growth and development. Different genotypes may behave differently under similar environmental conditions. Maize (*Zea mays* L.) development is primarily driven by temperature, with air temperature being theoretical to enhance maize development from emergence to physiological maturity (Cutforth and Shaykewich, 1990). Since crop development rate is highly temperature dependent, a warmer climate is expected to affect both these terms, by advancing phenological stages (shifting crop-growing period into a new climatic window) and by reducing the time for biomass accumulation (Peiris *et al.*, 1996; Harrison and Butterfield, 1996; Bindi and Moriondo, 2005). Although the maize responds to interaction of various climatic factors, the greater influence on culture are solar radiation, rainfall and temperature (Brachtvogel *et al.*, 2009). According to Verheul *et al.*,(1996), the temperature is the main factor that controls the growth and development of maize. Reducing the temperature limits the photosynthetic process with reduced growth and the leaf area because there is less balance and consequently lower accumulation of photoassimilate in plant tissues, which limits the leaf expansion (Andrade *et al.*, 1993).

If temperature remain at optimum required level for photosynthesis in maize, low RUE remains constant from emergence to grain filling period (Cirilo and Andrade, 1994). Sangoi *et al.*, (1998) concluded that if there is exposure of maize crop to low temperature during its active growth stages then the speed of growth and development slows down due to which crop absorbs more solar radiation and consume less for metabolism which results the problem of less number of leaves formation, stunted growth of plant etc. Streck *et al.,* (2012) reported that maize vegetative and reproductive development was delayed or hastened depending upon the emergence time of the year, and if the increase in air temperature is symmetric or asymmetric, indicating complex Genotype x Environment interactions and high vulnerability of maize development to climate change. Furthermore, using different temperature response functions for the vegetative and grain filling period could predict the time to maturity more accurately than a single function for both periods (Dwyer *et al.,* 1999). Most of the empirical evidence indicates that the phenological temperature response function for the vegetative period of maize is sigmoidal (Muchow and Carberry, 1989; Ellis *et al.,* 1992; Shaykewich, 1995; Yin *et al.,* 1995; Jame *et al.,* 1999; Bonhomme, 2000; Kim *et al.,* 2004).

Increases in temperature during the vegetative period of maize crops hastens the growth rate more than the development rate, resulting in taller plants with a larger biomass (Van Dobben, 1962). Thus, under field conditions, rising temperature reduces the duration of crop growth, and consequently planting date reduces the time during which incident radiation can be intercepted and transformed into dry matter (Cirilo and Andrade, 1994). It was mainly due to prevailing high maximum and minimum temperature, which resulted in quick growth of the plants in early dates of planting since temperature plays a key role in the physiological and morphological development of the crops. Similar results had been reported by Panahi *et al.,* (2010) and Azadbakht *et al.,* (2012).

In general, early planting is preferable, but temperatures must be high enough to ensure quick germination and emergence. As a rule, maize should not be sown until the soil temperature approaches 10°C. Under cold soil conditions (below 10°C), grains will readily absorb water but will not initiate root or shoot growth, which leads to grain rot and poor emergence (Abendroth*et al.,* 2017; Hall*et al.,* 2016). Early sown maize plants are able to face and tolerate the adverse weather and environment. In rainfed situation, the planting of maize is generally done with the onset of monsoon rains. Most suitable temperature for germination is 21ºC and for growth 32ºC (Jain, 1973). Shrestha *et al.,* (2016) reported that when maize planting date is shifted to late spring, higher temperature stress during major crop period will hinder plant growth and development.

In maize the high air temperature (greater than 38ºC) compounded by water stress at anthesis decreases the kernel set under dry land environments (Ramadoss *et al.,* 2004). Herbek *et al.,* (1986) reported that delayed planting of corn in hot and dry conditions reduced yield and had harmful effects on pollination and grain filling. In contrast, Oktem *et al.,* (2004) obtained the highest fresh ear yields for a 25 July planting date and the lowest fresh ear yields for 25 April. Planting date in a hot and dry region of Turkey. Determining the optimal planting date for corn is thus very crucial for maximizing crop yields (Abdel Rahman *et al.,* 2002).

Dahmardeh *et al.,* (2012) reported that the maximum grain yield was observed in the plant that was planting late in summer, which progressively decreased to the minimum when the temperature increased (6th July). The results of the present study show that when the temperature decreased (20th August) or increased (6th July) towards the maturity of the plant, the biological and grain yield decreased. Kharazmshahi *et al.,* (2015) reported that the period from November to February is the best time for the highest dry matter production in the Khartoum area. It also was reported that the mean daily temperature is the major environmental factor that affects the crop development and yield (Elkarouri and Mansi, 1980; Begna *et al.,* 2000). Chen *et al.,* (2011) reported that daily minimum temperature was the dominant factor in maize production. Maize yield was significantly correlated with daily minimum temperature in May and September. Avoiding late planting date or early planting can avoid environmental stress like solar radiation, unbalanced growth period interval, low temperature that can harm plant growth and reduce grain yield (Shrestha *et al.,* 2018). While early planting results in reduced IPAR because of delayed LA development, high temperatures under late planting situations also reduce IPAR in the two week period either side of flowering by reducing calendar time for crop development, thereby decreasing yields (Otegui *et al.,* 1996). Cool nights during grain filling, common under late planting situations, may also reduce radiation use efficiency (RUE) (Jones *et al.,* 1986).

The relationship between the time of planting and its harvesting stage may bring possibility of higher yield during extreme temperature and rainfall since maize development varies with ambient temperature from emergence to physiological maturity (Adelabu and Modi, 2017). Anwar *et al.,* (2015) explained that extreme temperatures caused developmental shifts and disrupting reproduction processes. Also, late planting maize may experience cooler conditions during its early vegetative growth stage and extended towards grain filling stage which may lengthens the grain filling period. However, if water stress is severe, kernel may store relatively lesser sugar, resulting in lower kernels weight and yields. Shim *et al.,* (2017) reported that grain yield tended to decrease with temperature elevation above ambient, showing a sharper linear decrease with mean growing season temperature increase.

The average temperature on the planting date was reported to affect the duration of sprouting (Gyorffy *et al.,* 1965). Nagy (2009) stated that selecting the correct planting date for maize, various factors should be considered, including the temperature during the growing season, soil texture, geographical location. Therefore, the negative effects of the climate and cold soil hinder the earlier planting of corn and this restricts corn planting at April. The negative effects of late planting of corn are high temperature and hot dry winds due to cause fertilization problems in corn (Öktem *et al.,* 2004). Martin *et al.,* (1976) stated that the production of corn requires a mean summer temperature of 21 to 27ºC, and a mean night temperature exceeding 13ºC. Corn is grown extensively in hot climates, but yields are reduced where the mean summer temperatures are above about 27ºC. Cold weather retards the shedding of pollen, while hot dry conditions tend to hasten it. Stress can reduce maize grain yield and quality and any further rise in temperature reduces the pollen viability and silk receptivity, resulting in poor grain set and reduced grain yield (Aldrich *et al.,* 1986; Samuel *et al.,* 1986; Johnson, 2000). Some researchers stated that delaying the planting date resulted in decreased yields (Mc Cormick, 1974; Ishimura *et al.,* 1984; Tomorga *et al.,* 1985; Imholte and Carter, 1987), whereas Herbek *et al.,* (1986) reported that yields increased with a delayed planting date.

Shrestha *et al.,* (2016) stated that maize planted in earlier spring season is facilitated by favorable temperature, availability of reserved soil moisture of long winter for vegetative growth, but drought problem during reproductive period creates stressful environment to the crop. When maize planting date is shifted to late spring, higher temperature stress during major crop period will hinder plant growth and development. Hongyong *et al.,* (2007) concluded that grain yield of summer maize were increased with delay in harvest. Differences in temperature for growth, development and maturity were observed by planting maize cultivars at different dates during summer.

Temperature is a major environmental factor that drives maize phenology (Streck *et al.,* 2008; Bergamaschi and Matzenauer, 2009). In order to fully understand agricultural challenges in the future, it is important to address not only how crops yield respond to climate change (Kim *et al.,* 2007; Travasso *et al.,* 2009), but also to assess how climate change impacts crops phenology (Tao *et al.,* 2006). Shim *et al.,* (2017) reported that vegetative and reproductive growth durations showed variation depending on planting date, experimental year, and cultivar. Growth duration tended to decrease, but not necessarily, with temperature elevation, but somewhat increased again above a certain temperature. High temperature-dependent variation was greater during grain filling than in the vegetative period before anthesis. Elevated temperature showed no significant effects on duration or peak dates of silking and anthesis, and thus on anthesis–silking interval. Thus, rate of development of maize from planting to anthesis is a function of temperature rather than photosynthesis (Brower *et al*., 1970).

Heat stress above optimum temperature should be quantified in calculating thermal time effects on maize development, as reported by Cicchino *et al.,* (2010). Shim *et al.,* (2017) reported that elevated temperature showed no significant effects on durations and peak dates of silking and anthesis in either cultivar. Anthesis-to-silking interval (ASI), measured as the difference in days between peaks of silking and anthesis, was not significantly different among temperature elevation treatments. In contrast, some studies have found that high temperature increased asynchrony between anthesis and silking by increasing ASI due to heating during late vegetative stage (Cicchino *et al.*, 2010) and by reducing ASI due to heat stress during 15 days immediately before anthesis (Edreira *et al.*, 2011).

Soler *et al.,* (2005) stated that the final number of leaves and the duration from planting to silking was highly correlated, results also reported by previous studies (Chase and Nanda, 1967; Muchow and Carberry, 1989). Tollenaar & Hunter, (1983) stated that the final number of leaves that is initiated is modulated by genotypic and environmental effects during a photoperiod and temperature sensitive interval, which has been reported to extend from the 4th to the 8th leaf stage. There is evidence that maize, which is a short-day plant, responds to an increased photoperiod by delayed tassel initiation (Warrington and Kanemasu, 1983; Ellis *et al.,* 1992; Birch *et al.,* 1998; Tollenaar, 1999). In addition, the lengths of the vegetative (V), vegetative and reproductive (VR) phases were negatively correlated with mean temperature reported by Wang *et al.,* (2016).

Asynchronous timing of anthesis and silking is also an important factor leading to decrease of fertilized ovules (Shrestha *et al.,* 2014) and is known to be highly influenced by drought stress (Bolaños and Edmeades, 1993 ; Ngugi *et al.,* 2013) and heat stress (Cicchino *et al.,* 2010; Edreira *et al.,* 2011). Heat stress during the early stage of kernel development disrupts endosperm development and leads to abortion or premature cessation of growth (Cheikh and Jones, 1994). The latter authors reported that long-term heat stress, applied at 35°C for 8 days beginning three days after pollination, resulted in abortion of 97% of kernels, whereas short-term heat stress at

35°C for 4 days resulted in less abortion, of 23%, owing to a recovery of kernel growth and water content following heat stress. Kernel weight is determined by biomass accumulation within kernels during the grain-filling period that is dependent mainly on kernel growth rate and the duration of the effective filling period (Borrás *et al.,* 2004; Borrás and Gambín, 2010), both of which are affected by temperature and assimilate availability (Cirilo and Andrade, 1994 ; Cirilo and Andrade, 1996). High temperature stress during this period reduces the duration of grain filling (Badu *et al.,* 1983), potential kernel size by inhibiting endosperm cell division and amyloplast biogenesis (Commuri and Jones, 1999; Commuri and Jones, 2001), and assimilate availability, leading to reduced final kernel weight. Heat stress effects on final kernel weight were larger when the stress occurred during the first half of effective grain filling than when it occurred around flowering, and larger for temperate than for tropical varieties (Edreira and Mayer, 2014).

Heat stress decreased grain filling duration (Hellewell *et al.*, 1996; Prasad *et al.,* 2006) due to which test weight of 7th May sown cultivars were found less. Shrestha *et al.,* (2016) reported that higher temperature had accelerated development rate in 7th April and 22nd May planted cultivars. Also, Hasanuzzaman *et al.,* (2013) reported that the accumulated high temperatures could have caused an array of morphological, physiological and biochemical changes within plant such as decrease in the number of grains and kernel weight.

Akasha, (1968) showed that high temperature reduced the number of tillers and grain weight, because the period between anthesis and senescence was shortened by relatively higher temperature. Fischer, (1985) showed that the thermal time requirement needed by a specific growth stage is more or less constant. Temperature changes in the field can be created by planting at different dates in a season, so that the plant will grow at different temperature. Kara, (2011) observed that Growth and development of maize are strongly dependent on temperature. Maize develops faster when temperatures are warmer and more slowly when temperatures are cooler. Elkarouri and Mansi, (1980) reported that the mean daily temperature is the major environmental factor that influences the crop development and yield.

### 2.1.7 Growing degree days (GDD)

Air temperature based agrometeorological indices *viz*., growing degree days (GDD) and phenothermal index (PTI) have been used to describe changes in phonological behaviour and growth parameters (Streck *et al*., 2008; Kumar *et al.,* 2010). Crop phenology is primarily affected by the air temperature and secondarily by the soil temperature. Kara *et al.,* (2011) reported that two common environmental signals that affect plant growth and development are photoperiod and temperature. Modern corn varieties respond little to photoperiod, but are affected by temperature. The responses to temperature for corn growth rate and the amount of time to progress from one stage of development to the next stage are nearly linear from about 10°C to 30°C. The most common temperature index used to estimate plant development is growing degree days (GDD), or thermal unit (TU) or heat units (HU). The accumulation of GDD determines the maturity of plant, yield and yield components (Dahmardeh, 2012). Understanding the accumulation of GDD or heat units and the relationship of GDD to corn development allows us to predict when important stages will occur. Growing degree days can also be used to compare varieties for adaptation (Kara *et al.*, 2011). Numerous studies have demonstrated the usefulness of temperature indices, like growing degree days or heat units, for predicting crop growth and development, classifying crop species, varieties and varieties, or evaluating climates for specific crop-management combinations (Neild and Seeley, 1977; Fairey, 1983; Kara *et al.*, 2011).

Moreover, a study by Wang *et al.*, (2014) showed that, over the past 30 years, the numbers of growing degree days during the summer maize (*Zea mays* L.) season have increased. These large increases in temperature are thought to have had considerable impacts on summer maize growth and harvest (Tao *et al.*, 2006). Shrestha *et al.*, (2016), who reported phenophases were attained earlier in summer season and also relatively higher GDD values within short period influenced higher Phenothermal index **(**PTI) values. However, the number of growing degree days (GDD) needed for maize varieties to reach various developmental stages is fairly uniform across environments (Hoegemeyer, 2013). An application of the GDD approach was developed by Neild and Richman, (1981) where they combined thermal units with precipitation in an agroclimatic index to determine where different corn varieties could be grown around the world.

Sutton and Stucker, (1974) confirmed that late planting causes shortening of Growing Degree Days (GDDs) requirement during planting to physiological maturity stage as shifted from early planting date. Shrestha *et al.*, (2016) stated that the statistically similar GDD was recorded for different planting dates and higher PTI values were noticed with delay in planting. Similarly, heat use efficiency (HUE) was found higher in early planting date. Early and mid-planting have averagely warm temperature and rainfall necessary for optimal growth and development while drop in temperature and rainfall during the late planting resulted in deficit GDD which hasten flowering in late planting at both season observed by Adelabu *et al*., (2017).

Adelabu *et al.*, (2017) observed that the accumulated GDD for tasseling and silking were higher under warm temperature and sufficient availability water for plant uses (early and mid-planting) while it was shortened in late planting. Thereby, causing maize planting lately to flower earlier because of deficit in accumulated GDD as compared to plants from early and mid-planting dates. Parthasarathi *et al*., (2013) reported similar finding that GDD accumulation at the time of flowering leads to early flowering in cereals. Shrestha *et al.*, (2016) observed that planting date exhibited significant different ($p<0.05$) on GDD accumulation at knee height, anthesis stages. Growth degree days to knee height stage was higher for those cultivars which were sown in 7th April (545.4) and 7th May (540.3). Poshilo makai-1 had higher growth degree days at knee height stage (569.5), anthesis (1138) and silking (1210) but at grain fill duration RML-4/RML- 17 had higher growth degree days (1190) than other cultivars. Though thermal interval required for silking to maturity stage always vary, frequent estimation of thermal time interval required for this grain filling stage is essential to be done under GDD system of measurement. Barger, (1969) suggested that to maximize the yield response of hybrid maize varieties requires clear study about interaction between maize yield response, late planting date and required thermal time interval.

The plant sown on 5th August, accumulated suitable GDD and produced the highest grain yield, biological yield and harvest index. Generally, 5th August plantation accumulated more suitable GDD in comparison with the other planting dates (6th July, 21st July and 20th August), as such, it exhibited higher grain yield, biological yield and harvest index (Dahmardeh, 2012). Maize SC701 cultivar is one of the commonly southern African grown varieties. The cultivar’s desired traits were its large ear size, long shelf life high yield and moderate drought tolerance (ARC, 2014). It is a late maturing cultivar which requires an average of 1028 GDD from emergence (VE) to physiological maturity ($R_6$) and an average of 6.4 mm/day of water from 12 leaf stage to full dent stage (Darby and Lauer, 2002). The relationship between the maturity length of a maize hybrid and its GDD accumulations at a given location determine their optimal harvesting period and its adaptability.

Martin and Williams, (2008) investigated different planting date in the sweet corn crop observed that the number of days between emergence and $R_1$ varied with the times of planting, different to the thermal sum that little has changed. This fact is explained because corn requires an accumulation of degree days to complete the development stages and only then move on to another stage (Tsimba *et al.,* 2013b). On the other hand, the thermal unit is directly proportional the temperature (Cross and Zuber, 1972; Gaile, 2012). Then, at low temperatures the daily thermal units are smaller, justifying the extension of the phenological phases to complete the required thermal sum accumulation (Bergamaschi *et al.,* 2006).

Dahmardeh *et al.,* (2012) stated that Temperature or accumulated growing degree days (GDD) strongly influences the growth and development of corn. Corn requires about 110-120 GDD to emerge under typical conditions, although deep planting or heavy residue increases the number of GDD for emergence. Likewise, 101-105 day varieties require about 1300 GDD from emergence to silking, although hot and dry conditions in July will delay silking and thus increase the number of GDD. Muchow, (1990) showed that grain growth may be directly influenced by air temperature. Different planting dates might cause different environmental conditions from emergence to grain filling. Sur and Sharma, (1999) reported that the full GDD decreased from 1731 to 1621 with delay in planting, as the later sown plant experienced lower temperature during the grain filling period.

Girijesh *et al.,* (2011) reported that the maximum heat units of 1768.8 degree days from planting to physiological maturity were recorded by planting in first fortnight of July which is almost equal to June first fortnight planting (1766.8 degree days). However, at grainling stage (up to 30 DAS) highest heat units were recorded in June first fortnight planting. Kara, (2011) conducted a research to determine optimum planting date and GDD of sweet corn using different planting dates from April to June during growing seasons under semi-arid ecological conditions of the Southwestern Anatolia Region. They found Growing degree days of sweet corn were accumulated from grainling emergence until milk stage period. Total GDD accumulated as milk stage period of sweet corn in different planting dates occurred between 578.9-1025.5°C. GDD accumulated of sweet corn increased when planting date was delayed to the June. In China, the maize growth period from planting to maturity and from heading to maturity − 2.71 and − 1.07 day/°C, respectively (Meng *et al.,* 2015).

## 2.2. Planting date effect on maize

Growth, productivity and quality parameters can be affected by planting maize crop earlier or later than the optimum date. The increase in yield of sown crops in optimal planting date could be due to length growing period and depending on absorbing maximum nutrients from the soil and light for the sun resulting in maximum photosynthesis (Kara, 2011). Under different planting date, crop sown pass through each developmental stage at different times and therefore, under different environmental condition (especially photoperiod and temperature), thus any one of the development stage which determine the components of yield could conceivably occur under more or less favourable conditions in late sown crops as reported by Swanson and Wilhelm (1996). Planting date was reported to affect the growth and yield of maize significantly (Bhusal *et al.*, 2016). Determination of optimum planting time for maize crop is very difficult due to occurrence of continuous distinct variation in disease and pest incidence that effect plant growth and development observed every year (Oktem, 2000).

Mohi-ud-din *et al.*, (2017) observed that earlier planting resulted in taller plants compared to delay planting because of the fact that the early sown crop got longer time period to utilize available growth resources. Similar results were reported by Imholte and Carte (1987) and Morin and Dormency (1993). The results are in agreement with observation of Moosavi *et al.*, (2012) who reported that there is a significant decline in the plant height with the delay in planting date of corn, this significant decrease in plant height and stem traits following the delay in planting can be associated with higher temperatures that the plants at third and fourth planting dates experienced, which limited their growing period and assimilate building because of the early maturity of plants.

Results obtained by Mahmud and Rahuma, (2018) they revealed that early planting date (mid-April) produced significantly tallest plants (242.30 cm) and largest ear leaf area (880.38 cm$^2$), however maize sown in (mid-May) showed the highest ears compared with the latest planting date (mid-July). Increasing percentages of the three growth characters over the latest plantings were (24.55%, 11.60% and 7.07%), respectively. The experiment was conducted by Prasad *et al.(*2017) which consisted of four dates of planting (15th June, 25th June, 5th July and 15th July) and five maize (*Zea mays* L.) varieties of different maturity group. They found ten days advance, normal and 10 days delay planting being at par recorded significantly higher plant height, dry matter, crop growth rate, as compared to delay in planting by 20 days from normal planting. Sangoi (1993) found hybrid maize planted during earlier planting date elongated growth period of more than 2 weeks than planted in delayed date. The yield reduction of maize due to delayed planting was to an extent of 22 and 41 per cent in crop planting during second fortnight of June and first fortnight of July, respectively.

Kolawole and Samson(2009) reported that the grain yield was increased significantly with the planting of maize on 25 Oct than early and late sown crop and these enhancement were due to more diameter of ear and weight of ears per plant might be due to the better translocation system in maize plant enhance the production of yield due to the fact that good photosynthetic accumulated in leaves and its transfer to economic part like grains, ears etc. Nevertheless, the reduction in vegetative growth on plants sown in March probably limited source of photosynthetic (Tollenaar, 1999) which resulted in lower values of yield components. Also the ear girth might be decreased in the June sown crop due to pollination and fertilization problems (Oktem *et al.,* 2004; Farsiani *et al.,* 2011). Results of the experiment by Mohi-ud-din *et al.,* (2017) revealed that 24th May planting recorded significantly highest plant height and number of functional leaves as compared to other planting dates (*viz*. 2nd June, 11th June and 19th June). More number of days was taken by sweet corn sown on 24th May and accumulated more heat compared to delay planting.

Aldrich *et al.,* (1975) found late planting favored plant exposure to short growth period, more pest and disease infection, drought, cold temperature, less radiation availability etc. finally reducing grain yield. Otegui and Melon (1997) supported that late planting cause crop exposure to more thermal condition during its active vegetative stage which leads to over vegetative development reducing dry matter accumulation in kernel that ultimately reduces the final grain yield. Only late planting could not be sole factor reducing grain yield in crops (Green *et al.*, 1985).

## 2.3 Interaction

Planting date is one of the most important aspects of management in agricultural system which can affect yield through influencing emergence date, plant density, normal growth, and pollination and maturity date (Noor mohammadi *et al*., 1997). Grain planting in suitable date results in root development, increment of plant tolerance against stresses and maize growth cycle completion and finally yield increment (Dasilva *et al*., 1999). Damor *et al.,* (2017) stated that to augment higher crop yield per unit area, proper planting date is the most important factor. Planting of the crop at right time ensures better plant growth and also inhibits weed growth. There are evidences that optimum time of planting is one of the several cultural manipulations and play a vital role in boosting up the yield, particularly in Indian sub-continent where the optimum time of planting varies to great extent due to widely varying agro-climate conditions.

For optimization of yield, planting at an appropriate time is very critical (McCutcheon *et al.,* 2001). Ali *et al.,* (2018) reported that one of the most important factors contributing to yield gap is a planting of maize on appropriate planting dates. Dekhane *et al.,* (2017) contended that early planting in the spring is optimum and more efficient than delayed planting as through early planting germination occurs when days are longer and sun shines impact is more by way of an acute angel; whereas delaying planting date results in decrease in maize grain yields. As delay in planting date can lead to a linear decrease in grain yields (Anapalli *et al*., 2005). [Timely planting is critical for maximizing yield for both grain and biomass in maize (Bunting, 1968; Van Roekel and Coulter, 2012) and therefore, growers are concerned about the yield response of maize to planting date (Olson and sander, 1988; Abendroth *et al.*, 2017). Dahmardeh, (2012) reported that the grain yield increased little by little with the delay in planting date; the lowest grain yield was obtained at early planting date and in delay planting date, grain yield was decreased. The delay in planting gradually decreased the yield because of decrease in temperature at the end of the season.

# MATERIALS AND METHODS

# CHAPTER III

## MATERIAL AND METHODS

This chapter includes the general materials and methods covering the description of the experimental site, climate and soil. The second section described the specific materials and methods, especially relevant for a particular experiment. To meet research objectives of the present study, three field experiments at Sher-e- Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, was conducted for three white maize growing seasons (Rabi-Kharif-Rabi) from 2016-2017, 2017 and 2017-2018 respectively.

Three experiments were conducted using various treatments to observe the performance of variety and date of planting to monitor Days to emergence, Days to attaining specific growth stages (Days to emergence, 6-collar leaf, 10-collar leaf, 12-collar leaf, first tasseling, 50% tasseling, first silking, 50% silking and physiological maturity; also other vegetative and reproductive parameters. Daily weather data from nearby meteorological station was collected.

### 3.1 Description of the experimental site

The field experiments were conducted at Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka district during the (Rabi-Kharif-Rabi) of 2016-2017, 2017 and 2017-2018. The Sher-e-Bangla Agricultural University research field is situated in the middle part of Bangladesh and located at $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level. The experimental site lies at AEZ-28 (Madhupur Tract Agro-ecological zone) of Bangladesh. (FAO/UNDP, 1988). Location map have been given in (Appendix-I).

### 3.2 Soil characteristics

The soil belongs to “The Modhupur Tract”, AEZ-28 (FAO, 1988). The SAU farm belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles, Soil pH 6.5. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period (Appendix-II).

### 3.3 Climate of the experimental area

The climate of the locality is sub-tropical. It has characterized by high temperature, high humidity, and heavy rainfall during Kharif season (April to September) and low rainfall associated with moderately low temperature during Rabi season (October to March). There are three distinct seasons in Bangladesh: a hot, humid summer from March to June; a cool, rainy monsoon season from June to October; and a cool, dry winter from October to March. In general, maximum summer temperatures range between 30°C and 40°C. May is the warmest month in most parts of the country. January (12.75˚C) is the coldest month, when the average temperature for most of the country is about 10°C. The temperature and relative humidity were also moderate and varied with the different seasons. The relative humidity was also relatively low and it was ranged from 50 to 65 on an average in Rabi season. The metrological data for crop growing season (2016-2017and 2017-2018) were collected from Dhaka Metrological Office, Agargaon (Appendis-III-VI).

### 3.4: Experimental details

### Experiment 1. Phenology, growth, yield attributes and yield of white maize varieties as influenced by varying planting dates in Rabi season 2016-17

### 3.4.1 Experimental location

The experimental field was in upland soil of Sher-e- Bangla Agricultural University farm, Sher-e- Bangla Nagar, Dhaka.

### 3.4.2 Experimental period

The experiment was undertaken during the period from November, 2016 to April, 2017 in three different planting dates (25th November, 10th December and 25th December of 2016) with four different white maize varieties to find out the following objective.

### 3.4.3 Experimental materials

#### 3.4.3.1 Seeds:

The four selected white maize varieties were used as a plant material. These varieties bear good phenotype characters and agronomic performance.

### 3.4.3.2 Sources of seeds:

White maize seeds of variety PSC 121 was collected from the country of India and other three varieties Yangnuo-30, Changnau-6 and Youngnau-7 were collected from the country of China.

### 3.4.3.3. Description of the varieties:

The varietiesPSC 121, Yangnuo-30, Changnau-6 and Youngnau-7 are promising white maize varieties due to its stable and high yield. These varieties produce an average grain yield of 4.0 - 14.0 t/ha$^{-1}$. It has 100-grains weight of 20-45 gm and matured within 110-135 days.

### 3.4.3.4 Fertilizers:

In this experiments nitrogen, phosphorus, potassium, sulpher, zinc and boron were used. The amounts of fertilizer in the form of Urea, Triple Super Phosphate, Muriate of Potash, Gypsum, Zinc Sulphate and Boric Acid recommended by Fertilizer Recommendation Guide (BARI, 2016)

### 3.4.4 Methods:

### 3.4.4.1 Experimental Treatments

In this experiment the four *varietal* and three different planting dateswere used as treatment. 60 cm×20 cm spacing for each variety was used. For better understanding their interactions with planting datesdifferent growth stages were evaluated. So the treatments in the entire experiment were as follows:

**Factor A.** Four Varieties

- $V_1$ = PSC 121
- $V_2$ =Yangnuo-7
- $V_3$ = Youngnau30
- $V_4$ = Changnuo-6

**Factor B.** Three planting time

- $S_1$= 25/11/2016
- $S_2$= 10/12/2016
- $S_3$= 25/12/2016

### 3.4.5 Preparation of experimental land

The land was prepared with power tiller ploughed for several times until it got the desirable tilth condition. The stubble and weeds were removed then experimental land was divided into unit plots following the design of experiment. Fertilizers were mixed as with the soil of plot.

**Plot size: 2.4m × 3.5 m = 8.4 m$^2$**

### 3.4.7 Fertilizer and manure application

The amount of fertilizer in the form of Urea, Triple Super Phosphate (TSP), Murite of Potash (MoP), Gypsum, Zinc Sulphate,and Boric acid were calculated according to Krishi Projukti Hatboi, BARI, 2016 and the total amount of Triple Super Phosphate, Murite of Potash, Gypsum, Zinc Sulphate,and Boric acid and 1/3$^{rd}$ of total urea were broadcasted and incorporated in a plot 2 days before seed planting. The rest of the urea were top dressed in 2 installments: 1/3 portion of total urea was top dressed at 4-6 leaf stage and rest 1/3$^{rd}$ of total urea was top dressed at 10-12 leaf stage (pre tasselling stage). Cow dung was applied @ 5 ton/ha at the time of final land preparation (BARI, 2016).

**Table-1: Name of the different chemical fertilizer used in the field with rate and application method.**

| SL. No. | Name of Fertilizer | Rate (Kg/ha) | Application |
|---|---|---|---|
| **1.** | Urea | 550 kg/ha | 1/3$^{rd}$ basal, 1/3$^{rd}$ at4-6 leaves, 1/3$^{rd}$ at 10-12 leaves of total urea. |
| **2.** | Triple Super Phosphate (TSP) | 250 kg/ha | Full amount as basal dose |
| **3.** | Murite of Potash (MoP), | 220 kg/ha | Full amount as basal dose |
| **4.** | Gypsum | 220 kg/ha | Full amount as basal dose |
| **5.** | Zinc Sulphate | 12.5 kg/ha | Full amount as basal dose |
| **6.** | Boric acid | 6 kg/ha | Full amount as basal dose |

Source: Krishi Projukti Hatboi, BARI, 2016.

### 3.4.8 Planting of seeds

Seeds of four varieties were sown on according to three different planting dates 25th November, 10th December and 25th December 2016. Line planting was done by opening 3-4 cm deep furrows and covered by the soil on the ridge beside each furrow.

Line planting was done by putting two seeds in each hill$^{-1}$. Seeds were treated with savin power@ 2.5-3g/kg before planting to control ant, termite and seed bone diseases.

### 3.4.9 Intercultural operations

Intercultural operations such as thinning, weeding, watering, earthing up etc. were done.

#### 3.4.9.1.**Thinning**

Only one healthy seedling hill$^{-1}$ was kept and the rest were thinned out at 15 DAS.

#### 3.4.9.2. Weed control

During plant growth period two weeding were done. First weeding was done at 25 DAS second weeding was done at 55 DAS.

#### 3.4.9.3. Earthing up

Two earthing up were done by 35 DAS and 55 DAS respectively.

#### 3.4.9.4. Irrigation and drainage

Irrigation was done through canal water as per crop water demand. Proper drainage system was also developed for draining out excess water.

#### 3.4.9.5. Crop protection

During the entire growing period the crop was observed carefully to take protection measures.

### 3.4.10. Sampling and harvesting

Plants were randomly selected from the central two rows of each plot for collecting data on yield attributes and yield. At full maturity, the crop was harvested plot-wise at three different time ranges. Cobs were dried in bright sunshine, shelled and the grains were cleaned properly. Grains obtained from ten plants were oven-dried to 12% moisture and weighed carefully and ten cobs yield was recorded in gram and converted into metric tons per hectare (t/ha$^{-1}$). Stalks obtained from ten plants were oven-dried and final stalk yield was recorded in gram and converted into metric tons per hectare (t ha-$^{1)}$.

### 3.4.11. Collection of experimental data

The details procedures to determine the growth, phenological, yield and yield contributing characteristics were followed have been discussed below:

#### 3.4.12.1. Growth contributing parameters

#### 3.4.12.1.1. Plant height

Plant height was measured at harvest by measuring tape from soil surface to the highest tip of the tassel and plant height was measured in cm.

#### 3.4.12.1.2. Leaf number per plant

Total number of leaves of each plant was counted at harvest. All leaves were counted including those that were senesced as long as they were identifiable.

#### 3.4.12.2. Phenological parameters:

#### 3.4.12.2.1. Days to emergence

The days to first planting was recorded by visual observation (Kara *et al*., 2011). The number of days from planting to first of the plants in the plot are in emergence. Coleoptile tip emerges above soil surface. Elongation of coleoptile and 1st true leaves rupture from the coleoptile tip.

#### 3.4.12.2.2. Days to 6-collar leaf

Each leaf stage is defined according to the uppermost leaf whose collar is visible. Beginning at about V6, increasing stalk and nodal root growth combine to tear the small lowest leaves from the plant. The number of days from first planting to first of the plants in the plot are in leaves. All plant parts are present aboveground. Growing point and tassel (differentiated in $V_5$) are above the soil surface. Stalk is beginning a period of rapid elongation. Tillers (suckers) begin to emerge at this time. Degeneration and loss of lower leaves

#### 3.4.12.2.3. Days to 10-collar leaf

Number of kernel rows is set and number of ovules (potential kernels) on each ear and size of ear is being determined. The number of days from planting to first of the plants in the plot are in leaves.

#### 3.4.12.2.4. Days to 12-collar leaf

Number of kernel rows is set and number of ovules (potential kernels) on each ear and size of ear is being determined. The number of days from planting to first of the plants in the plot are in leaves.

#### 3.4.12.2.5. Days to first tasseling

The days to first flowering was recorded by visual observation. The number of days from planting to first of the plants in the plot are in bloom.

#### 3.4.12.2.6. Days to 50% tasseling

The days to first flowering was recorded by visual observation. The number of days from planting to first of the plants in the plot are in 50% bloom.

#### 3.4.12.2.7. Days to first silking

The days to first silking was recorded by visual observation. The number of days from planting to first of the plants in the plot are in emerge of silks.

#### 3.4.12.2.8. Days to 50% silking

The days to first silking was recorded by visual observation. The number of days from planting to first of the plants in the plot are in emerge of 50% silks.

### 3.4.13. Growth

Leaf area index (LAI), dry matter and grain yield (DM/GY, oven dried at 70°C until constant weight) production were measured from 3-6 plants during the growing season at 30-day intervals. Development stages of plant in each treatments were also recorded using a standardized maize development stage system (Ritchie *et al*., 1992) and the date was recorded at which 50% or more of the maize plants in each plot reached the vegetative (VS) and reproductive (RS) stages as: planting dates (PT), emergence stage (VE), tasseling stage (VT), silking stage ($R_1$) and physiological maturity stage ($R_6$). Relative chlorophyll concentration of maize leaves was measured using a SPAD-502 (Minolta, Japan) portable chlorophyll meter. Measurements were started at 6-leaf stage ($V_6$) of maize growth, one week before second part of N application and continued in the reproductive period with about 2 week interval. Chlorophyll meter readings were obtained on the latest fully developed leaf of 5 plants in each plot.

On the basis of dry matter accumulation, the values for crop growth rate (CGR, g crop m-2 d-1), and relative growth rate (RGR, d-1) and net assimilation rate (NAR, g crop m-2 leaf d-1) were calculated by the following equations (Zhao *et al*., 2007):

$CGR = (W_2 - W_1)/ (T_2 - T_1)$

$RGR = (\ln W_2 - \ln W_1)/ (T_2 - T_1)$

$NAR=CGR*[\ln (LA_2)-\ln (LA_1)]/ (LA_2-LA^1)$

Where W, LA and T are shoot dry matter (g m-2), leaf area (cm2) and measuring time (day), respectively. The numbers 1 and 2 refer to two successive measuring times.

### 3.4.13.1. Days to maturity

The days to maturity was recorded when the plant and cob turned to straw in color. The blister stage is approximately 10 to 14 days after silking. During this stage the kernel is white and shaped like a blister. Milk stage (18 to 22 days after silking), the kernel is yellow with a white milky inner liquid. At this stage dry matter accumulation is very rapid. Silks on the corn ear are brown and dry. During the dough stage (24 to 28 days after silking) the inner fluid begins to thicken due to starch accumulation. The kernels will have accumulated half of their total dry weight. At dent stage (35 to 42 days after silking) the kernels begin to dry down from the top of the kernel towards the cob. Each kernel will have a dent at the top. If a frost occurs during this stage, the black layer can form prematurely preventing additional dry matter accumulation. The kernels continue to gain weight until black layer formation or physiological maturity (55 to 65 days after silking) occurs. The black layer forms where the kernel attaches to the cob.

### 3.4.13.2. Growing Degree Days (GDD)

For evaluating GDD in each developmental stage, weather daily statistics were used. In equation, Tmax and Tmin were maximum and minimum daily temperatures, respectively. The temperatures upper than 30°C and lower than 10°C, were considered 30°C and 10°C, respectively. Also temperature base (Tb) was considered 10°C.

$$GDD=\sum(Tmax+Tmin)/2-Tb$$

### 3.4.13.3. Yield and yield contributing parameters

#### 3.4.13.3.1. Cob length

Length of ten randomly selected cobs from each plot was measured by measuring tape and then average cob length (cm) was calculated.

#### 3.4.13.3.2. Numbers of rows per cob

Numbers of rows per cob was calculating by selecting ten cobs randomly from each plot and counted individually and then average was taken to get information about the numbers of rows per cob.

#### 3.4.13.3.3. Number of grains per row

Number of grains per row of each cob from ten randomly selected cobs was counted individually and then average was calculated.

#### 3.4.13.3.4. Number of grains per cob

Number of grain rows per cob was calculated by selecting ten cobs randomly from each plot and then average was taken to get grain rows per cob. Cobs from ten randomly selected plants were counted and average number of cobs per plat was worked out.

#### 3.4.13.3.5. Total weight of grains (g) / cob after Oven dry

Total weight of grain were calculated after dried at 70ºC for 48 hours. As well as Chaff wt. (g) /10 cobs) after oven dry and Shell wt. (g) /cobs after oven dry were also calculated.

#### 3.4.13.3.6. 100-seeds weight

Three samples of 100-grains were taken randomly from the seed lot of each plot, weighted separately and then average was taken. Grain weight per cob was also calculated.

#### 3.4.13.3.7. Grain yield

Ten plants from each sub plot were harvested, cobs were removed and kernels were separated from the cobs then the grains of sub sample was oven dried (at 70°C for 48 hours) and reweighed to determine moisture content. After drying to 12.5% moisture content, the final grain weight was determined and recorded, which was later converted into ton per hectare.

### 3.4.14. Temperature

In general, January (12.75˚C) is the coldest month, when the average temperature for most of the country is about 10°C. The maximum and minimum temperature were recorded and measured average monthly minimum and maximum temperature. The metrological data for crop growing season (2016-2017and 2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.4.15. Relative Humidity

The relative humidity was also moderate and varied with the different seasons. The relative humidity was also relatively low and it was ranged from 50 to 65 on an average in Rabi season. The RH was recorded according to month wise. The metrological data for crop growing season (2016-2017and 2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.4.16. Rainfall

The rainfall was also moderate and varied with the different seasons. The rainfall was also relatively low and high in response to different season. The rainfall was recorded according to month wise. The metrological data for crop growing season (2016-2017and 2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.4.17. Statistical analysis

Data recorded for growth, phonological, yield and yield contributing characters were compiled and tabulated in proper form for statistical analysis. The collected data were analyzed statistically by using the statistics 10 computer package. Least Significant Difference (LSD) technique at 5% level of significance was used to compare the mean differences among the treatments (Gomez and Gomez, 1984).

## Experiment 2. Phenology, growth, yield attributes and yield of white maize varieties as influenced by varying planting dates in Kharif season 2017

### 3.5.1 Experimental location

The experiment was conducted at SAU farm, Dhaka. The experimental field comprises of upland soils.

### 3.5.2 Experimental period

The experiment was accomplished during the period from May, 2017 to July, 2017. It was Kharif season.

### 3.5.3 Species description

Four species usually PSC 121, Yangnuo-30, Changnau-6, Youngnau-7 were used as white maize variety.

### 3.5.4. Experimental Treatments

There were four varietal and three different planting dates treatments were evaluated and also their combined performance. The treatments throughout the experiment were as follows

**Factor A. (Four varieties)**

- $V_1$ = PSC 121
- $V_2$ =Yangnuo-7
- $V_3$ = Yangnuo-30
- $V_4$ = Changnau-6

**Factor B: (Three planting time)**

- 1st Planting : 29/05/2017
- 2nd Planting: 21/06/2017
- 3rd Planting: 06/07/2017

### 3.5.6. Land preparation

The land was prepared with power tiller ploughed on 20 May, 2017. Other land preparation practices were done as described in experiment number 1.

### 3.5.7. Fertilizer and manure application

The experimental plots were fertilized with manures and fertilizers (Urea, TSP, MoP, Gypsum, Zinc Sulphate and Boric acid) recommended by Fertilizer Recommendation Guide (BARI, 2016) where fertilizers were not counted as treatments. Other fertilization practices were done as described in experiment number 1.

### 3.5.8 Planting of seeds

Seeds were sown on 29th May 2017 by maintaining given plant geometry. Other practices were done as described in experiment number 1.

### 3.5.9. Intercultural operations

Intercultural operations were done as described in experiment number 1.

### 3.5.10. Sampling and harvesting

Ten plants were randomly selected from the central two rows of each plot for collecting data on yield attributes and yield. At full maturity, the crop was harvested plot-wise. Other practices were done as described in experiment number 1.

### 3.5.11. Collection of experimental data

The details procedures to determine the growth, phonological, yield and yield contributing characteristics were followed have been discussed as described in experiment number 1.

### 3.5.12. Temperature

In general, maximum summer temperatures range between 30°C and 40°C. May is the warmest month in most parts of the country. The maximum and minimum temperature were recorded and measured average monthly minimum and maximum temperature. The metrological data for crop growing season (2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.5.13. Relative Humidity

The relative humidity was also moderate and varied with the different seasons. The relative humidity was also relatively high and it was ranged from 80 to 95 on an average in Kharif season. The RH was recorded according to month wise. The metrological data for crop growing season (2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.5.14. Rainfall

The rainfall was also moderate and varied with the different seasons. The rainfall was also relatively high in response to different season. The rainfall was recorded according to month wise. The metrological data for crop growing season (2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.5.15. Statistical analysis

As described in exp.1.

## Experiment 3: Phenology, growth, yield attributes and yield of white maize varieties as influenced by varying dates in Rabi season 2017-18

### 3.6.1 Experimental location

The experiment was conducted at SAU farm, Dhaka. The experimental field comprises of upland soils.

### 3.6.2 Experimental period

The experiment was accomplished during the period from November, 2017 to May, 2017. It was Rabi season.

### 3.6.3 Species description

As described in Exp.1

As described in Exp.1

### 3.6.4. Experimental Treatments

As described in Exp.1

### 3.6.5 Design and layout

As described in Exp.1

### 3.6.6. Land preparation

The land was prepared with power tiller ploughed on 20 November, 2017. Other land preparation practices were done as described in experiment number 1.

### 3.6.7. Fertilizer and manure application

The experimental plots were fertilized with manures and fertilizers (Urea, TSP, MoP, Gypsum, Zinc Sulphate and Boric acid) recommended by Fertilizer Recommendation Guide (BARI, 2016) where fertilizers were not counted as treatments. Other fertilization practices were done as described in experiment number 1.

### 3.6.8 Planting of seeds

Seeds were sown on 25 November, 2017 by maintaining given plant geometry. Other practices were done as described in experiment number 1.

### 3.6.9. Intercultural operations

Intercultural operations were done as described in experiment number 1.

### 3.6.10. Sampling and harvesting

Ten plants were randomly selected from the central two rows of each plot for collecting data on yield attributes and yield. At full maturity, the crop was harvested plot-wise. Other practices were done as described in experiment number 1.

### 3.6.11. Collection of experimental data

The details procedures to determine the growth, phonological, yield and yield contributing characteristics were followed have been discussed as described in experiment number 1.

### 3.6.12. Temperature

In general, January (12.75˚C) is the coldest month, when the average temperature for most of the country is about 10°C. The maximum and minimum temperature were recorded and measured average monthly minimum and maximum temperature. The metrological data for crop growing season (2016-2017and 2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.6.13. Relative Humidity

The relative humidity was also moderate and varied with the different seasons. The relative humidity was also relatively low and it was ranged from 50 to 65 on an average in Rabi season. The RH was recorded according to month wise. The metrological data for crop growing season (2016-2017and 2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.6.14. Rainfall

The rainfall was also moderate and varied with the different seasons. The rainfall was also relatively low and high in response to different season. The rainfall was recorded according to month wise. The metrological data for crop growing season (2016-2017and 2017-2018) were collected from Bangladesh Meteorological Department, Agargan, Dhaka.

### 3.6.15. Statistical analysis

As described in Exp.1

#### 3.6.15.1. Regression analysis

In this study an approach has been tried to fit the regression curves (linear and polynomial) to the data collected. This was done plotting data of the yield attributes and yield on the X axis while data of the GDD were put on the Y axis. The GDD values of the planting date, varities and their interactions were used against the parameters' values of the respective treatments. The data were fitted to both linear curve and polynomial curves.

Regression[1]involves estimating the mathematical relationship between one variable called the response variable, and one or more explanatory variables. In linear Regression if y = bx + a; the value of b is called the slope, (or gradient), of the line. It can be positive, negative or zero. If the slope is positive, *y* increases as *x* increases, and the function runs "uphill" (going left to right). If the slope is negative, *y* decreases as *x* increases and the function runs downhill. If the slope is zero, *y* does not change remaining constant at a horizontal line. Again if 'x' value is zero, the regression equation predicts that y value is negative.

Slope is usually expressed as an absolute value. A positive value indicates a positive slope, while a negative value indicates a negative slope. In statistics, a graph with a negative slope represents a negative correlation between two variables. This means

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that as one variable increases, the other decreases and vice versa. Negative correlation represents a significant relationship between the variables $x$ and $y$, which, depending on what they are modelling, can be understood as *input* and *output*, or *cause* and *effect*.

Polynomial regression is considered to be a special case of multiple linear regression and *can* be used in those situations where the relationship between dependent and independent variables *is* curvilinear wherein the relationship between the independent variable $x$ and the dependent variable $y$ is modeled as an ‘n’th order polynomial. A polynomial regression can be expressed as $Y' = a + b1X1 + b2X12$. A positive polynomial regression with a significant regression coefficient values represents a quadratic function between the two tested parameters, dependent and independent.

# RESULTS AND DISCUSSION

# CHAPTER IV

# RESULTS AND DISCUSSION

The First Rabi experiment was conducted during 2016-17 and the second one during 2017-18 and the results are presented together, that is the results of the experiment 1 and those of experiment 3 have been presented in this manuscript together to for ease of comparison and explanation. The Kharif experiment (experiment 2) was done in 2017 and the results are presented at the end.

## Experiment 1 & 3 (Rabi): Phenology, growth, yield attributes and yield of white maize varieties as influenced by varying planting dates in Rabi season 2016-17 and 2017-18

### 4.1.1 Days to emergence

In this trial the variety, planting dates and their interactions had significant effect on days to emergence. The results are presented below in Fig 1 to 4.

### Effect of planting date

Date of emergence is the function of effective germination time. Data on date of emergence have been presented in Fig-1. Different planting dates showed statistically significant differences on date of emergence. Crop sown on December 25 ($S_3$) recorded the highest date of emergence (6.08 DAS), however, which was not statistically at per with November 25 planting (6.00). The lowest date of emergence (5.00 days) was observed from $S_1$ (25 Nov) showing the value of 5.33 DAS.

### Effect of variety

Seedling emergence (VE stage) was considered when the coleoptile was found to emerge above the soil surface. It was observed that $V_1$ and $V_3$ emerged at the earliest (5.22- 5.67 days after planting, DAS), while the $V_4$ at the latest (5.67-6.11 DAS). $V_2$ emerged at 5.56-5.78 DAS. Normally maize seed’s emergence under favourable conditions occurs within 4 to 5 days after planting. If cool or dry conditions exists, emergence may be delayed several weeks. At the VE stage, the nodal root system begins to grow.

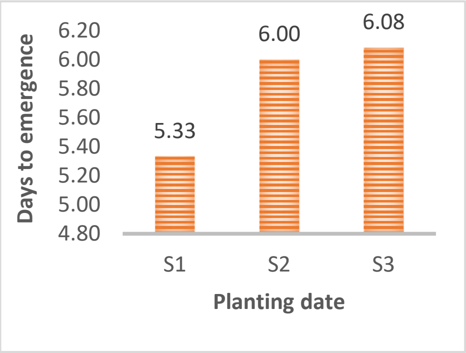


Fig-1: Days to emergence of white maize varieties grown in Rabi 2016-2017 season across varying planting dates ($S_1$=25 November 2016, 10th December 2016 and 25th December 2016; $LSD_{5\%}$ =0.67)

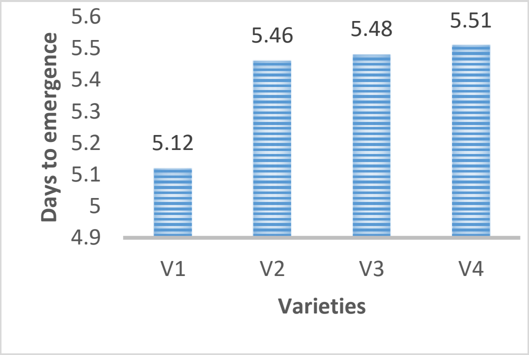


Fig.-2: Days to emergence of different white maize varieties grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $LSD_{5\%}$ = 0.77)

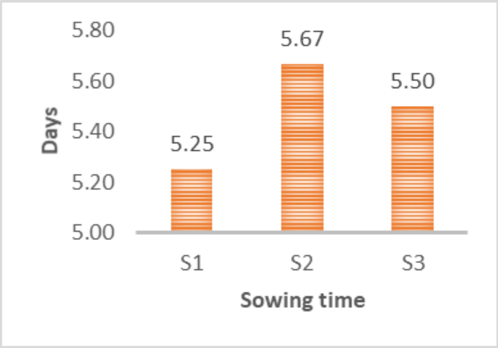


Fig-3: Days to emergence of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season (S1=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% =0.09)

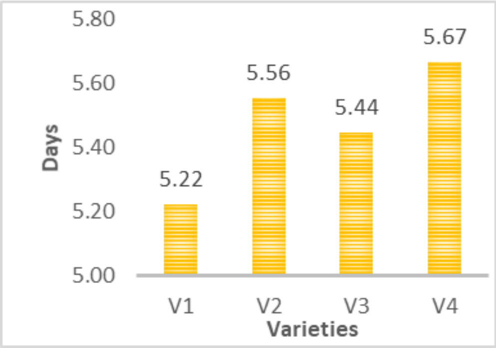


Fig-4: Days to emergence of different white maize varieties grown in Rabi 2017-2018 season (V1=PSC-121, V2= Yangnuo-7, V3= Yungnuo-30, V4= Changnuo-6; LSD5% =0.11)

### Interaction effect of planting dates and variety

Interaction effect of white maize varieties and planting dates sowed significant differences on date of emergence (Fig-5 & 6). In Rabi 2016-17, The highest date of emergence (6.67 days ) was observed from $V_4S_2$ that is with December 10 planting with Changnuo-6 variety while in 2017-18 that was with $S_2V_4$ (6.67 days). In the first year it was then followed by $V_4S_3$ (6.33 days) (Changnuo-6 with December 25 planting) while in the second Rabi season by $S_3V_4$ and $S_2V_4$.

While the shortest emergence (5.00 days) was obtained from the treatment combination $V_3S_1$ that means with the combination treatment of November 25 planting and Yungnuo-30 variety. Again this value was then followed by 5.33 days of emergence in 2016-17 while in 2017-18 it was with $V_3S_1$ (5 days).

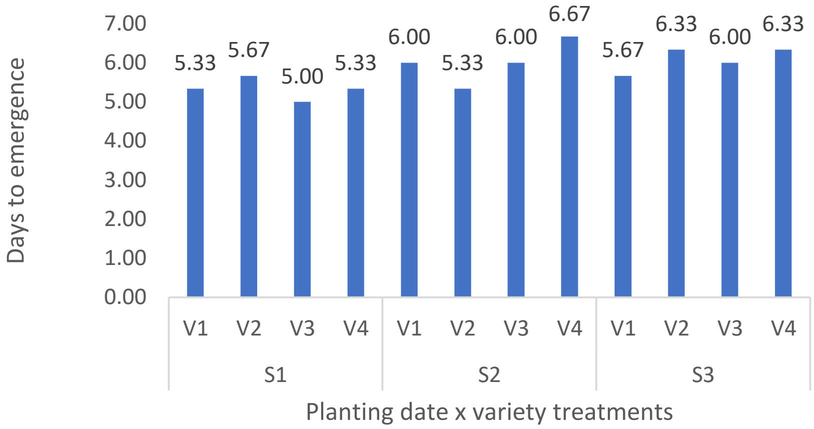


Fig-5: Days to emergence of white maize grown in Rabi 2016-2017 season across as influenced by varying sowing dates and varieties ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 1.34)

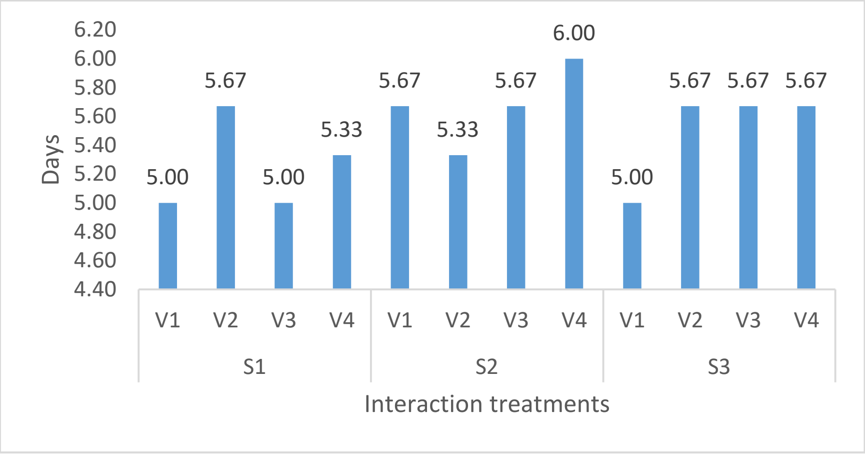


Fig-6: Days to emergence of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and varieties ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =0.19)

In this trial, days to emergence was significantly ($p<0.05$) affected by varieties, planting time and also by their interactions. Banotra *et al. (*2017) reported that the crop sown on April 15, March 29 and April 30 recorded statistically similar but significantly more plant height, leaf area index, dry matter accumulation, cob length, and grain yield than the crop sown on 15 May and onwards. Sangoi (1993) found that hybrid maize planted during earlier planting date had elongated growth period of more than 2 weeks than planted in delayed date. The reduction in vegetative growth on plants sown in March probably limited source of photosynthetic (Tollenaar, 1999) which resulted in lower values of yield components.

### 4.1.2. Days to 6-collar leaf stage ($V_6$)

In this trial the variety, planting dates and their interactions had significant effect on days to 6-collar leaf stage. The results are presented below in Fig.-7 to 10.

During these stages the uppermost ear and tassel is initiated and kernel row numbers are determined. The growing point of the corn plant stands near the surface.

### Effect of planting date

Data on date to 6-collar leaf stagehas been presented in (Fig. 7 and 8). Planting date was found to affect 6-collar leaf stagesignificantly. Crop sown on December 25 recorded the highest date to 6-collar leaf stage (27.83 in 2016-17; 39.75 in 2017-18) days) which was statistically higher than December 10 planting (26.37 and 37.67 days respectively). The lowest dates to six leaf stage (25.32 days) was observed with $S_1$, that means November 25.

### Effect of variety

Statistically significant variation was observed for different white maize varieties in terms of days to 6-collar leaf stage (Fig. 9 & 10). The highest date to 6-collar leaf stagewas found from $V_1$ (29.56 and 42.44 days respectively) that is PSC-121 which was statistically similar to $V_3$ (28.16 and 40.00 days respectively) with Yungnuo-30. Such happened probably due to variation in varieties' differential response to the surrounding temperature and other field conditions.  The shortest date of emergence was found from $V_2$ i.e. Yungnuo-7 (22.48 and 32.11 days respectively) probably due to its minimum seed size.

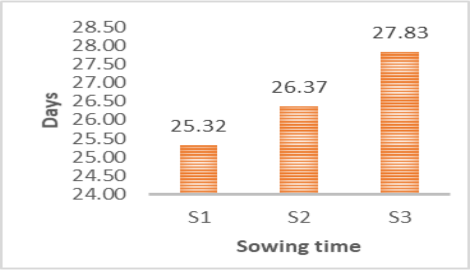


Fig-7: Days to 6-collar leaf stage of white maize grown in Rabi 2016-2017 season across varying genotypes ($S_1$=25th November 2016, 10th December 2016 and 25th December 2016; $LSD_{5\%}$ = 0.53)

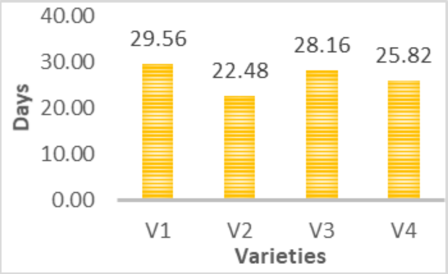
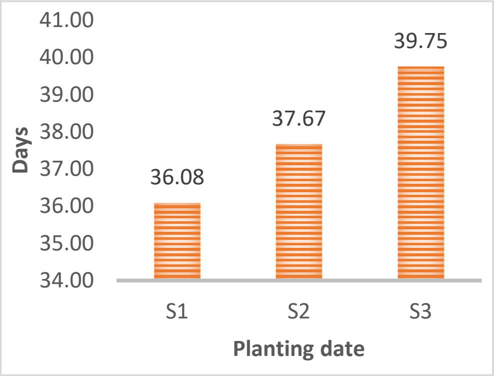


Fig-8: Days to 6-collar leaf stage of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, V4= Changnuo-6; $LSD_{5\%}$ = 0.61)



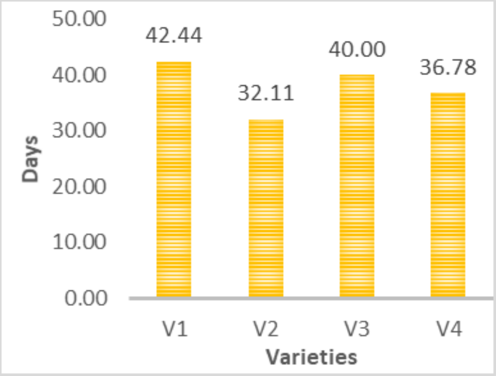


Fig-9: Days to 6-collar leaf stage of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% =0.09)

Fig-10: Days to 6-collar leaf stage of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.11)

## Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date to 6-collar leaf stage (Fig. 11 & 12). The highest date to 6-collar leaf stage (30.33 and 43.67 days respectively) was observed from $V_1S_3$ that means December 25 planting with PSC-121 variety followed (29.40 days) by $V_3S_3$ from Yungnuo-30 with December 25 planting during 2016-17; and statistically similar results (28.93 days) was also found from V1S1 that mean December 10 planting with PSC-121 variety. While the lowest date to 6-collar leaf stage (21.00 and 30 days respectively) was obtained from the treatment combination $V_2S_1$ that mean November 25 planting with Yungnuo-30 variety followed (22.40 days) by $V_2S_2$ that mean November 25 planting with Yungnuo-7 variety. Higher date to 6-collar leaf stageunder December 25 planting was attributed to the delayed development of this treatment to the surrounding environmental factors.

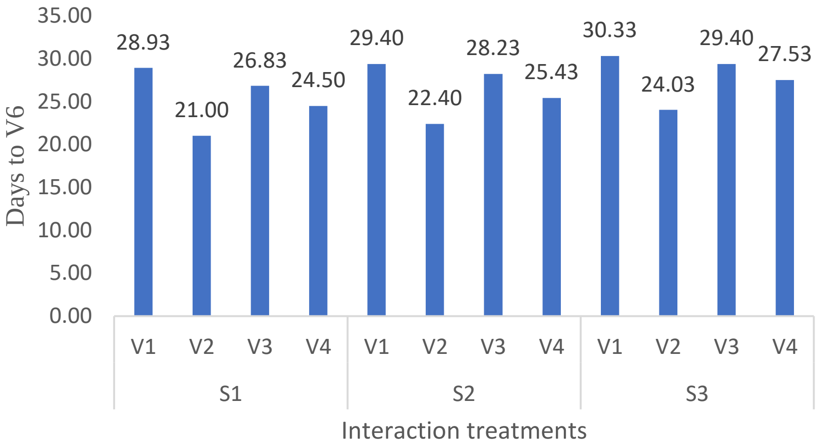


Fig-11: Days to 6-collar leaf stage of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; $LSD_{5\%}$ = 1.06)

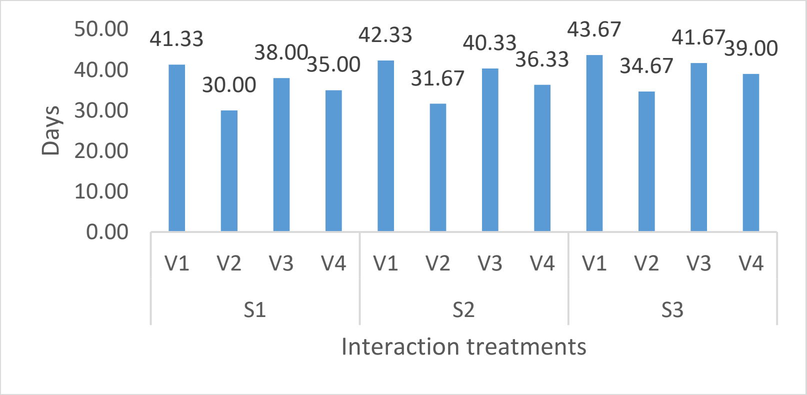


Fig-12: Days to 6-collar leaf stage of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =0.19)

In order to minimized negative effect of some abiotic and biotic stress on plant, planting date can play a major role in determining the seed yield, quality, seed germination and understanding whole phenological stages in many crops in diversified regions (Koca and Canavar, 2014).

### 4.1.3 Days to 10-collar leaf stage ($V_{10}$)

This stage begins the rapid growth rate. If the corn plant is stressed, lower leaves may die at this stage. During the $V_{10}$ growth stages, any management practice that helps reduce plant stress and allows for adequate nutrient levels can help maximize yield potential. It is reported that when 10 leaf-stage has completed, the corn stalk elongates, and the tassel rapidly grows during this phase.

In this trial the variety, planting dates and their interactions had significant effect on days to 10 collar leaf stage. The results are presented below in Fig. 13 to 16.

### Effect of planting date

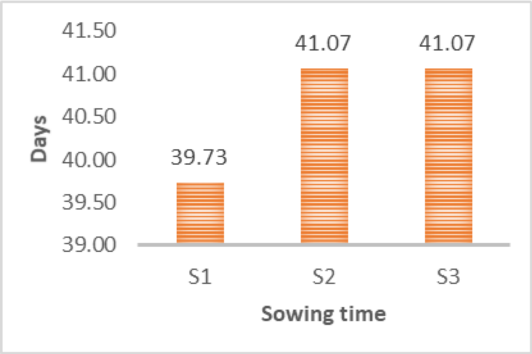
Data on date to 10-collar leaf stagehave been presented in (Fig. 13 and 14). Planting date significantly affected date to 10-collar leaf stageof white maize. Crop sown on December 25 recorded the highest date to 10-collar leaf stage (41.06 and 58.92 days respectively). The lowest date to 10 collar leaf stage (39.73 and 56.67 days respectively) was observed from $S_1$ that means from November 25.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to 10-collar leaf stage (Fig.15 & 16). The highest date to 10-collar leaf stagewas found from $V_1$ (43.24 days) with PSC-121 in 2016-17 while in 2016-17 $V_1$ and $V_3$ took similar days (61.56 and 61.67 days). In the firar year it was then followed byy $V_3$ (43.09 days) with Yungnuo-30. $V_2$ had the earliest development of the 10th collar leaves with Yangnuo-7 in 36.63 and 52 days respectively in the first and second year.

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates showed significant differences on date to 10-collar leaf stage (Fig.17 & 18). The highest date to 10-collar leaf stage (44.33 days) was observed from V1S3 that means with December 25 planting by PSC-121 variety while in 2016-17 it was with $V_1S_3$ (63.33 days). This was followed by V1S1 from PSC-121 with December 10 planting (43.63 days) in the first year, but this was statistically similar to the results of from $V_3S_1$ that is the interaction treatment November 25 planting and Yungnuo-30 variety (42.47 days). The lowest date to 10-collar leaf stage in both the seasons (35.93 and 51 days) was obtained from the treatment combination $V_2S_1$ that is the combination treatment November 25 planting with Yungnuo-7 variety.



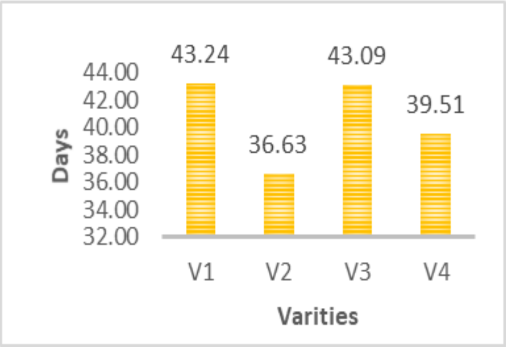
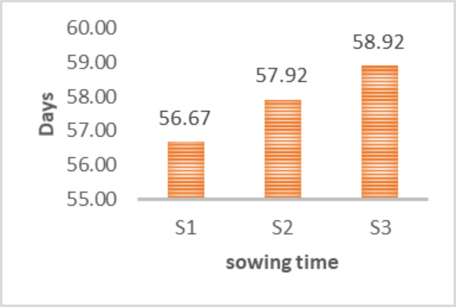


Fig.13: Days to 10-collar leaf stage of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; $LSD_{5\%}$ =0.61)

Fig.14: Days to 10-collar leaf stage of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $LSD_{5\%}$ =0.70)



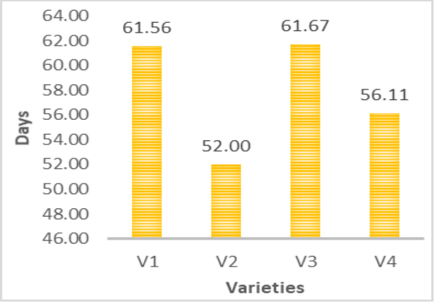


Fig.15: Days to 10-collar leaf stage of white maize as influenced by varying planting dates grown in Rabi 2018 season ($S_1$=26 November 2016, 11th December 2016 and 26th December 2016) (LSD5% =0.8)

Fig.16: Days to 10-collar leaf stage of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.9)

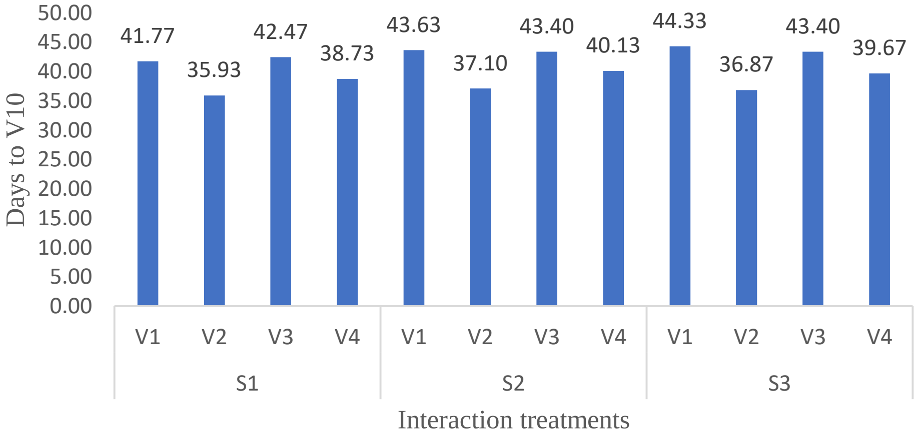


Fig 17: Days to 10-collar leaf stage of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; $LSD_{5\%}$ =1.22)

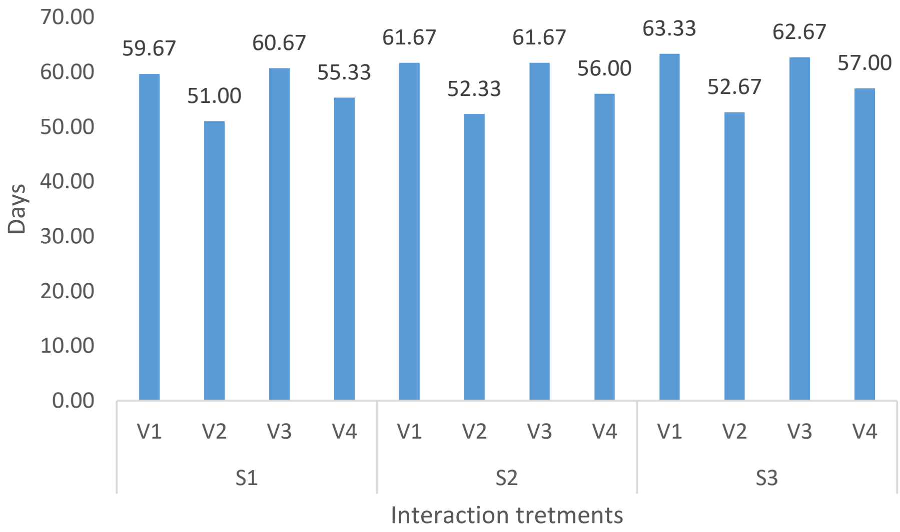


Fig. 18: Days to 10-collar leaf stage of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =0.16)

### 4.1.4 Day to 12-collar leaf stage ($V_{12}$)

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to 12-collar leaf stage. The results are presented below in Fig. 10 to 12.

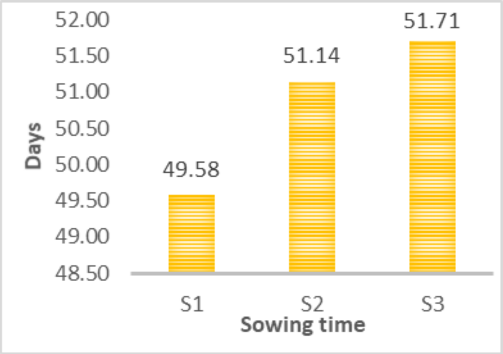
At $V_{12}$, kernel row differentiation becomes almost complete. As the plant approaches pollination, soil moisture and nutrient availability becomes increasingly critical for yield determination.

#### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to 12-collar leaf stage (Fig. 4.20 & 4.22). The highest date to 12-collar leaf stagewas found from $V_3$ (54.31 and 63.67 days respectively) with Yungnuo-30 which was statistically similar to $V_1$ (53.27 and 62.44 days respectively) with PSC-121. The shortest days to 12-collar leaves stage (45.99 and 53.89 days respectively) with $V_2$ (Yangnuo-7).

#### Effect of planting date

Data on date to 12-collar leaf stagehave been presented in (Fig. 19 & 21). Planting date significantly affected date to 12-collar leaf stageof white maize. Crop sown on December 25 recorded the highest date to 12-collar leaf stage **in bothe the years (**51.70 and 60.83 days respectively**)** which was statistically at per with December 10 planting (51.14 days) in the first year while there was a significant difference in the second Rabi season. Significantly the lowest date 12-collar leaf stage (49.58 and 58.33 days respectively) was observed from $S_1$ that was November 25.



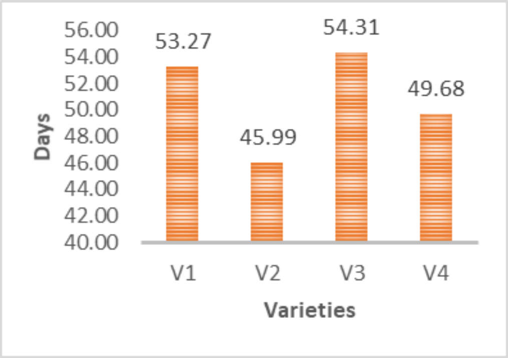
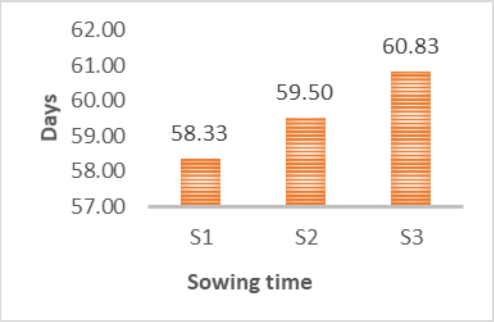


Fig.19: Days to 12-collar leaf stage of white maize grown in Rabi 2016-2017 season across varying genotypes ($25^{th}$ November 2016, $10^{th}$ December 2016 and $25^{th}$ December 2016; $LSD_{5\%}$ =0.35)

Fig.20: Days to 12-collar leaf stage of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $LSD_{5\%}$ =0.41)



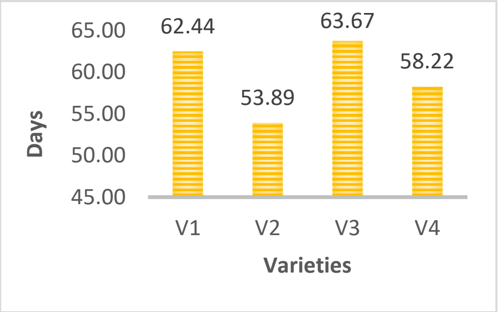


Fig.21: Days to 12-collar leaf stage of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% =0.8)

Fig.22: Days to 12-collar leaf stage of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5%= 0.9)

**Interaction effect of planting dates and variety**

Date to 12-collar leaf stage was affected by interactions of planting date and variety, that is, the interaction effect of white maize genotypes and planting dates showed significant differences on date to 12-collar leaf stage (Fig. 23 & 24). The highest date to 12-collar leaf stage(55.25 and 65 days respectively) was observed from $V_3S_3$ that means December 25 planting with Yungnuo-30 variety. In the 2016-17 season this was then followed by $V_3S_2$ with Yungnuo-30 and December 10 planting combination treatment (54.97 days). However, this was statistically similar to the results of $V_3S_1$ treatment that is November 25 planting with Yungnuo-30 variety (52.70 days). While the shortest time to 12-collar leaf stage(44.77 and 52.67 days respectively) was obtained from the treatment combination $V_2S_1$, that means November 25 planting with Yungnuo-7 variety which was again followed by $V_2S_2$ (46.47 days), that means December 10 planting with Yungnuo-7 variety in the first year.

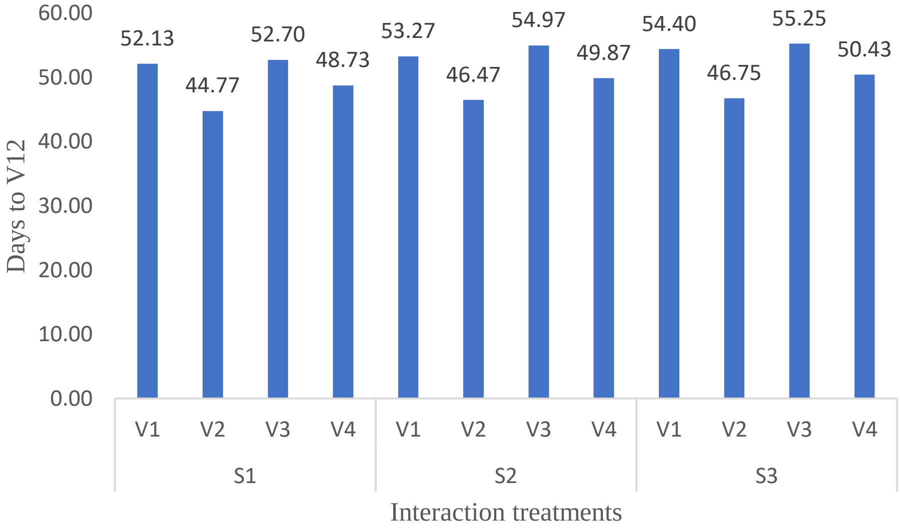


Fig.23: Days to 12-collar leaf stage of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; $LSD_{5\%}$ =0.71)

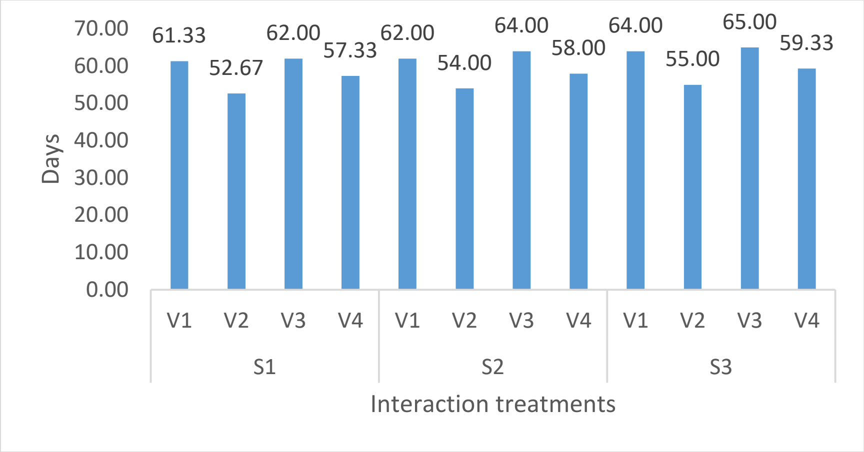


Fig.24: Days to 12-collar leaf stage of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =0.16)

### 4.1.5 Days to First tasseling

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to first tasseling. The results are presented below in Fig. 25 to 27.

Pollination begins around 9 or 10 weeks after corn emergence. Moisture and heat stress during pollination may cause the greatest yield reduction, which can result in barren tips or loss of entire ears. Tassel stage begins when the last branch of the tassel is visible, but silks have not emerged. Tassels normally appear 2 to 3 days before silk emergence. Pollen shed typically occurs in the morning or evening.

#### Effect of planting date

Date of tasseling have been presented in (Fig. 25 & 27). Planting date significantly affected date of tasselingof white maize which is observed to be delayed with the delay of planting. Crop sown on December 25 recorded the delayed date of tasselling (65.67 and 65.66 days respectively). This was statistically longer compared with that of December 10 planting (63.75 and 62 days respectively). The lowest date of emergence (62 days) was observed from $S_1$ that means November 25 planting in both the years.

#### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to tasseling (Fig. 26). During 2016-17, the highest date to tasseling was found in $V_3$ (67.89 days) Yangnuo-30 which was statistically similar to $V_1$ (66.56 days) PSC-121. The earliest date of tasseling was found from $V_2$ (55.67 days) Yungnuo-7.

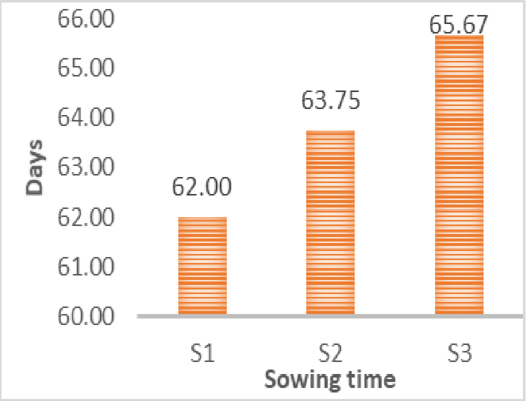


Fig.25: Days to first tasseling of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; $LSD_{5\%}$ =0.73)

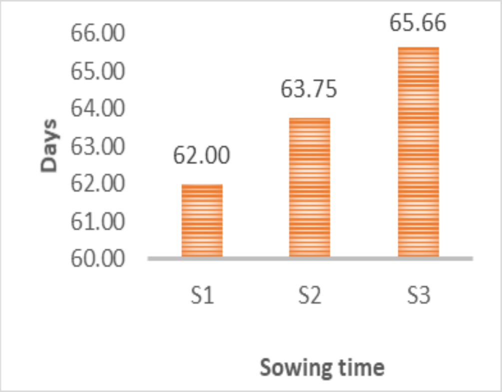


Fig.26: Days to first tasseling of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5 %= 0.8)

## Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of tasseling (Fig. 28 & 29). The highest date of tasseling (69.33 days) was observed from V1S3 that mean December 25 planting with PSC-121 variety while in addition to that treatment it was also $V_3S_3$ in the second Rabi season followed (69.00 – 69.00 days) by $V_3S_3$ from Yungnuo-30 with December 25 planting. Statistically similar results (68.00 days) was also found from $V_3S_2$ that mean December 10 planting with Yungnuo-30 variety in 2016-17. The lowest date of tasseling (55.67 days) was obtained from the treatment combination $V_2S_1$ that means November 25 planting with Yungnuo-7 variety. A bit longer days to tasseling was observed (57.67 days) with $V_2S_2$ that means December 10 planting with Yungnuo-7 variety.

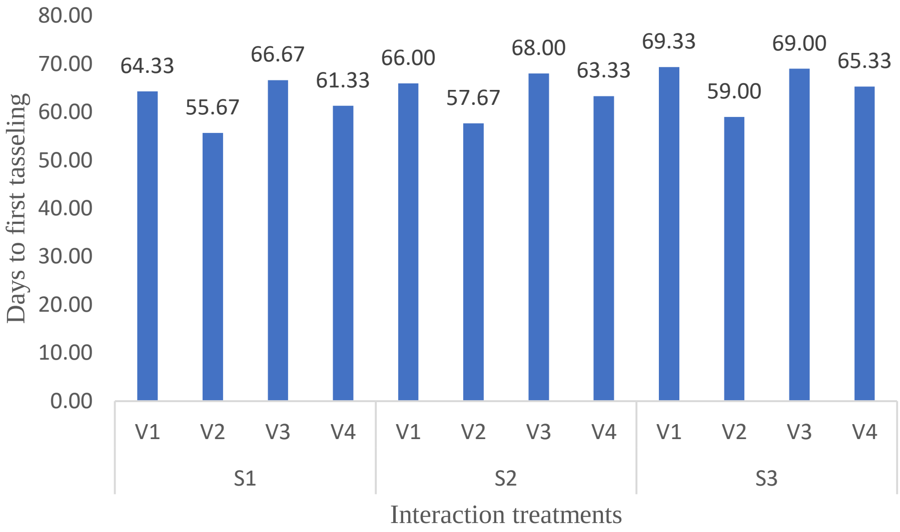


Fig.27: Days to first tasseling of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; $LSD_{5\%}$ =1.46)

Khan *et al. (*2011) reported that days to tasseling were significantly affected by planting date. Days to tasseling decreased with delay in planting. Since, tassel initiation is correlated with maturity of genotype and so late maturing genotype will take more days to tasseling (Lejeune and Bernier, 1996) and vice versa. Maize variety Azam was found to be belonged to medium maturity group (Khan *et al.*, 2004) and accordingly it took significantly less days to tasseling like the Yangnuo-7 of this study. Days to tasseling decreases with delay in planting from March to July.

In this study it was observed that the days to tasseling was significantly ($p>0.05$ and $p<0.01$) affected by genotypes, planting time and their interactions. Planting date and variety treatments had statistically significant effect on variety of PSC-121, Yungnuo-7, Yungnuo-30, and Changnuo-6 at the days to tasseling. However, days to tasseling was found to be insignificantly affected by genotypes, planting time and their interactions in some instances which agrees well the report of Kharazmshahi *et. al.* (2015) who conducted a study with planting date in two levels of planting (15 and 30 May) wherein they reported significant difference in days to emergence of tassel due to the variation in planting date and sweet maize genotypes.

### 4.1.6 Days to 50% tasseling

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to 50% tasseling stage. The results are presented below in Fig. 29 – 32.

## Effect of planting date

Date of 50% tasseling has been presented in (Fig. 29 & 31). Planting date significantly affected date of 50% tasselingof white maize. Crop sown on December 25 recorded the latest date of 50% tasseling (72.66 days in both the seasons) which was statistically at per with that of December 10 planting (70.66 and 70.58 days respectively). The earliest date of tasselling (68.88 and 68.67 days respectively) was observed from $S_1$ that mean with November 25.

## Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to 50% tasseling (Fig 30 & 32). The highest date of 50% tasseling was found from $V_1$ (77.33 and 66.56 days respectively) PSC-121 which was statistically similar to that of $V_3$ (73.33 days) Yangnuo-30 in the first season. The earlier date of 50% tasseling was found from $V_2$ (61.33 and 57.44 days respectively) Yungnuo-7.

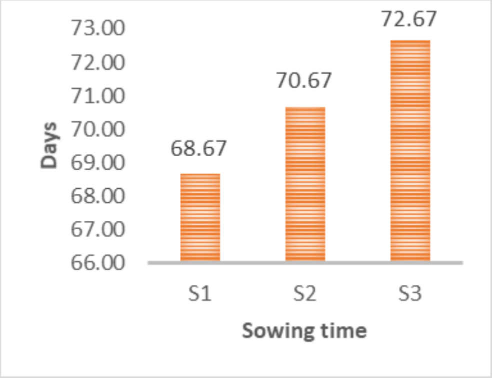


Fig.28: Days to 50% tasseling of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.47)

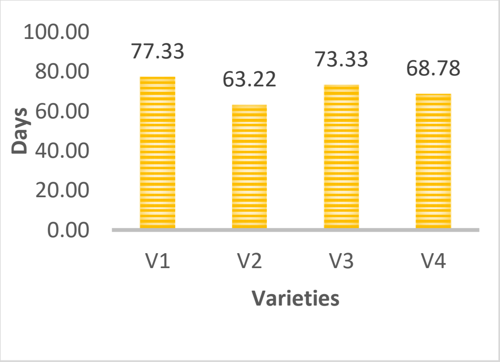
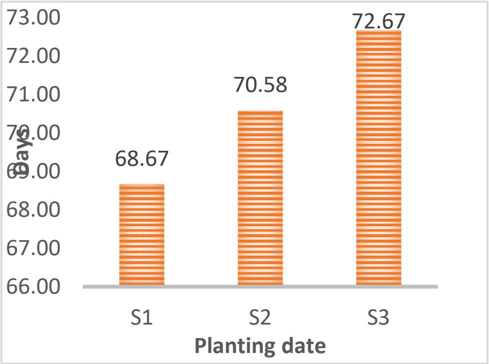


Fig.29: Days to 50% tasseling of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.54)



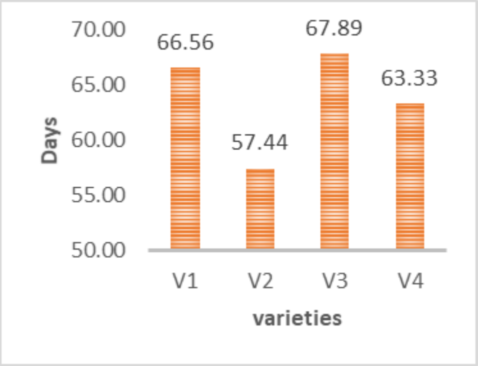


Fig.30: Days to 50% tasseling of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% =95.92

Fig.31: Days to 50% tasseling of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =110.9

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of 50% tasseling (Fig. 33). During 2016-17, the latest date of 50% tasseling (80.00 days) was observed from $V_1S_3$ that mean December 25 planting with PSC-121 variety followed (77.67 days) by V1S1 from PSC-121 with December 10 planting and statistically similar result (74.33 days) was also found from $V_1S_1$, that means November 25 planting with PSC-121 variety. While the earliest date of 50% tasseling (61.33 days) was obtained from the treatment combination $V_2S_1$, that means November 25 planting with Yungnuo-7 variety which was then delayed (63.33 days) by $V_2S_2$ that is, December 10 planting with Yungnuo-7 variety.

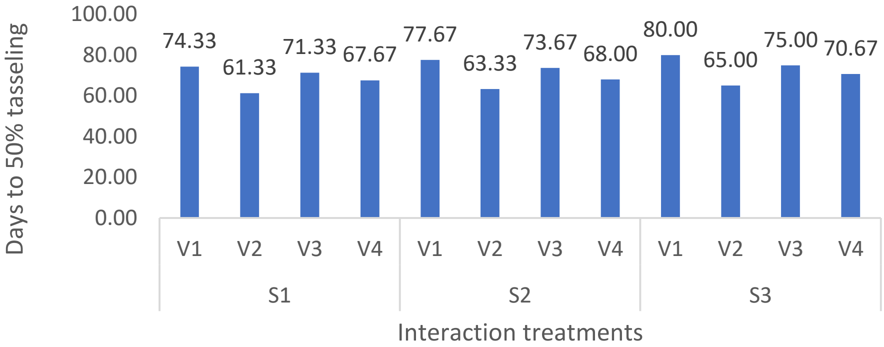


Fig.32: Bar diagram showing the average days to 50% tasseling of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.94)

As a result season robi-2016 and robi-2017 required more days as comparison with other seasons and PSC-121 took more days to emergence to tasseling stage compare with Yangnuo-7. Prasad *et al*. (2017) reported that days taken to 50 % tasseling were delayed with delay in planting by 20 days from normal planting date as compared to 10 days advance, normal and 10 days delayed planting and the later three being at par.

As observed in this study, the days to 50% tasseling was significantly ($p<0.05$ and $p<0.01$) affected by the genotypes, planting time and their interactions. Planting date and variety treatments had statistically significant effect on days to 50% tasseling and this has also been previously reported by Ali*et al.* (2018) who conducted an experiment at Peshawar (Pakistan) in which ten selected genotypes were sown at six different planting dates. At the end of the trial they concluded that the early planting with one of the tested variety performed better in respect to days to tasseling.

### 4.1.7 Days to First silking

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to first silking stage. The results are presented below in Fig. 34 & 35.

The silking stage begins when the silk (hair like structure at the apex of the ear) is visible outside the husk. Pollen falls onto the silks to potentially fertilize the ovules. Each ovule can produce an individual kernel. Moisture stress at this time can cause the desiccation of silks and/or pollen grains, which could reduce seed set.

#### Effect of planting date

Date of first silking have been presented in (Fig. 34). Planting date significantly affected date of first silkingof white maize. In 2016-17, crop sown on December 25 recorded the longest date of first silking (73.83 days) which was statistically longer than that with December 10 planting (71.41 days). Significantly the lowest date of emergence (69.83 days) was observed from $S_1$ that means November 25.

#### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to first silking (Fig. 35). In the first season, the delayed date first silking was found from $V_1$ (79 days) with PSC-121 which was statistically later compared to that of $V_3$ (73.67 days) that is Yangnuo-30. Significantly the earliest date of first silking was found from $V_2$ (62.00 days) Yungnuo-7.

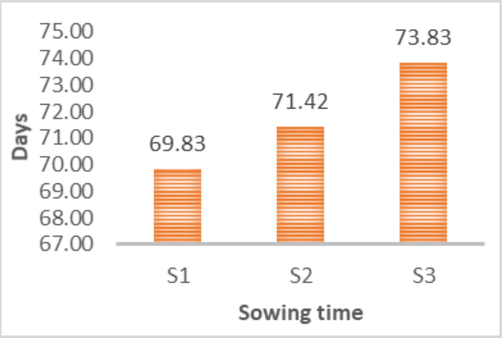


Fig.33: Days to first silking of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.35)

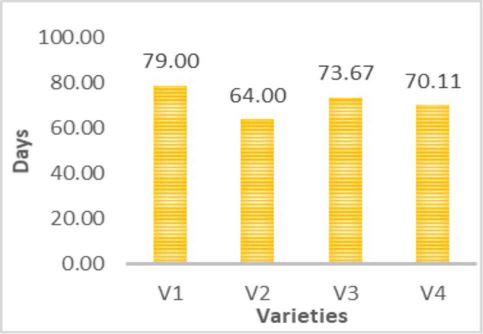


Fig.34: Days to first silking of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.41)

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of first silking (Fig. 36). The highest date of first silking (81.33 days) was observed from $V_1S_3$ that mean December 25 planting with PSC-121 variety followed (78.67 days) by V1S1 from PSC-121 with December 10 planting and statistically similar results (77.00 days) was also found from $V_1S_1$ that mean November 25 planting with PSC-121 variety. While the lowest date of first silking (62.00 days) was obtained from the treatment combination $V_2S_1$ that mean November 25 planting with Yungnuo-7 variety; and it was then followed (63.67 days) by $V_2S_2$ that is, December 10 planting with Yungnuo-7 variety.

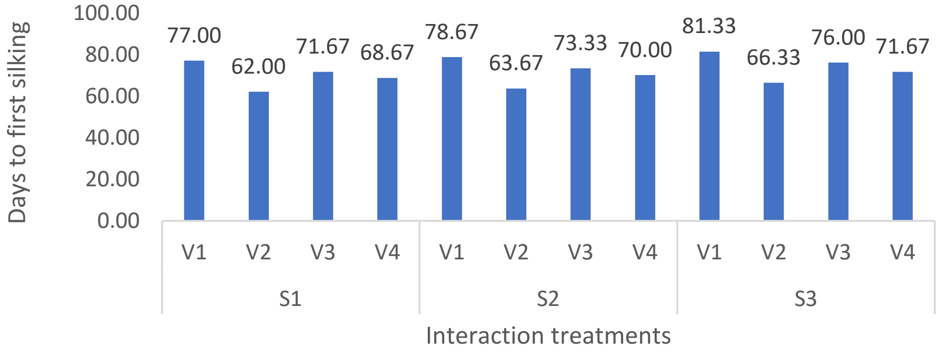


Fig.35: Days to first silking of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.71)

Khan *et al.* (2011) reported that days to silking were significantly affected by planting dates. Sweet corn planted on 17th March took more days to silking (72.2). Delay in planting decreased days to silking and minimum days up to 56.73 days which was noted with 26th the July planted crop. This decrease in days to silking may be due to increase in mean temperature with delay in planting date. The results in relation to silking of this study is also in agreement with Mederski and Jones (1963) who reported a decrease in the number of days from planting to silking as the soil temperature increased. Shrestha *et al.* (2016) in another study observed that April 7th planting showed longest days to silking (58.08) and also seed fill duration (51.25) than other planting dates. The reason for lengthening of different phonological stages were due to relatively cooler temperature in the surrounding atmosphere.

In this study the days to silking was significantly ($p<0.05$ and $p<0.01$) affected by genotypes, planting time and their interactions. Determination of planting dates for maize genotypes is crucial for higher crop yields. Significant effects of planting date and landraces on days to silking in corn were also reported by Khan *et al*. (2009) and Shafi *et al.* (2006).

### 4.1.8 Days to 50% silking

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to 50% silking stage. The results are presented below in Fig. 37 & 38.

**Effect of planting date**

Date of 50% silking have been presented in (Fig. 37). Planting date significantly affected date of 50% silkingof white maize. Crop sown on December 25 recorded the highest date of 50% silking (77.33 days) which was statistically at per with December 10 planting (75.33 days). The lowest date of 50% silking (73.17 days) was observed from S1 that means November 25.

**Effect of variety**

Statistically significant variation was observed for different white maize genotypes in terms of days of 50% silking (Fig. 38). The highest date 50% silking was found from $V_1$ (82.56 days) PSC-121 which was statistically higher than $V_3$ (77.44 days) Yangnuo-30. Whereas, the lowest date of 50% silking was found from $V_2$ (66.22 days) Yungnuo-7 due to susceptible characters.

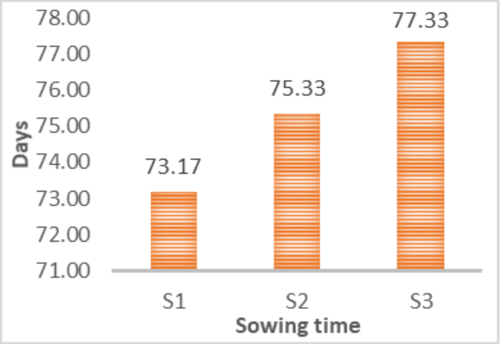


Fig.36: Days to 50% silking of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.45)

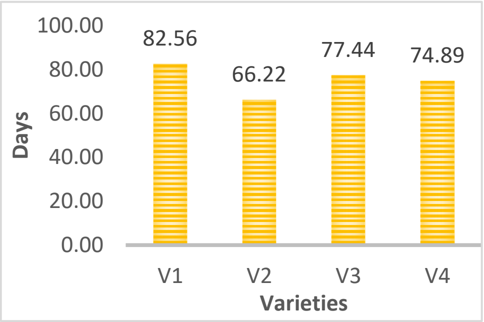


Fig. 37: Days to 50% silking of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.52)

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of 50% silking (Fig. 39 & 40). In the first seasons, the highest date of 50% silking (81.33 days) was observed from $V_1S_3$ that means December 25 planting with PSC-121 variety which was then followed by V1S1 from PSC-121 with December 10 planting (82.33 days). It was then followed by the result which was statistically similar (77 days) as was obtained from $V_1S_1$ representing November 25 planting with PSC-121 variety. The lowest date of 50% silking (62.00 days) was obtained from the treatment combination $V_2S_1$ that mean November 25 planting with Yungnuo-7 variety.

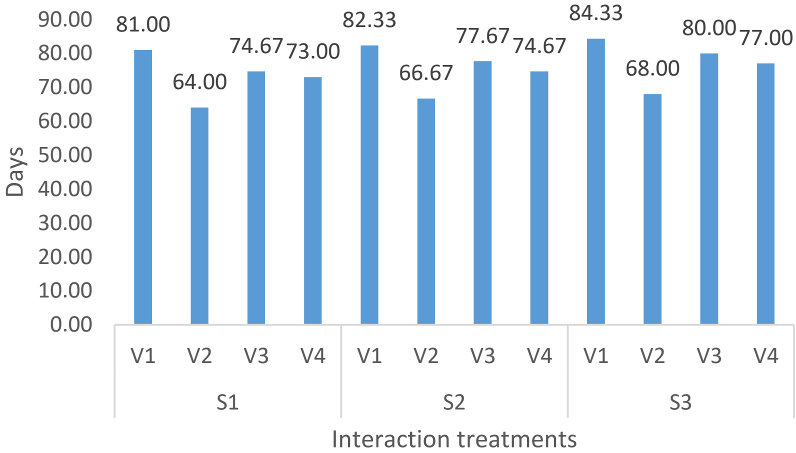


Fig.38: Days to 50% silking of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =0.7)

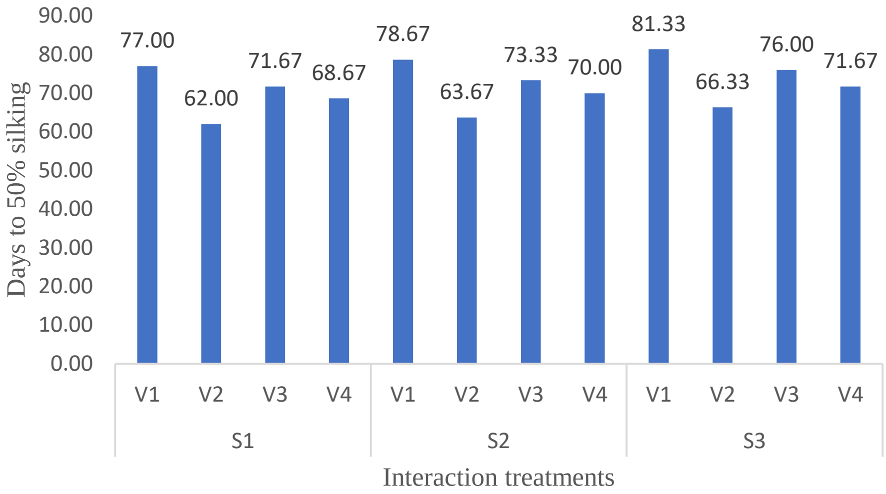


Fig.39: Bar diagram showing the average days to 50% silking of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.91)

Late planting of maize caused elongation of silking to physiological maturity period due to adverse effect of low temperature on pace of maturity period as well as proper grain black layer filling was also affected (Tollenaar and Bruulsema, 1998). Daynard, (1972) observed that time interval requirement of thermal condition during planting to mid – silking stage in maize crop was lengthened whereas, the requirement of thermal exposure interval by mid – silking to grain black layer formation stage was shortened as a result of late seed planting.

Banotra *et al*. (2017) found a significant difference in silking due to varietals effect. The cultivar Misthi took maximum days (60.71 days) to silking which was then followed by cultivar Sugar-75 (60.32 days) and Gold star (60.21 days). This variation in the number of days taken to silking was due to genetic variation of the different sweet corn cultivars as was also observed by Khan *et al.* (2009).

Days to 50% tasseling was significantly ($p<0.05$ and $p<0.01$) affected by genotypes, planting time and their interactions. Determination of planting dates for maize genotypes is crucial for better crop yield. In this study, the planting date and variety treatments were statistically significant on variety of PSC-121, Yungnuo-7, Yungnuo-30, and Changnuo-6 at the days to 50% tasseling.

### 4.1.9 Days to Physiological Maturity

Grain fill is the last set of stages of the corn growth cycle. The plant now directs nutrients for reproductive growth instead of vegetative growth. While the number of kernels has already been determined in earlier stages, the size of the kernels is set during grain fill stages.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to physiological maturity stage. The results are presented below in Fig. 41 to 44.

### Effect of planting date

Date of physiological maturity have been presented in (Fig. 41 & 43). Planting date significantly affected date of physiological maturity of white maize. Crop sown on December 25 recorded the highest date of physiological maturity (130.58 and 132.17 days respectively) which was statistically at higher with December 10 planting (128.25) in the first season. The shortest physiological maturity (126.25 days in both the seasons) was observed from $S_1$ that means November 25.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to physiological maturity (Fig. 42 & 44). The greatest date physiological maturity was found from $V_1$ (136.11 and 138.78 days respectively) PSC-121 which was statistically similar to $V_3$ (134.89 134.89 days respectively) Yungnuo-30. Whereas, the lowest date of physiological maturity was found from $V_2$ (113.33 days in both the years) with Yungnuo-7.

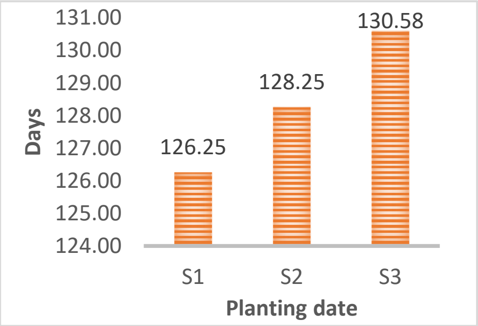


Fig.40: Days to physiological maturity of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =1.22)

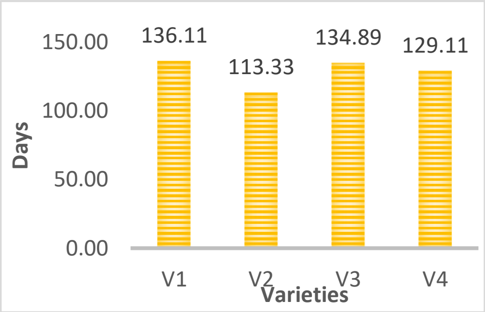


Fig. 41: Days to physiological maturity of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =1.41)

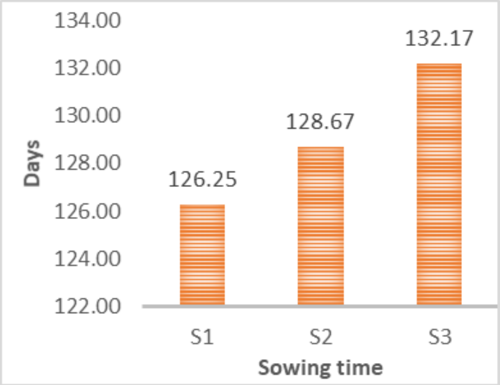


Fig.42: Days to physiological maturity of white maize as influenced by varying planting dates ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) grown in Rabi 2017-2018 season (LSD5% =0.07

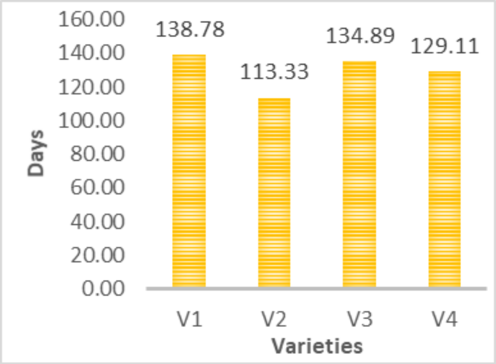


Fig.43: Days to physiological maturity of different white maize genotypes ($V_1$= PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$=Changnuo-6; LSD5% =0.08 grown in Rabi 2017-2018 season

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of physiological maturity (Fig. 45). In the first season, the delayed date of physiological maturity (139.33 days) was observed from $V_3S_3$ that mean December 25 planting with Yungnuo-30 variety followed (136.67 days) by V1S1 from PSC-121 with December 10 planting and statistically similar results (136.67 days) was also found from $V_1S_1$ that mean November 25 planting with PSC-121 variety. While the earliest date of physiological maturity (111.00 days) was obtained from the treatment combination $V_2S_1$ that mean November 25 planting with Yungnuo-7 variety; this was then followed (113.33 days) by $V_2S_2$ that means, December 10 planting with Yungnuo-7 variety.

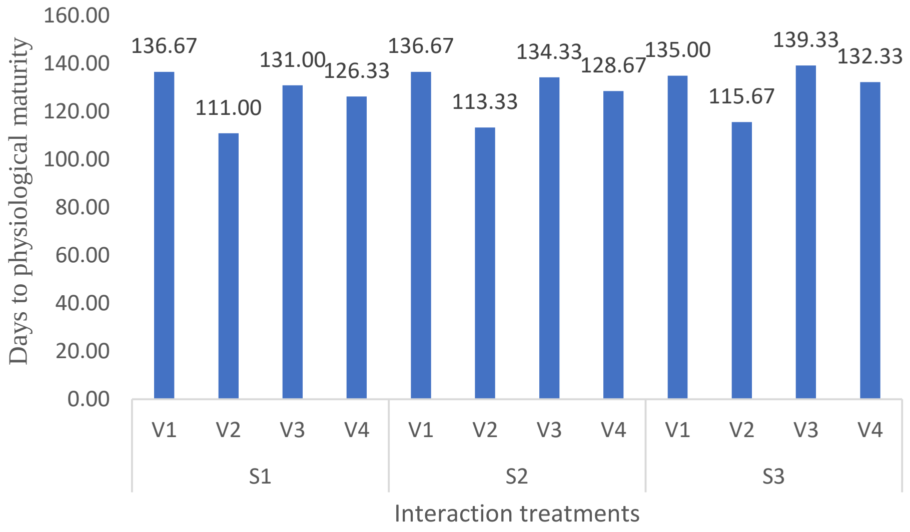


Fig.44: Days to physiological maturity of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =2.44)

Banotra *et al*. (2017) studied six planting dates (29 March, 15 April, 30 April, 15 May, 30 May and 19 June) on three sweet corn cultivars (Misthi, Sugar-75 and Gold star) and revealed that maximum of 94.67 days was taken by the crop to reach harvest maturity with March 29 sown crop which was statistically at par with that of the April 15 and April 30 sown crops showing 94.57 and 94.26 days, respectively. Sweet corn crop planted on June 19 planting required minimum days to reach these stages. Among the different genotypes, cultivar Misthi has been found to be adjudged as the best cultivar and the period from 29 March to 30 April as the optimum planting window with 15 April as appropriate planting date for judicious utilization of applied resources for optimization of yields under sub-tropical Jammu, India.

Days to maturity was significantly ($p<0.05$ and $p<0.01$) affected by genotypes, planting time and their interactions. Determination of planting dates for maize genotypes is crucial for better crop yield. Planting date and variety treatments were statistically significant on variety of PSC-121, Yungnuo-7, Yungnuo-30, and Changnuo-6 at the days to maturity. However, days to maturity was insignificantly affected by genotypes, planting time and their interactions between (PSC-121 and Yungnuo-30) and (Yungnuo-30, and Changnuo-6) in some instances.

### 4.1.10 Plant height

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on plant height. The results are presented below in Fig. 28 to 30.

### Effect of planting date

Plant height has been presented in (46 & 48). Planting date significantly affected plant height of white maize. Crop sown on November 25 recorded the highest plant height (201.25 and 201.24 cm respectively) which was not statistically at per with December 10 planting (180.17 cm) in the first season. The lowest plant height (156.67 and 158.25 cm respectively) was observed from S3 that mean December 25.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of plant height (Fig. 47 & 49). The longest plant was found from $V_1$ (204.11 and 203.47 cm respectively) PSC-121 which was statistically similar to $V_4$ (182.44 cm) Changnuo-6 whereas, the lowest height was found from $V_2$ (157.67 and 158.20 cm respectively) Yungnuo-7.

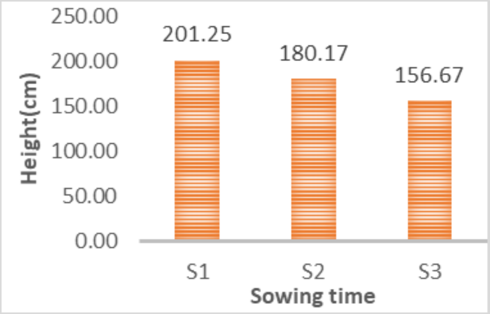


Fig.45: Bar diagram showing the average plant height of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =11.24)

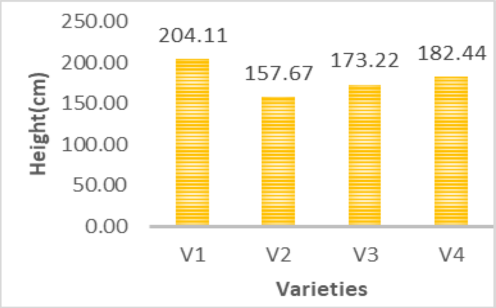


Fig.46: The average plant height of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =12.98)

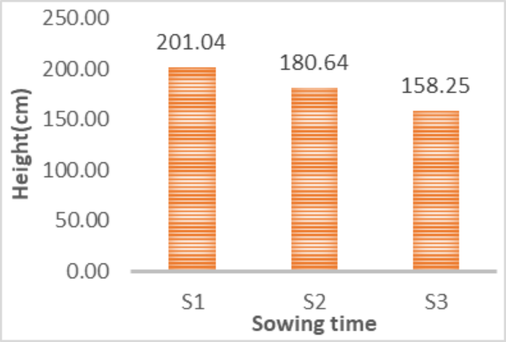


Fig.47: Plant height of white maize as influenced by varying planting dates ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) grown in Rabi 2017-2018 season (LSD5% =0.08

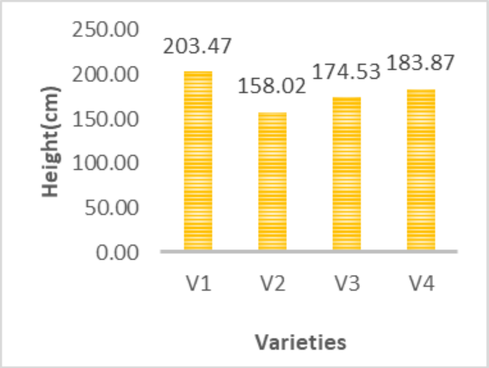


Fig.48: Plant height of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo -7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% 0.09

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on plant height (Fig. 50 & 51). The highest plant height (220.67 cm) was observed from $V_3S_3$ (139.33 cm) that mean Dec 25 planting with Changnuo-1 variety in the first season while in the second Rabi season it was with $V_1S_1$ (217.67 cm). In the first season it was then followed (136 cm) by $V_1S_1$ and $V_1S_3$ from PSC-121 with December 10 and 25 planting. While the shortest plant height (137.33 cm) was obtained from the treatment combination $V_2S_1$ that mean Nov 25 planting with Yungnuo-7 variety in the first season while in the second season it was with the $V_2S_3$ (137.33 cm).

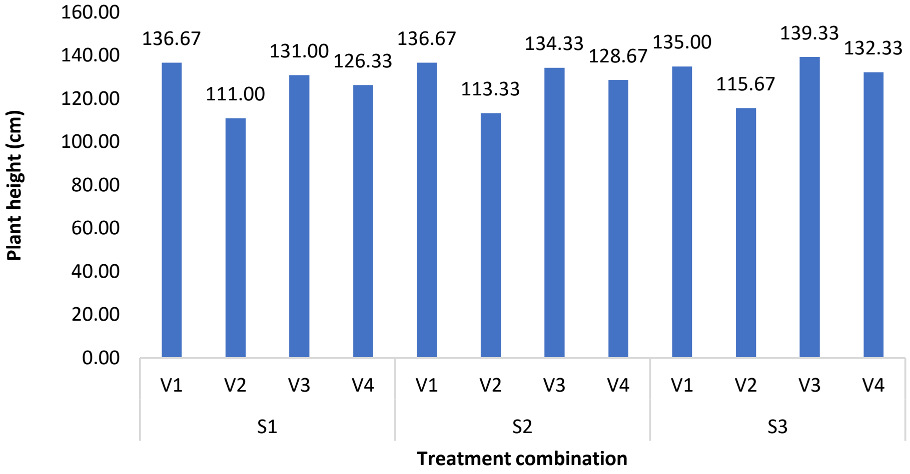


Fig.49: The average plant height of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =22.49).

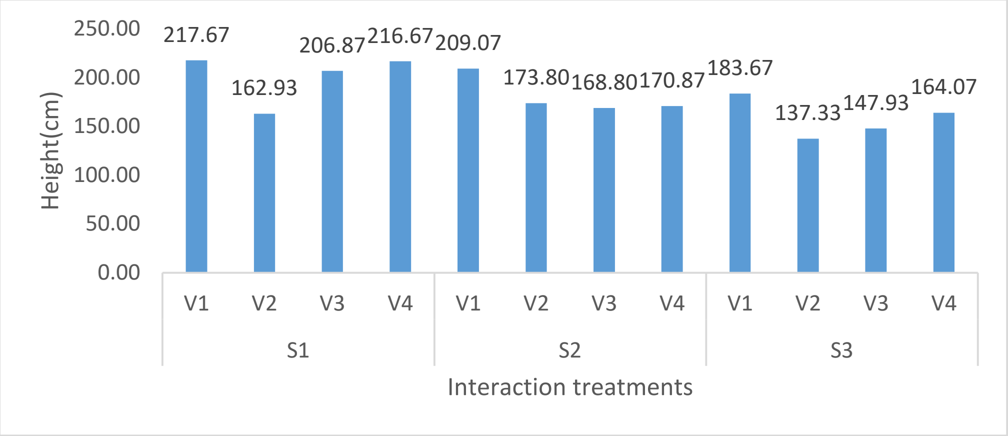


Fig.50: Plant height of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =017)

### 4.1.11 Number of leaf

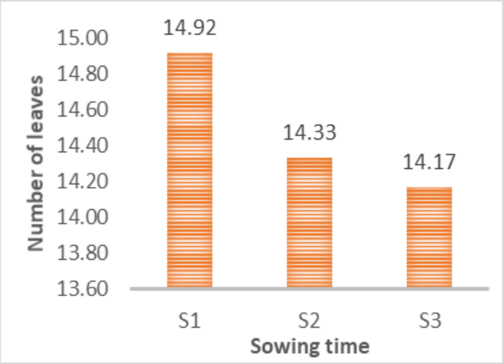
In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on number of leaf. The results are presented below in Fig. 52 to 55.

### Effect of planting date

Date of number of leaf have been presented in (52 & 54). Planting date significantly affected number of leaf of white maize. Crop sown on November 25 recorded the highest number of leaf (14.92 and 14.94) which was statistically at per with December 10, $S_2$ in 2016-17. Different planting dates showed statistically significant differences on date of number of leaf (Fig. 31). The lowest plant height (14.17 and 14.33 respectively) was observed from $S_3$ that mean December 25.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of number of leaf (Fig. 53 & 55). The highest number was found from $V_4$ (15.18 and 15.56) Changnuo-6 which was statistically similar to $V_1$ (15.11) PSC-121 in the 2016-17 season whereas the lowest number was found from $V_2$ (13.31 and 13.56) Yungnuo-7 due to susceptible characters.



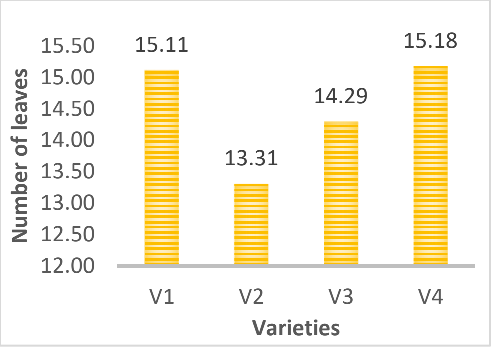
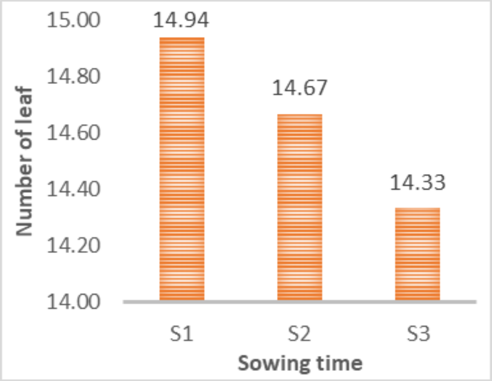


Fig. 51: Leaf number of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.81)

Fig.52: The number of leaves per plant of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.94)



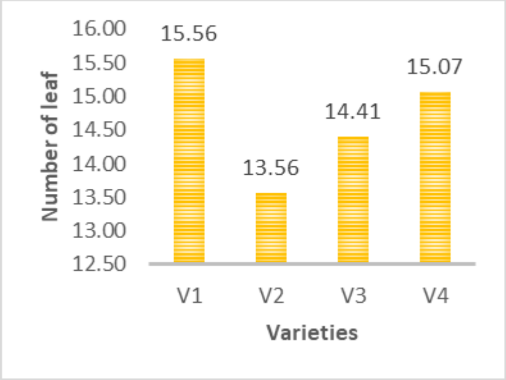


Fig.53: Number of leaves per plant of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% =1.15

Fig. 54: Number of leaves per plant of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =2.42

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of number of leaf (Fig. 56 & 57). The highest number of leaf (16 and 15.67 respectively) was observed from $V_4S_1$ that mean November 25 planting with Changnuo-6 variety. In the first season it was then followed (15) by $V_1S_1$ from PSC-121 with December 10 planting and statistically similar results (15) was also found from $V_4S_3$ that mean December 25 planting with Changnuo-6 variety. While the lowest number of leaf (13) was obtained from the treatment combination $V_2S_3$ that mean December 25 planting with Yungnuo-7 variety followed (13.67 and 13 respectively) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety. Higher date of number of leaf under November 25 planting.

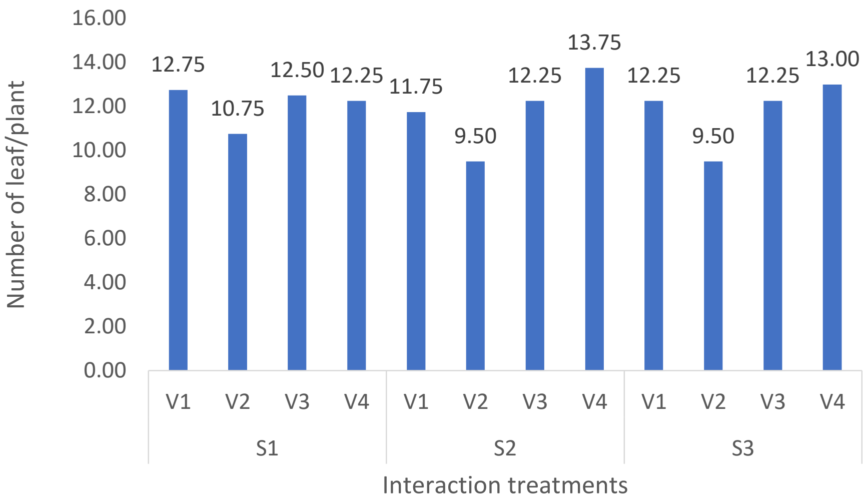


Fig.55: The leaf number of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =1.63).

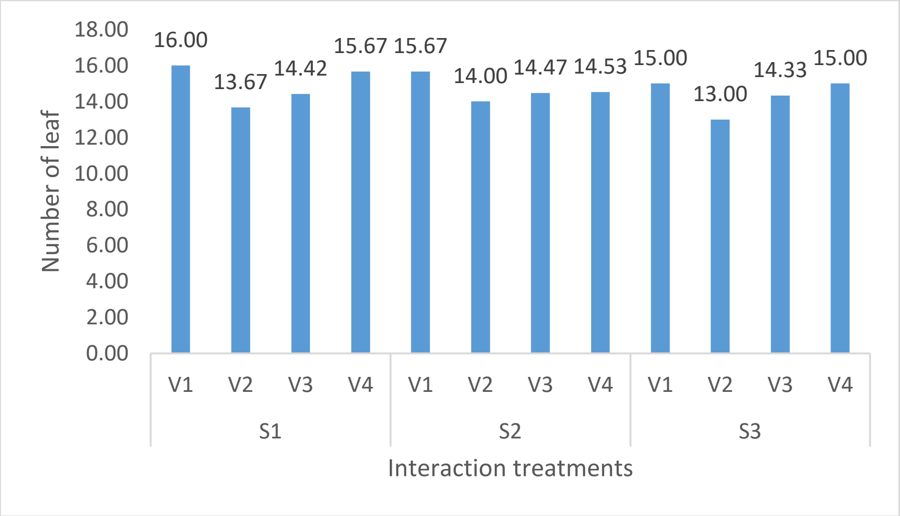


Fig.56: Number of leaves per plant of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =2.30)

### 4.1.12 Leaf area per plant

Leaf area per plant varied depending upon the growth stages, the smallest (0.017-0.034 $m^2$ at 30 DAS while the greatest (0.6763-0.7600 $m^2$ at maturity. That is with the advancement of plant age the leaf area of the individual plant progressively increased.

At the earlier stages the leaf area of the treatments were inconsistent while at the later stages the effect of the treatments were found to be conspicuous.

### Effect of planting dates

At the maturity the leaf area in most of the cases was found to be almost inconsistent in both the years. The highest leaf area was obtained from $S_3$ (0.749 and 0.721 $m^2$) while $S_1$ had the lowest values (0.730 and 0.720 $m^2$).

### Effect of genotypes

At the maturity the leaf area in most of the cases was found to be greater with the $V_4$ (Changnuo-6) having 0.769$m^2$ in 2016-17 while with $V_3$ (Yangnuo-30) having 0.753$m^2$. The lowest value was with $V_2$ (Yangnuo-7) in both the season (0.690 and 0.68$m^2$).

### Interaction effect of planting dates and genotypes

At the maturity the leaf area in most of the cases was found to be greater with the interaction effect of $V_1S_3$ (0.780) while with V3S3 in the second year (0.76 $m^2$). The lowest was with $V_2S_1$ (0.68 $m^2$) in 2016-17 while with $V_2S_3$ (0.67 $m^2$) in the year 2017-18.

## Table-2 Leaf area per plant of white maize grown in Rabi season 2016-2017 and 2017-18

| | Leaf areaplant$^{-1}$ (m$^{2}$) at different days after planting | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | | 45 | | 60 | | 75 | | 90 | | harvesting | |
| Treatments | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 |
| $S_1$ | 0.022 | 0.0216 | 0.052 | 0.0406 | 0.212 | 0.2103 | 0.436 | 0.4311 | 0.805 | 0.8061 | 0.728 | 0.7172 |
| $S_2$ | 0.023 | 0.0233 | 0.054 | 0.0372 | 0.218 | 0.2259 | 0.430 | 0.4095 | 0.794 | 0.8035 | 0.734 | 0.7198 |
| $S_3$ | 0.024 | 0.0243 | 0.057 | 0.0361 | 0.227 | 0.2210 | 0.466 | 0.4861 | 0.811 | 0.8229 | 0.749 | 0.7214 |
| LSD (0.05) | 0.03 | 1.39 | 0.05 | 0.03 | 0.36 | 0.26 | 0.25 | 0.08 | 0.18 | 0.08 | 0.14 | 0.07 |
| $V_1$ | 0.017 | 0.0194 | 0.050 | 0.0324 | 0.178 | 0.1789 | 0.447 | 0.3469 | 0.821 | 0.8391 | 0.732 | 0.7113 |
| $V_2$ | 0.023 | 0.0235 | 0.055 | 0.0422 | 0.250 | 0.2607 | 0.432 | 0.4989 | 0.735 | 0.7580 | 0.691 | 0.6843 |
| $V_3$ | 0.025 | 0.0246 | 0.056 | 0.0399 | 0.233 | 0.2277 | 0.434 | 0.4915 | 0.815 | 0.8690 | 0.756 | 0.7536 |
| $V_4$ | 0.028 | 0.0248 | 0.057 | 0.0373 | 0.216 | 0.2091 | 0.462 | 0.4315 | 0.840 | 0.7770 | 0.769 | 0.7286 |
| LSD (0.05) | 0.04 | 1.60 | 0.05 | 0.03 | 0.42 | 0.30 | 0.29 | 0.10 | 0.18 | 0.08 | 0.17 | 0.09 |
| $v_1s_1$ | 0.015 | 0.0161 | 0.045 | 0.0298 | 0.150 | 0.1502 | 0.441 | 0.3147 | 0.829 | 0.8576 | 0.707 | 0.7068 |
| V1S1 | 0.021 | 0.0206 | 0.054 | 0.0375 | 0.188 | 0.1911 | 0.462 | 0.3481 | 0.824 | 0.7956 | 0.708 | 0.7083 |
| $v_1s_3$ | 0.014 | 0.0216 | 0.052 | 0.0299 | 0.195 | 0.1953 | 0.437 | 0.3780 | 0.811 | 0.8642 | 0.780 | 0.7187 |
| $v_2s_1$ | 0.025 | 0.0263 | 0.052 | 0.0507 | 0.262 | 0.2787 | 0.429 | 0.5290 | 0.719 | 0.7334 | 0.684 | 0.6841 |
| $v_2s_2$ | 0.017 | 0.0181 | 0.042 | 0.0374 | 0.189 | 0.2048 | 0.398 | 0.4064 | 0.700 | 0.7660 | 0.693 | 0.6926 |
| $v_2s_3$ | 0.027 | 0.0262 | 0.072 | 0.0387 | 0.299 | 0.2986 | 0.469 | 0.5614 | 0.785 | 0.7747 | 0.697 | 0.6763 |
| $v_3s_1$ | 0.022 | 0.0219 | 0.045 | 0.0459 | 0.246 | 0.2041 | 0.450 | 0.5292 | 0.831 | 0.8725 | 0.748 | 0.7481 |
| $v_3s_2$ | 0.033 | 0.0341 | 0.066 | 0.0420 | 0.309 | 0.3136 | 0.433 | 0.4778 | 0.826 | 0.8670 | 0.759 | 0.7528 |
| $v_3s_3$ | 0.019 | 0.0177 | 0.055 | 0.0318 | 0.144 | 0.1654 | 0.420 | 0.4676 | 0.789 | 0.8677 | 0.760 | 0.7600 |
| $v_4s_1$ | 0.028 | 0.0222 | 0.065 | 0.0360 | 0.189 | 0.2083 | 0.423 | 0.3515 | 0.839 | 0.7607 | 0.775 | 0.7297 |
| $v_4s_2$ | 0.021 | 0.0206 | 0.056 | 0.0319 | 0.188 | 0.1940 | 0.427 | 0.4057 | 0.824 | 0.7853 | 0.776 | 0.7253 |
| $v_4s_3$ | 0.034 | 0.0317 | 0.050 | 0.0441 | 0.271 | 0.2249 | 0.537 | 0.5373 | 0.858 | 0.7851 | 0.757 | 0.7307 |
| LSD (0.05) | 0.07 | 0.078 | 0.10 | 0.06 | 0.72 | 0.52 | 0.51 | 0.17 | 0.32 | 0.15 | 0.29 | 0.15 |
| CV % | 26.87 | 18.4 | 16.10 | 15.29 | 30.07 | 19.82 | 10.17 | 3.47 | 3.58 | 1.68 | 3.52 | 1.93 |

### 4.1.13 Leaf Area Index (LAI)

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on leaf area index. The results are presented in Fig 34 to 37 showing the effect the individual variety on LAI at 30, 45, 60, 75, 90 and harvesting stage under different planting date treatments.

#### Effect of planting date

In 2016-17 Rabi season, LAI have been presented in (Fig. 34-37). Planting date significantly affected LAI of white maize. Crop sown on December 25 recorded the highest LAI which was statistically at per with November 25 planting. Different planting dates showed statistically significant differences on LAI (Fig. 34-37). The highest number (5.72) was recorded from S3 that means December 25 planting which was statistically similar (5.60) to $S_1$ and closely followed (5.54) by $S_1$. The lowest LAI (0.10) was observed from $S_1$ that mean November 25.

#### Effect of variety

In 2016-17 Rabi season, statistically significant variation was observed for different white maize genotypes in terms of Leaf area index (Fig 34-37). The LAI was found from $V_4$ (5.72) Changnuo-6 which was statistically similar to $V_4$ (5.60) Changnuo-6 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest number was found from $V_1$ (0.10) PSC-121 due to susceptible characters.

#### Interaction effect of planting dates and variety

In 2016-17 Rabi season, interaction effect of white maize genotypes and planting dates sowed significant differences on date of LAI (Fig. 58 – 65). The highest LAI (5.72) was observed from $V_4S_3$ that mean December 25 planting with Changnuo-6 variety followed (5.60) by $V_4S_1$ from Changnuo-6 with November 25 planting and statistically similar results (5.54) was also found from $V_3S_1$ that mean November 25 planting with Yungnuo-30 variety. While the lowest LAI (0.10) was obtained from the treatment combination $V_1S_1$ that mean November 25 planting with Yungnuo-7 variety followed (0.11) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety. Higher LAI under December 25 planting was attributed to LAI characters.

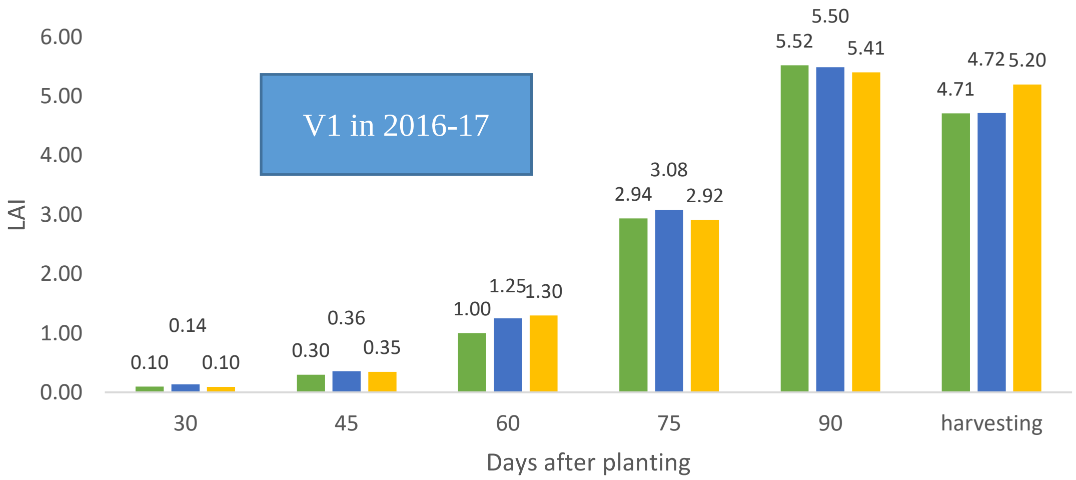


Fig.57: Bar diagram showing the average leaf area index of white maize variety (PSC-121) at different growth stages grown in Rabi 2016-2017 season across varying planting dates (bars) in sequence from left to right 25th November 2016, 10th December 2016 and 25th December 2016-17 respectively; LSD5% =0.04, 0.05, 0.42, 0.29, 0.18, 0.17)

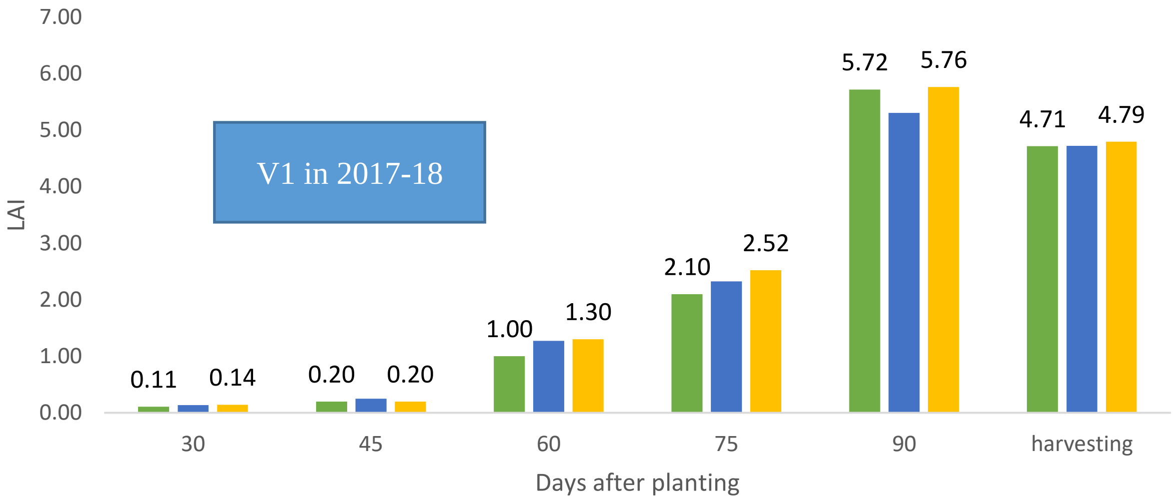


Fig.58: Number of leaves per plant of white maize variety PSC-121 grown in Rabi 2017-18 season as influenced by varying planting dates (bars) in sequence from left to right 25th November 2017, 10th December 2017 and 25th December 2017 respectively; LSD5% =1.6, 0.03, 0.30, 0.10, 0.08, 0.09)

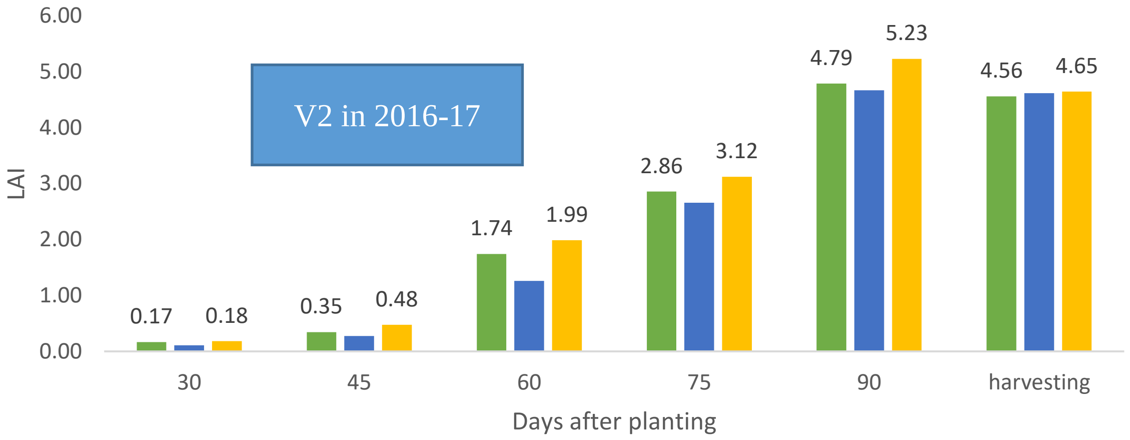


Fig.59: Bar diagram showing the average leaf area index of white maize variety (Yangnuo-7) at different growth stages grown in Rabi 2016-2017 season across varying planting dates (bars) in sequence from left to right 25th November 2016, 10th December 2016 and 25th December 2016 respectively; LSD5% = 0.51)

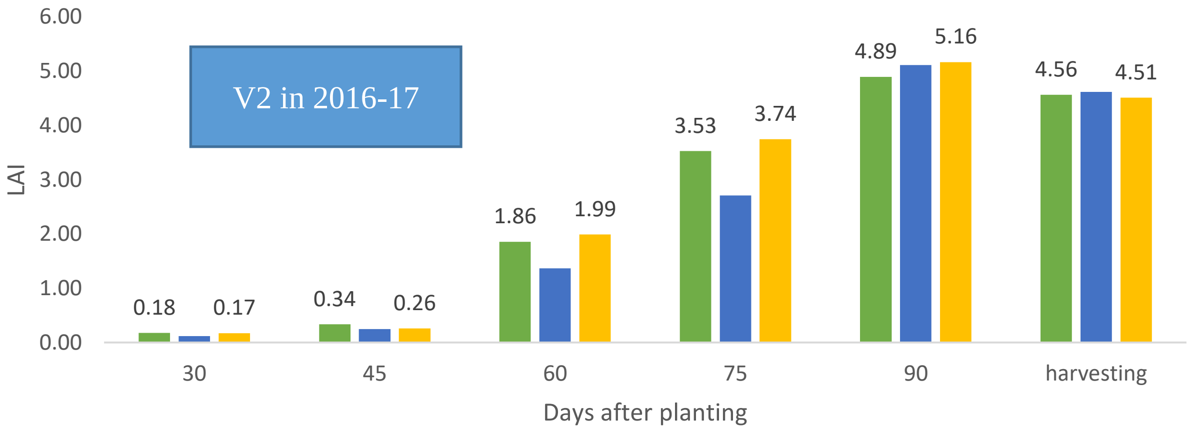


Fig.60: Number of leaves per plant of white maize variety Yangnuo-7 grown in Rabi 2017-18 season as influenced by varying planting dates (bars) in sequence from left to right 25th November 2017, 10th December 2017 and 25th December 2017 respectively; LSD5% =0.52

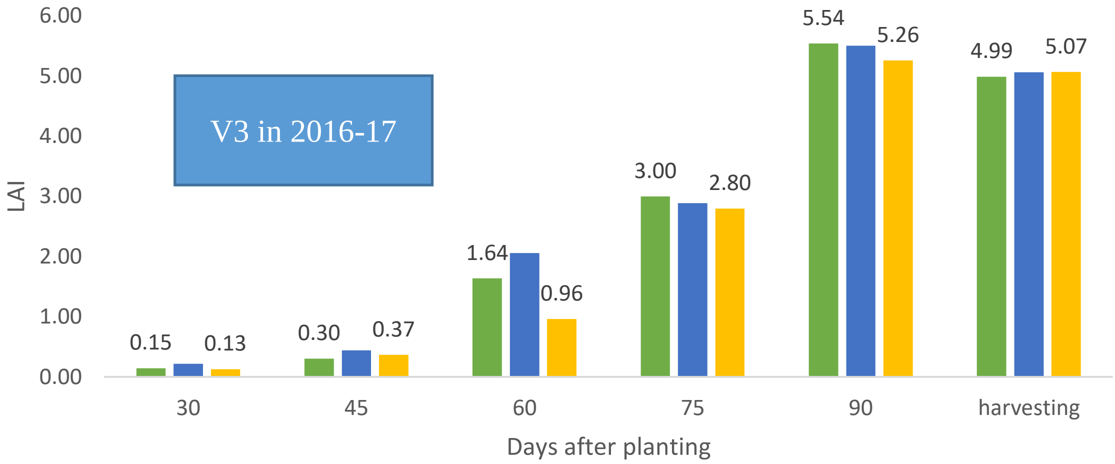


Fig.61: Bar diagram showing the average leaf area index of white maize variety (Changnuo-1) at different growth stages grown in Rabi 2016-2017 season across varying planting dates (bars) in sequence from left to right 25th November 2016, 10th December 2016 and 25th December 2016 respectively; LSD5% = 0.32)

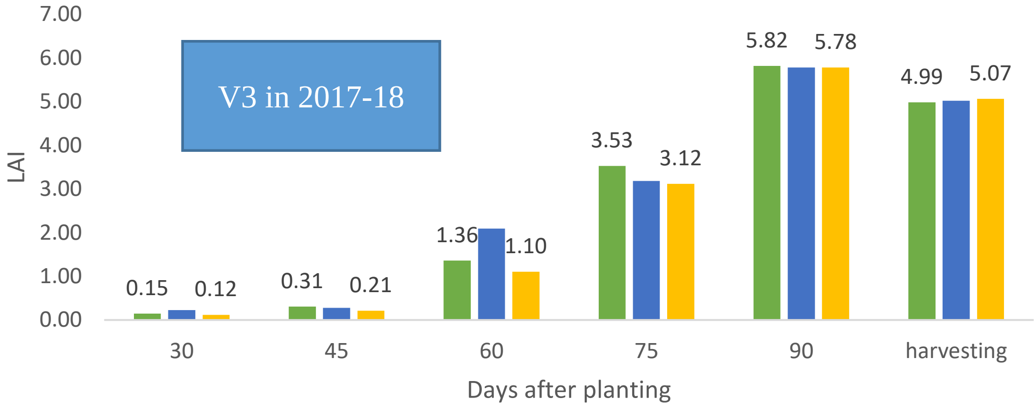


Fig.62: Number of leaves per plant of white maize variety Changnuo-1 grown in Rabi 2017-18 season as influenced by varying planting dates (bars) in sequence from left to right 25th November 2017, 10th December 2017 and 25th December 2017 respectively; LSD5% =0.17

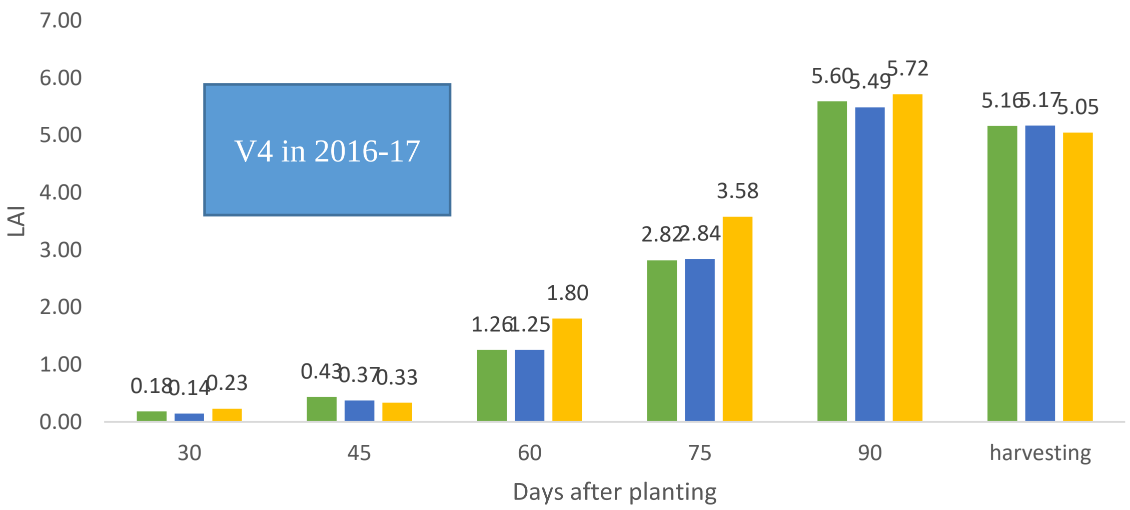


Fig.63: Bar diagram showing the average leaf area index of white maize variety (Changnuo-6) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (bars) in sequence from left to right 25th November 2016, 10th December 2016 and 25th December 2016 respectively; LSD5% = 0.32)

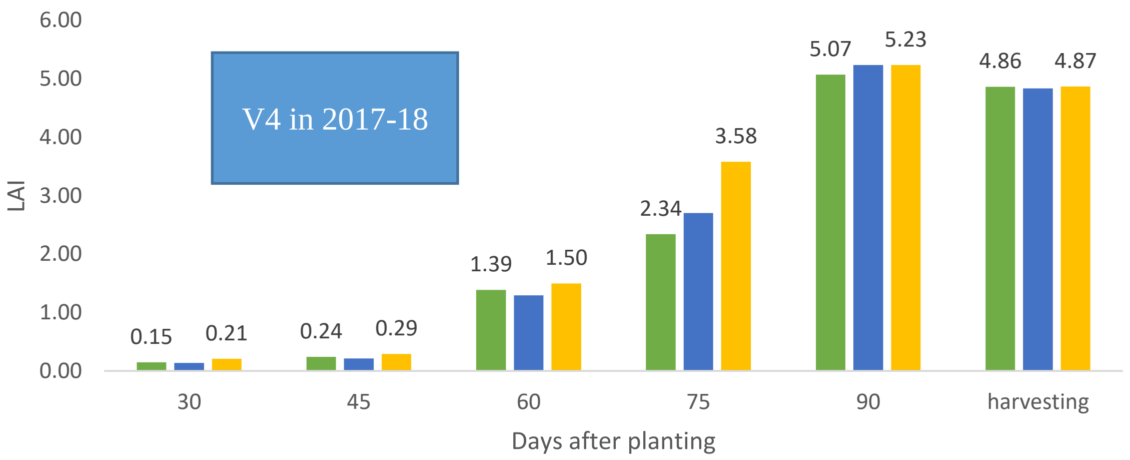


Fig.64: Number of leaves per plant of white maize variety Changnuo-6 grown in Rabi 2017-18 season as influenced by varying planting dates (bars) in sequence from left to right 25th November 2017, 10th December 2017 and 25th December 2017 respectively; LSD5% =0.15

### 4.1.14 Stover dry weight per plant from 30 to 90 DAS

Dry weight per plant increased progressively with the advancement of growth stages from 30 days after planting up to maturity. At 30 DAS each plant accumulated dry weight at around 20-21.12 g in the first season and and around or over 20 g in the second season. The dry weight gradually increased and attained 77.47-84.97 g at 75 (almost flowering) and then finally reached at around 123.70 g in both the seasons at maturity.

### Effect of planting dates

It was apparent that the dry weight was somewhat inconsistent with planting dates. However, in 2017-18 it tended to decrease with the delay in planting (Table 2).

### Effect of genotypes

The variety had significant effect on the dry weight per plant of white maize. At the maturity, the variety Yangnuo-7 had the least dry weight (108-110 g) compared to others (Table 2). The highest dry weight was obtained with Yangnuo-30 (over 123 g in both the years).

### Interaction effect

The interaction effect of the planting dates and variety was significant on the dry weight per plant. It ranged from 20.12-20.99 g at the 30 DAS while increasing progressively throughout the phenological stages showed dry matter ranged from 106.21-123.70 g at 90 DAS (Table 2).  Yangnuo-7 at all the growth stages had lower dry weight per plant (106.21-111.21 g) which were significantly lower than other interaction treatments. Other three genotypes had had almost invariable data although the highest dry weight was observed with Changnuo-1 under first and second planting (123.70 g) at 90 DAS in $V_1S_1$ and $V_3S_2$ or $V_3S_3$.

Table-3 Dry weight per plant at different growth stages of white maize genotypes under varying planting dates during Rabi 2016-17 and 2017-18 up to 90 DAS

|  |  |  |  |  |  |  | Growth stages |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | 30 DAS |  | 45 DAS |  | 60 DAS |  | 75 DAS |  | 90 DAS |  |
|  | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 |
| $S_1$ | 20.74 | 20.74 | 30.93 | 30.93 | 53.73 | 53.42 | 83.09 | 79.34 | 119.33 | 120.26 |
| $S_2$ | 20.69 | 20.64 | 30.93 | 29.68 | 54.35 | 53.42 | 82.47 | 80.28 | 118.39 | 119.64 |
| $S_3$ | 20.66 | 20.54 | 30.30 | 29.68 | 55.29 | 53.42 | 82.47 | 79.66 | 119.33 | 118.08 |
| LSD (5%) | 1.23 | 1.33 | 1.22 | 1.35 | 1.31 | 1.35 | 1.44 | 1.23 | 1.44 | 1.67 |
| $V_1$ | 20.42 | 20.42 | 29.99 | 31.24 | 55.39 | 54.15 | 84.13 | 81.63 | 122.87 | 122.45 |
| $V_2$ | 20.70 | 20.70 | 29.57 | 29.16 | 51.23 | 50.40 | 77.89 | 76.64 | 108.71 | 110.37 |
| $V_3$ | 20.72 | 20.66 | 31.24 | 29.99 | 56.23 | 54.56 | 84.13 | 80.38 | 123.28 | 122.45 |
| $V_4$ | 20.95 | 20.78 | 32.07 | 29.99 | 54.98 | 54.56 | 84.55 | 80.38 | 121.20 | 122.03 |
| LSD (5%) | 1.99 | 1.99 | 1.99 | 1.99 | 1.29 | 2.30 | 1.55 | 2,22 | 1.56 | 2,12 |
| $v_1s_1$ | 20.12 | 20.12 | 31.24 | 31.24 | 54.98 | 54.98 | 83.72 | 81.22 | 122.45 | 123.70 |
| V1S1 | 20.62 | 20.62 | 29.99 | 29.99 | 56.23 | 53.73 | 84.97 | 82.47 | 123.70 | 121.20 |
| $v_1s_3$ | 20.52 | 20.52 | 28.74 | 32.49 | 54.98 | 53.73 | 83.72 | 81.22 | 122.45 | 122.45 |
| $v_2s_1$ | 20.97 | 20.97 | 28.74 | 29.99 | 49.98 | 49.98 | 78.72 | 76.22 | 111.21 | 111.21 |
| $v_2s_2$ | 20.15 | 20.15 | 29.99 | 28.74 | 51.23 | 51.23 | 77.47 | 77.47 | 106.21 | 111.21 |
| $v_2s_3$ | 20.97 | 20.97 | 29.99 | 28.74 | 52.48 | 49.98 | 77.47 | 76.22 | 108.71 | 108.71 |
| $v_3s_1$ | 20.87 | 20.87 | 31.24 | 31.24 | 56.23 | 54.98 | 84.97 | 79.97 | 123.70 | 122.45 |
| $v_3s_2$ | 21.12 | 20.93 | 31.24 | 29.99 | 54.98 | 53.73 | 83.72 | 81.22 | 122.45 | 123.70 |
| $v_3s_3$ | 20.18 | 20.18 | 31.24 | 28.74 | 57.48 | 54.98 | 83.72 | 79.97 | 123.70 | 121.20 |
| $v_4s_1$ | 20.99 | 20.99 | 32.49 | 31.24 | 53.73 | 53.73 | 84.97 | 79.97 | 119.95 | 123.70 |
| $v_4s_2$ | 20.87 | 20.87 | 32.49 | 29.99 | 54.98 | 54.98 | 83.72 | 79.97 | 121.20 | 122.45 |
| $v_4s_3$ | 20.99 | 20.49 | 31.24 | 28.74 | 56.23 | 54.98 | 84.97 | 81.22 | 122.45 | 119.95 |
| LSD (5%) | 1.12 | 1.34 | 1.03 | 1.23 | 1.34 | 1.21 | 1.24 | 1.34 | 1.21 | 1.01 |
| CV (%) | 0.67 | 0.74 | 0.68 | 0.76 | 0.50 | 0.92 | 0.75 | 0.88 | 0.56 | 0.98 |

### Relationship of leaf area with per plant stover dry weight at 90 DAS

It was observed that the leaf area had a tremendous effect on the per plant dry weight showing a strong relationship ($R^2$=0.6785). That is, the regression coefficient was positive in both the years. In the first season, the $R^2$ value was higher (0.6785) than that (0.4047) of the second season. That is, in the first season the relationship was stronger.

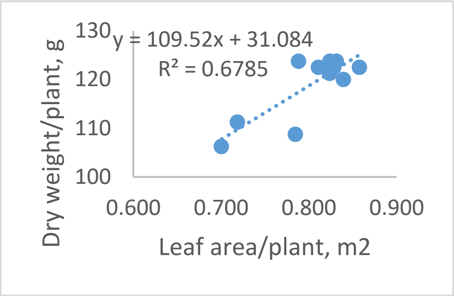


Fig. 65: Relationship of per plant stover dry weight with the leaf area of white maize

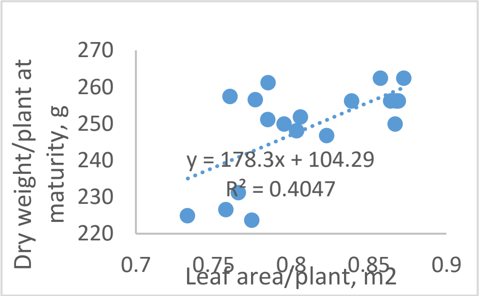


Fig. 66. Relationship of stover dry weight with leaf area

### 4.1.15 Crop Growth Rate (CGR)

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on crop growth rate. The results are presented below in Fig. 68 to 75 showing the effect of the individual variety at 30-45, 45-60, 60-75, 75-90 and harvesting under different planting time treatments in the first season.

### Effect of planting date

In the first season, the CGR have been presented in (Fig. 39-42). Planting date significantly affected CGR of white maize. Crop sown on November 25 recorded the highest CGR which was statistically at per with December 25 planting. Different planting dates showed statistically significant differences on CGR (Fig. 39-42). The highest CGR (23.32) was recorded from S1 that means November 25 planting which was statistically similar (23.12) to $S_3$ and closely followed (22.07) by $S_2$. The lowest CGR (3.45) was observed from $S_1$ that mean November 25.

### Effect of variety

In the first season, statistically significant variation was observed for different white maize genotypes in terms of CGR (Fig 39-42). The highest CGR was found from $V_1$ (23.32) PSC-121which was statistically similar to $V_1$ (23.12) Changnuo-6 due to its tolerance, temperature resistant and yield potentiality and whereas the lowest CGR was found from $V_2$ (3.45) Yungnuo-7 due to susceptible characters.

### Interaction effect of planting dates and variety

In the first season, interaction effect of white maize genotypes and planting dates sowed significant differences on date of CGR (Fig. 39-42). The highest CGR (23.32) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety followed (23.12) by $V_4S_3$ from Changnuo-6 with December 25 planting and statistically similar results (22.07) was aslo found from V1S1 that mean December 10 planting with PSC-121 variety. While the lowest CGR (3.45) was obtained from the treatment combination $V_2S_1$ that mean November 25 planting with PSC-121 variety followed (3.65) by $V_1S_3$ that mean December 25 planting with PSC-121 variety. Higher CGR under November 25 planting was attributed to CGR characters.

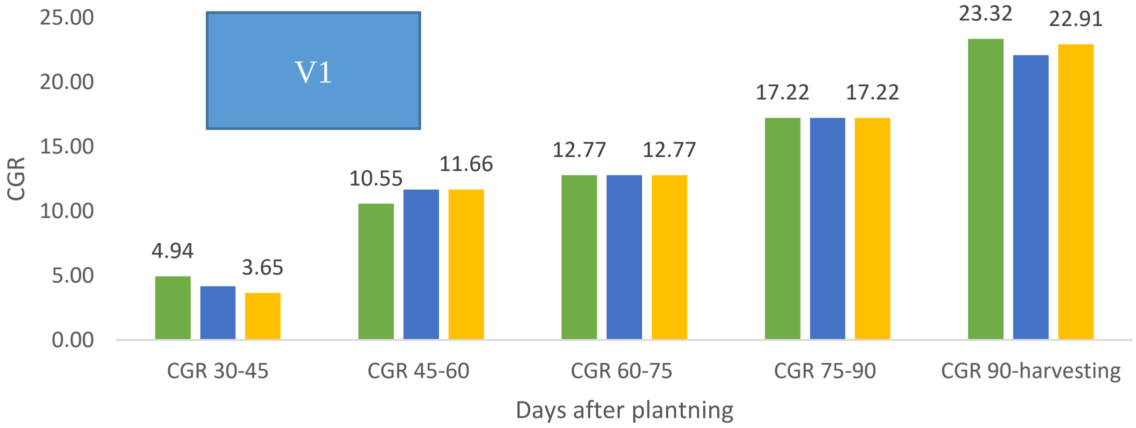


Fig.67: Bar diagram showing the average crop growth rate of white maize variety (PSC-121) at different growth stages grown in Rabi 2016-2017 season across varying sowing dates (sequentially from left to right): 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 0.65).

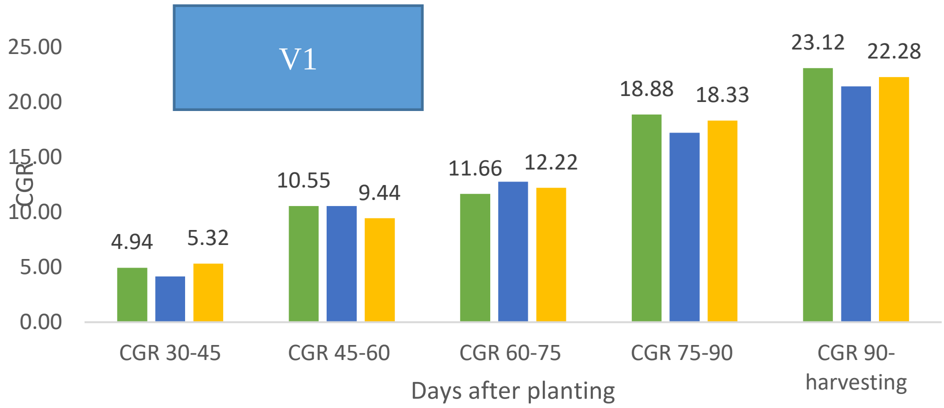


Fig.68: Crop growth rate of white maize variety PSC-121 grown in Rabi 2017-18 season as influenced by varying planting dates (sequentially from left to right): ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017

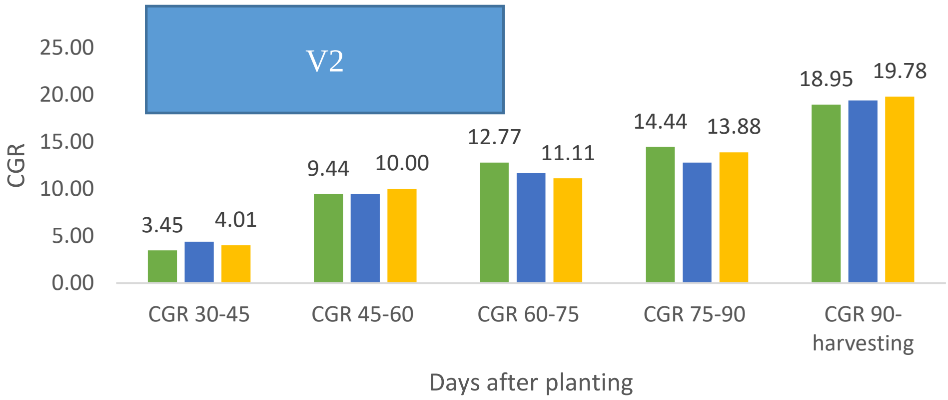


Fig.69: Bar diagram showing the average crop growth rate of white maize variety (Yangnuo-7) at different growth stages grown in Rabi 2016-2017 season across varying planting dates (sequentially from left to right): 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 1.3)

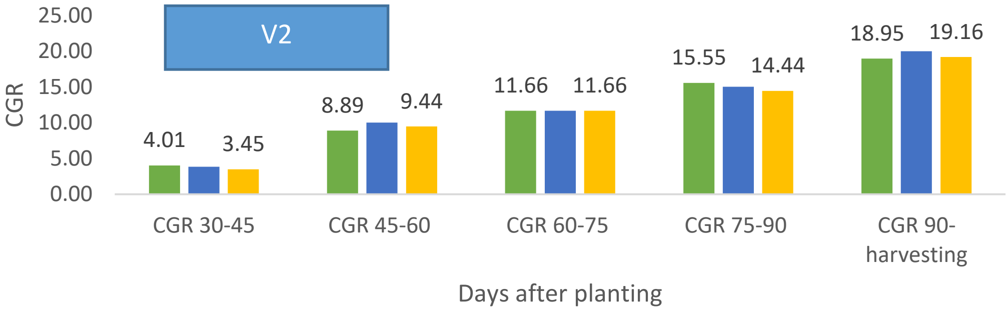


Fig.70: Crop growth rate of white maize variety Yangnuo-1 grown in Rabi 2017-18 season as influenced by varying planting dates (sequentially from left to right): ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017

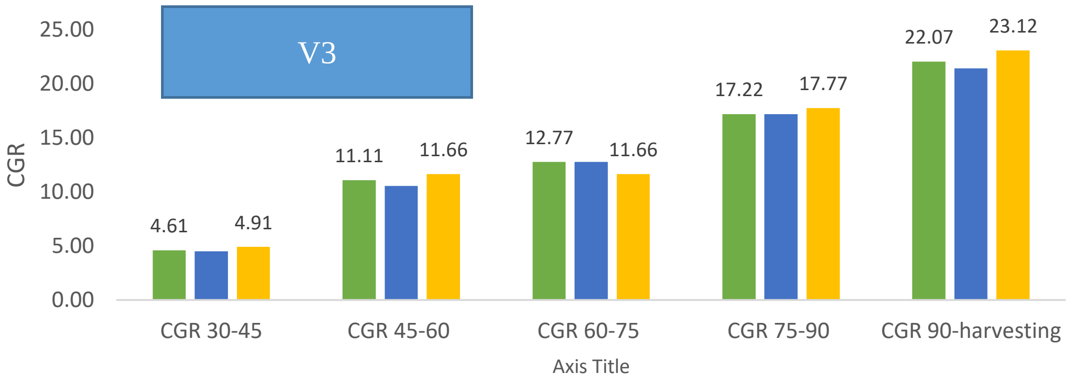


Fig.71: Bar diagram showing the average crop growth rate of white maize variety (Changnuo-1) at different growth stages grown in Rabi 2016-2017 season across varying planting dates (sequentially from left to right): 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 3.07)

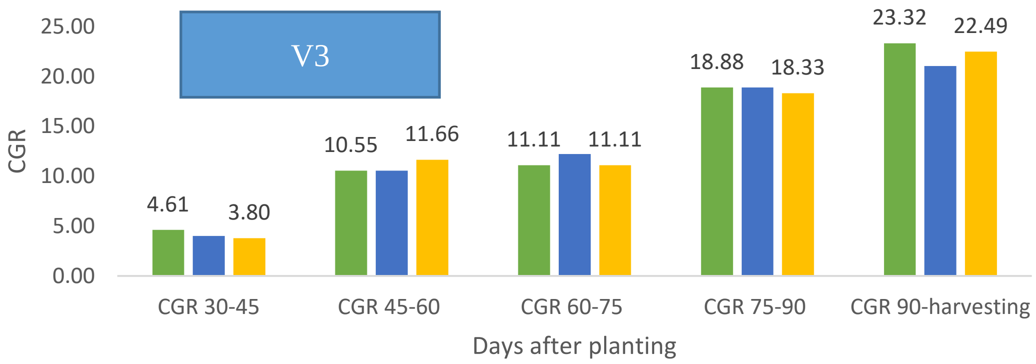


Fig.72: Crop growth rate of white maize variety Changnuo-1 grown in Rabi 2017-18 season as influenced by varying planting dates (sequentially from left to right): ($S^1$=25th November 2017, 10th December 2017 and 25th December 2017)

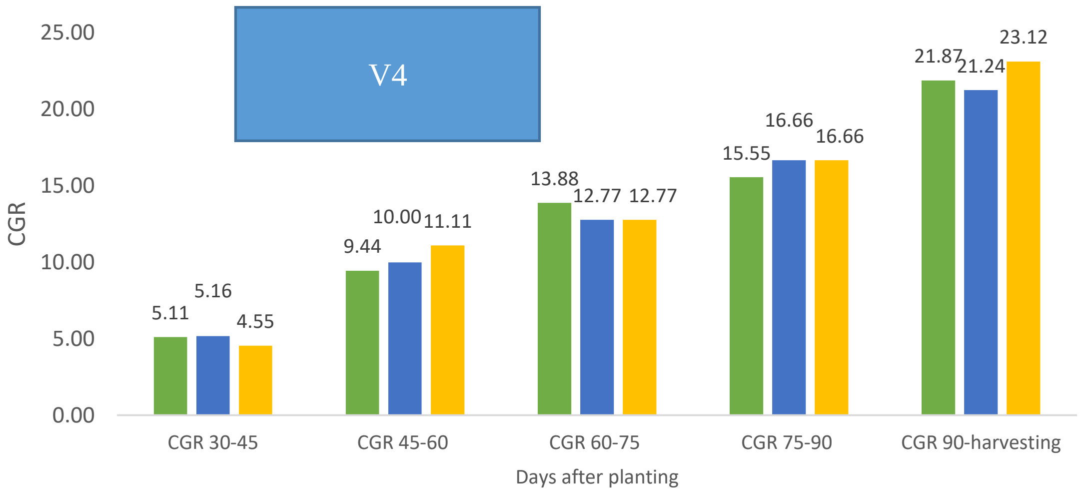


Fig.73: Bar diagram showing the average crop growth rate of white maize variety (Changnuo-6) at different growth stages grown in Rabi 2016-2017 season across varying planting dates (sequentially from left to right): 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 2.59)

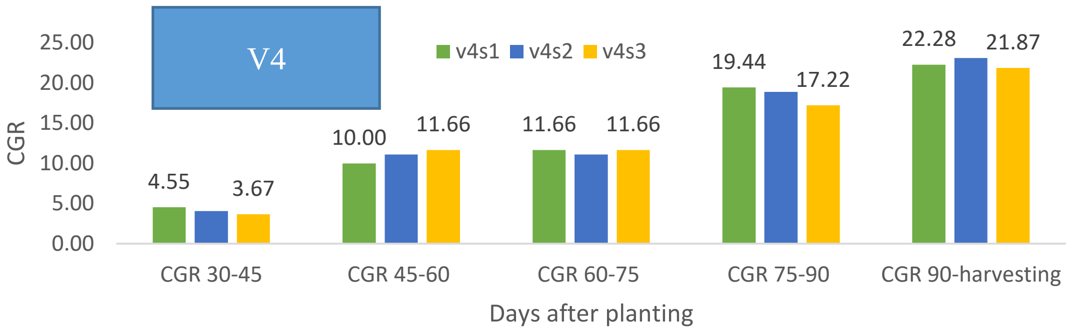


Fig.74: Crop growth rate of white maize variety Changnuo-6 grown in Rabi 2017-18 season as influenced by varying planting dates (sequentially from left to right): ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017)

### 4.1.16 Relative Growth Rate (RGR)

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on relative growth rate. The results are presented below in Fig. 76 to 83 showing the effect of the individual variety at 30-45, 45-60, 60-75, 75-90 and harvesting under different planting time treatments in the first season.

In the first season, the total crop dry matter is the spatial and temporal integration of all plant processes and therefore, crop dry matter is the most relevant parameter in the study of crop canopies. Rate of dry matter accumulation varies across the life cycle of a crop and dry matter and leaf area are sampled at intervals ranging from days to weeks to quantify effects of environmental influences or to analyze genotypic differences between crop cultivars. In growth analysis two basic measurements are made, dry weight and leaf area and a large number of parameters are derived from these measurements such as LAI, CGR, RGR and NAR. LAI reached its maximum value at harvesting stage days.

### Effect of planting date

In the first season, the RGR have been presented in (Fig. 43-46). Planting date significantly affected RGR of white maize. Crop sown on December 25 recorded the highest RGR which was statistically at per with November 25 planting. Different planting dates showed statistically significant differences on RGR. The highest RGR (0.21) was recorded from S3 that means December 25 planting which was statistically similar (0.20) to $S_1$ and closely followed (0.19) by $S_3$. The lowest RGR (0.1) was observed from $S_1$ that mean November 25.

## Effect of variety

In the first season, statistically significant variation was observed for different white maize genotypes in terms of RGR (Fig 43-46). The highest RGR was found from $V_3$ (0.21) Yungnuo-30 which was statistically similar to $V_1$ (0.20) PSC-121 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest CGR was found from $V_2$ (0.1) Yungnuo-7 due to susceptible characters.

## Interaction effect of planting dates and variety

In the first season, the interaction effect of white maize genotypes and planting dates sowed significant differences on date of RGR (Fig. 43-46). The highest RGR (0.21) was observed from $V_3S_3$ that mean December 25 planting with Yungnuo-30 variety followed (0.20) by $V_1S_1$ from PSC-121 with November 25 planting and statistically similar results (0.19) was also found from $V_1S_3$ that mean December 25 planting with PSC-121 variety. While the lowest RGR (0.1) was obtained from the treatment combination $V_2S_1$ that mean November 25 planting with Yungnuo-7 variety followed (0.1) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety. Higher RGR under December 25 planting was attributed to RGR characters.

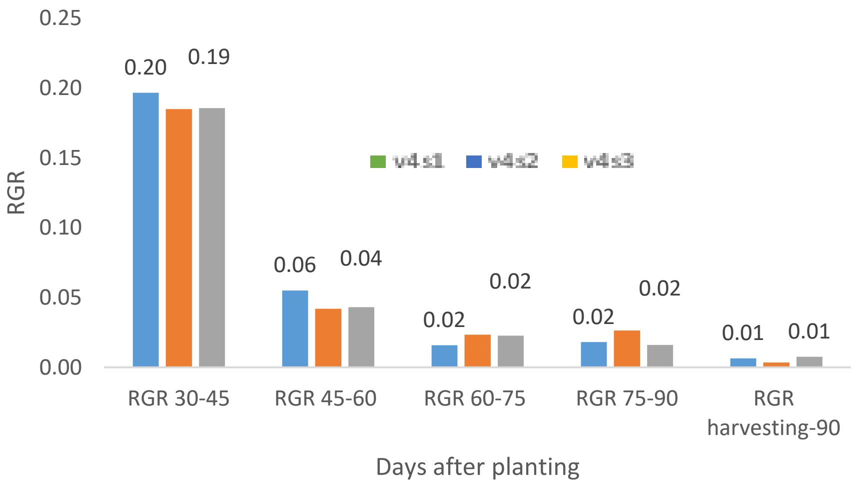


Fig 75: Bar diagram showing the average relative growth rate of white maize variety (PSC-121) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 0.02)

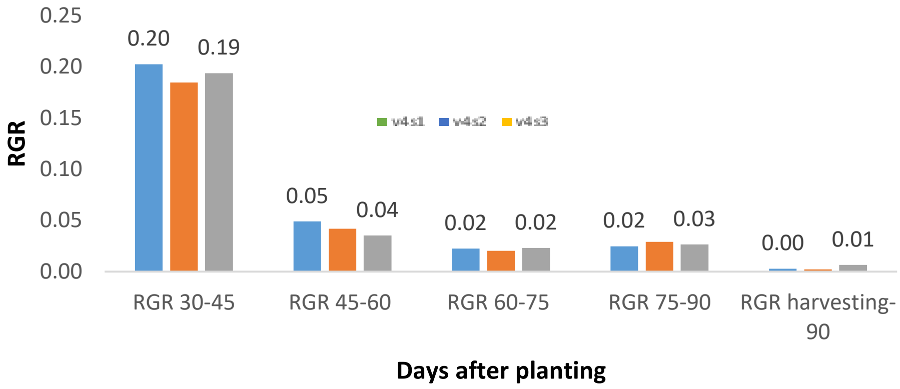


Fig 76: Relative growth rate of white maize variety PSC-121 grown in Rabi 2017-18 season as influenced by varying planting dates ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% =0.011)

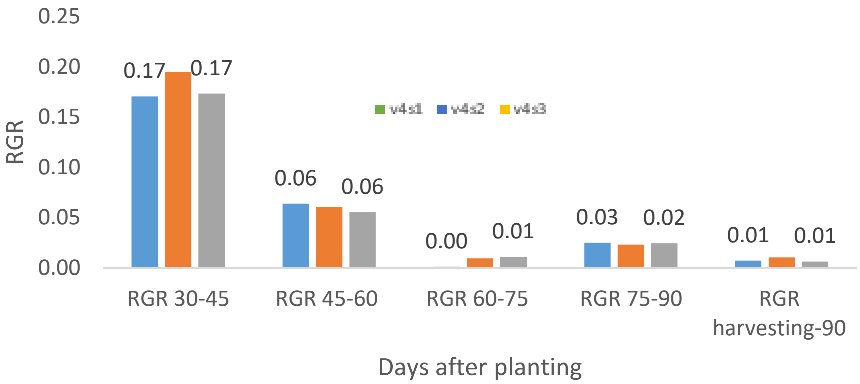


Fig 77: Bar diagram showing the average relative growth rate of white maize variety (Yangnuo-7) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 0.01)

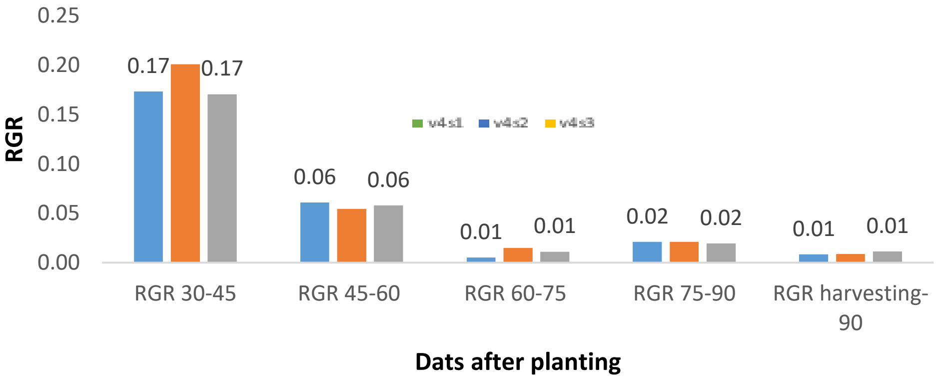


Fig 78: Relative growth rate of white maize variety Yangnuo-7 grown in Rabi 2017-18 season as influenced by varying planting dates ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% = 0.013)

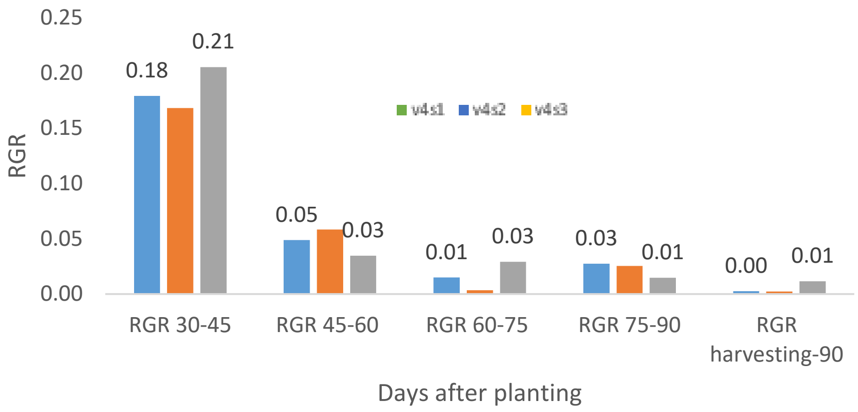


Fig 79: Bar diagram showing the average relative growth rate of white maize variety (Changnuo-1) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 0.01)

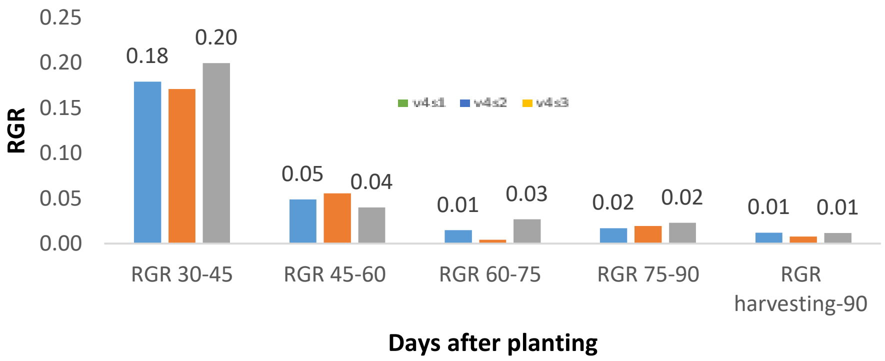


Fig 80: Relative growth rate of white maize variety Changnuo-1 grown in Rabi 2017-18 season as influenced by varying planting dates ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% = 8.6E-3)

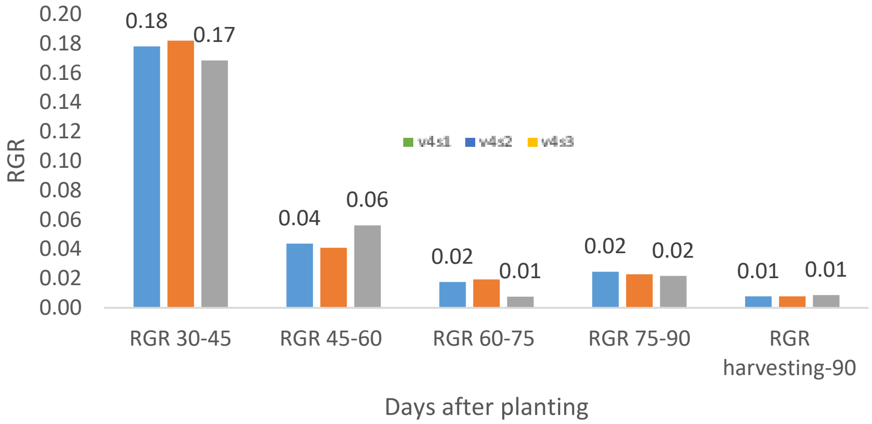


Fig 81: Bar diagram showing the average relative growth rate of white maize variety (Changnuo-6) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 0.01)

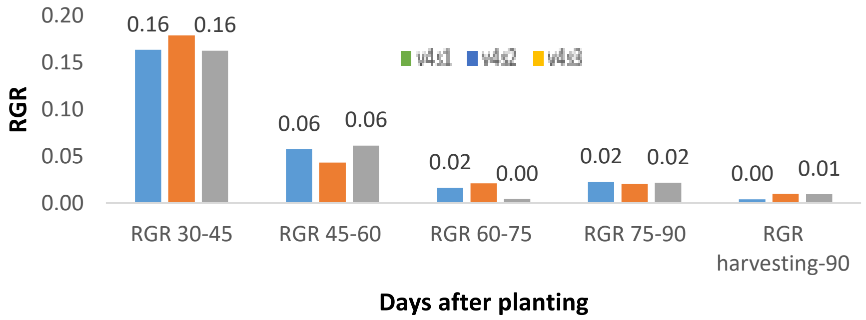


Fig 82: Relative growth rate of white maize variety Changnuo-6 grown in Rabi 2017-18 season as influenced by varying planting dates ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% =7.4E-3)

### 4.1.17 Net Assimilation Rate (NAR)

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on net assimilation rate. The results are presented below in Fig. 47 to 50 showing the effect of the individual variety at 30-45, 45-60, 60-75, 75-90 and harvesting under different planting time treatments in the Rabi 2016-17.

### Effect of planting date

In the Rabi 2016017 season, the NAR have been presented in (Fig. 47-50). Planting date significantly affected NAR of white maize. Crop sown on November 25 recorded the highest NAR which was statistically at per with December 25 planting. Different planting dates showed statistically significant differences on NAR. The highest NAR (0.006) was recorded from $S_1$ that means November 25 planting which was statistically similar (0.005) to $S_2$ and closely followed (0.005) by $S_3$. The lowest NAR (0.00) was observed from $S_1$ that mean November 25.

### Effect of variety

In the Rabi 2016017 season, the statistically significant variation was observed for different white maize genotypes in terms of NAR (Fig 47-50). The highest NAR was found from $V_1$ (0.006) PSC-121 which was statistically similar to $V_1$ (0.005) PSC-121 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest NAR was found from $V_2$ (0.000) Yungnuo-7 due to susceptible characters.

### Interaction effect of planting dates and variety

In the Rabi 2016017 season, the interaction effect of white maize genotypes and planting dates sowed significant differences on date of NAR (Fig. 47-50). The highest NAR (0.006) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety followed (0.005) by V1S1 from PSC-121 with December 10 planting and statistically similar results (0.005) was also found from $V_1S_3$ that mean December 25 planting with PSC-121 variety. While the lowest NAR (0.00) was obtained from the treatment combination $V_2S_1$ that mean November 25 planting with Yungnuo-7 variety followed (0.00) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety. Higher NAR under November 25 planting was attributed to NAR characters.

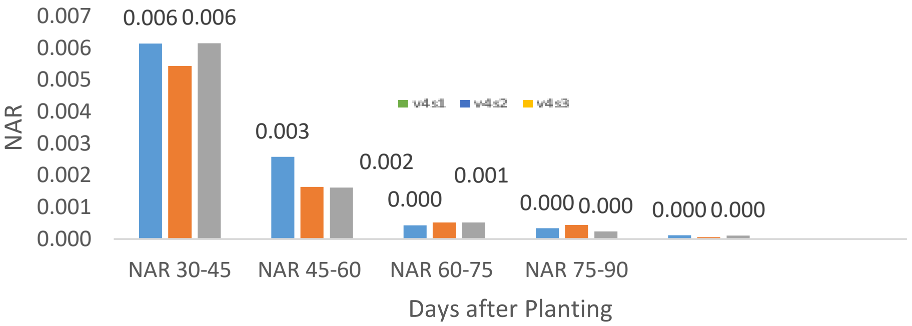


Fig. 83: Bar diagram showing the average net assimilation rate of white maize variety (PSC-121) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 1.33E-03)

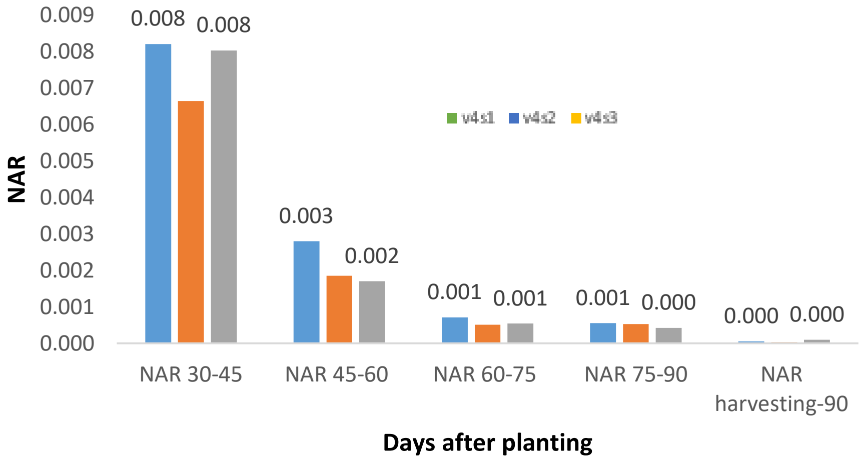


Fig. 84: Net assimilation rate of white maize variety PSC-121 grown in Rabi 2017-18 season as influenced by varying planting dates ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% = 1.68E-3)

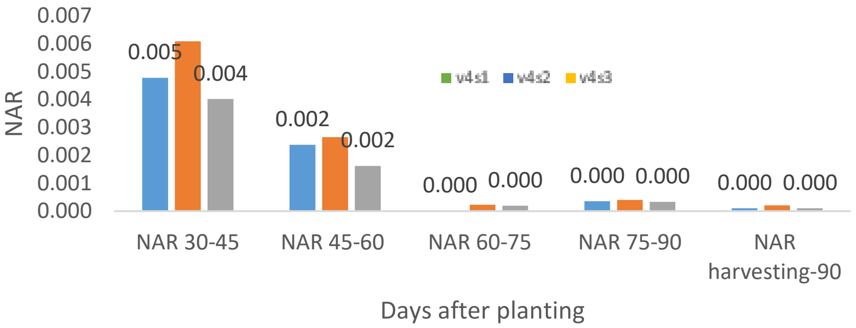


Fig.85: Bar diagram showing the average net assimilation rate of white maize variety (Yangnuo-7) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 5.33E-03)

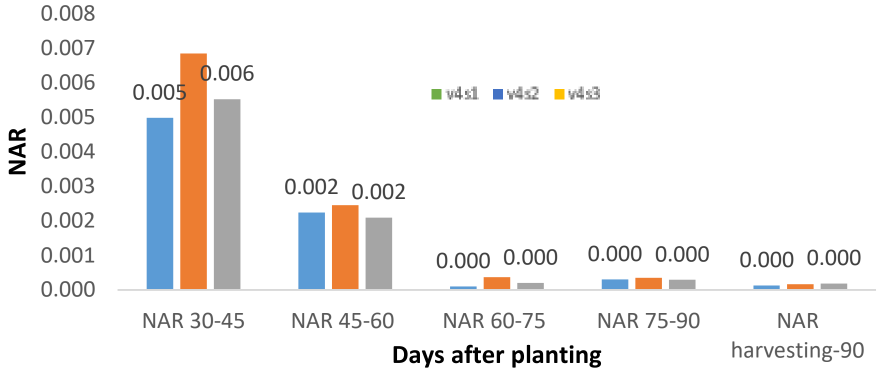


Fig.86: Net assimilation rate of white maize variety Yangnuo-7 grown in Rabi 2017-18 season as influenced by varying planting dates ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% = 6.68E-3)

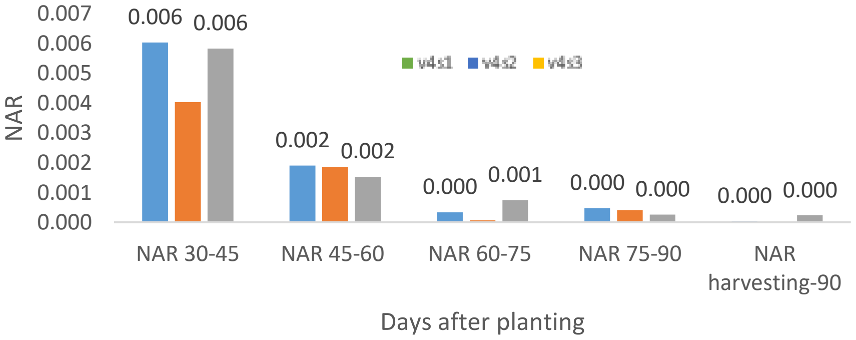


Fig.87: Bar diagram showing the average net assimilation rate of white maize variety (Changnuo-1) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 5.74E-03)

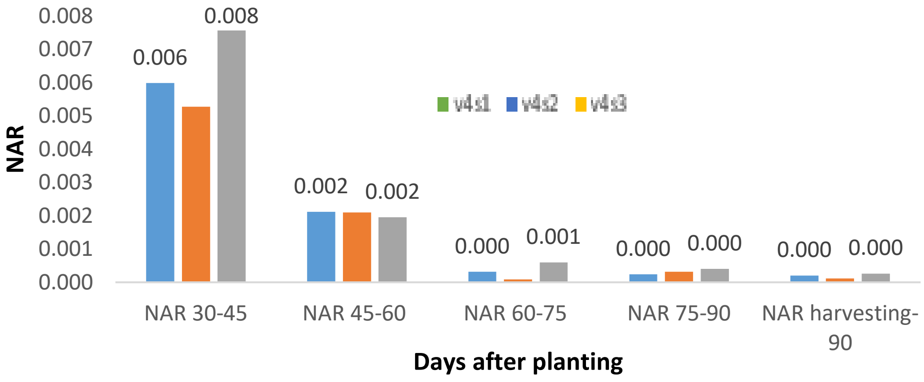


Fig.88: Net assimilation rate of white maize variety Changnuo-1 grown in Rabi 2017-18 season as influenced by varying planting dates ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% = 8.55E-3)

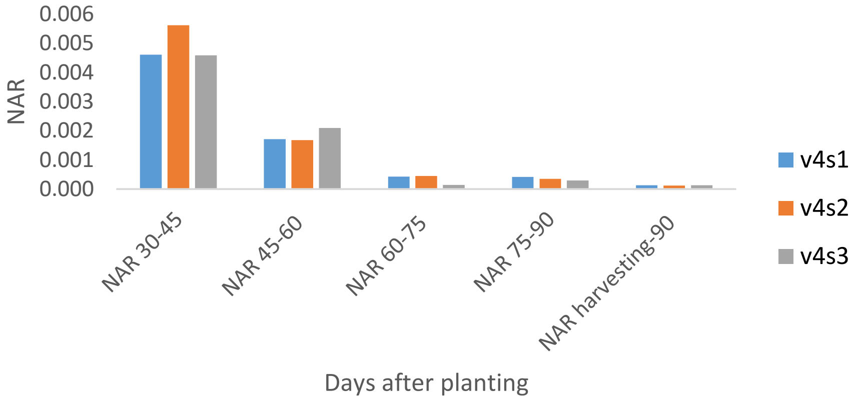


Fig.89: Bar diagram showing the average net assimilation rate of white maize variety (Changnuo-6) at different growth stages grown in Rabi 2016-2017 season across varying planting dates: (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% = 5.88E-04)

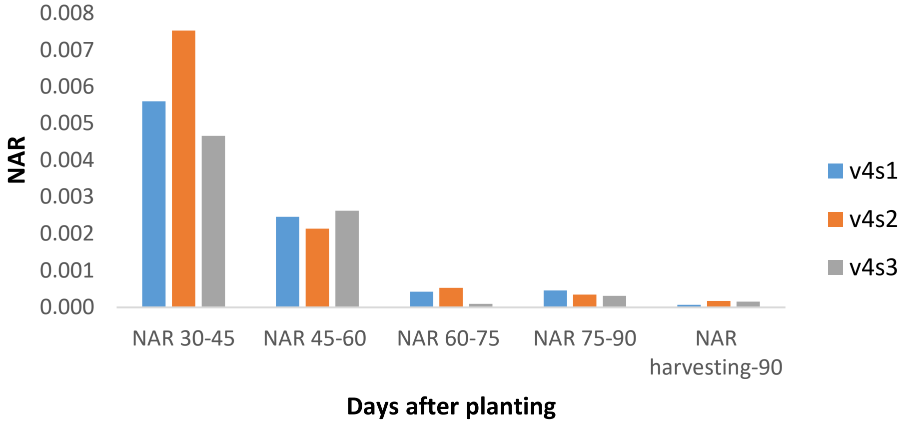


Fig.90: Net assimilation rate of white maize variety Changnuo-6 grown in Rabi 2017-18 season as influenced by varying planting dates ($S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% = 8.80E-3

### 4.1.18 Stover weight at maturity

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on stover weight. The results are presented below in Fig. 92-97 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

**Effect of planting date**

The stover weight at maturity have been presented in (Fig. 92 & 94). Planting date significantly affected stover weight of white maize. Crop sown on November 25 recorded the highest stover weight which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on stover weight (Fig. 51-53). The highest weight in both the season (112.97 and 114.63 g) was recorded from $S_3$ and S1 respectively. The lowest stover weight of 111.51 and 110.78 g were observed from $S_2$ and S3 respectively.

**Effect of variety**

During the first Rabi season, the statistically significant variation was observed for different white maize genotypes in terms of stover weight (Fig. 93 & 95). The highest stover weight was found from $V_4$ and $V_1$ in 2016-17 and 2017-18 having values respectively of 122.31 and 123.38 g). The lowest stover weight was found from $V_2$ (90.60 and 86.18 g) Yungnuo-7 in both the years.

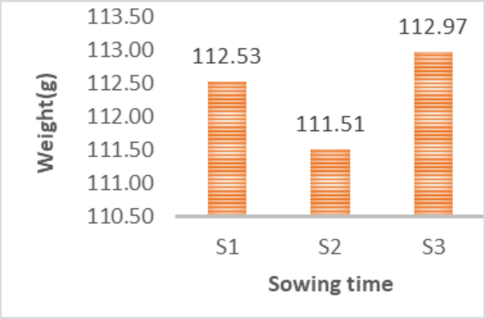


Fig.91: The average stover weight per plant of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.64)

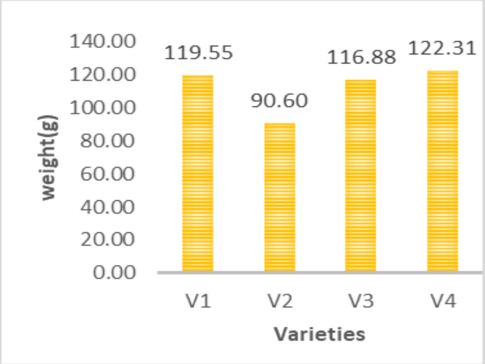


Fig.92: The average stover dry weight of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$= Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.74)

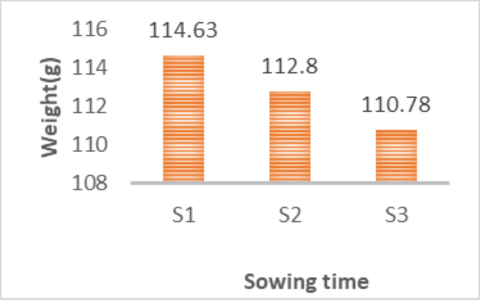


Fig.93: Stover dry weight of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% = 0.87)

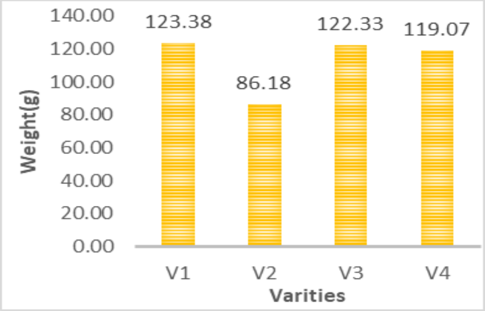


Fig.94: Stover dry weight of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 1.01)

**Interaction effect of planting dates and variety**

During first season, interaction effect of white maize genotypes and planting dates sowed significant differences on stover weight (Fig. 96). The highest weight in both the years were with $V_4S_3$ that mean December 25 planting with Changnuo-6 variety in the first season (122.93 g) while that was with $S_1V_1$ (125 g). While the lowest weight (89.75 g) was obtained from the treatment combination $V_2S_3$ that mean December 25 planting with Yungnuo-7 variety followed (90.58 g) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety in the first year while with $V_2S_3$ in the second year.

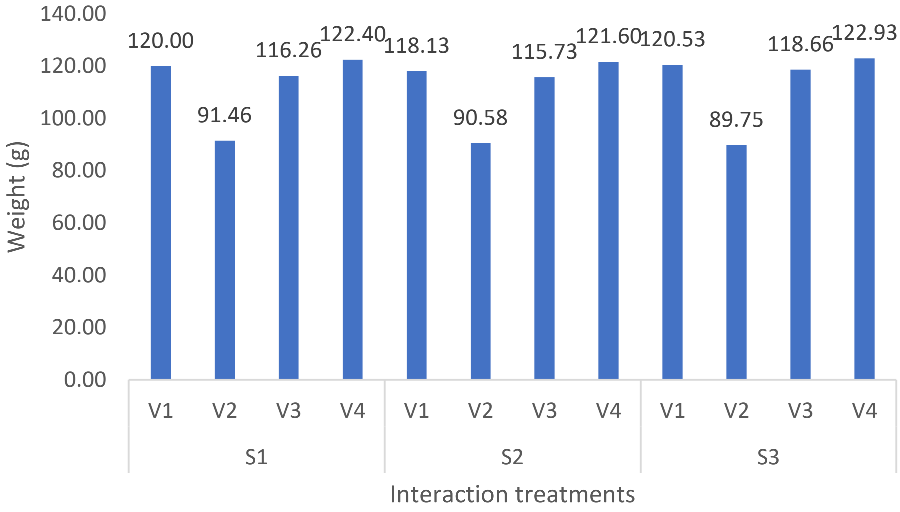


Fig.95: The average stover dry weight per plant of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =1.28)

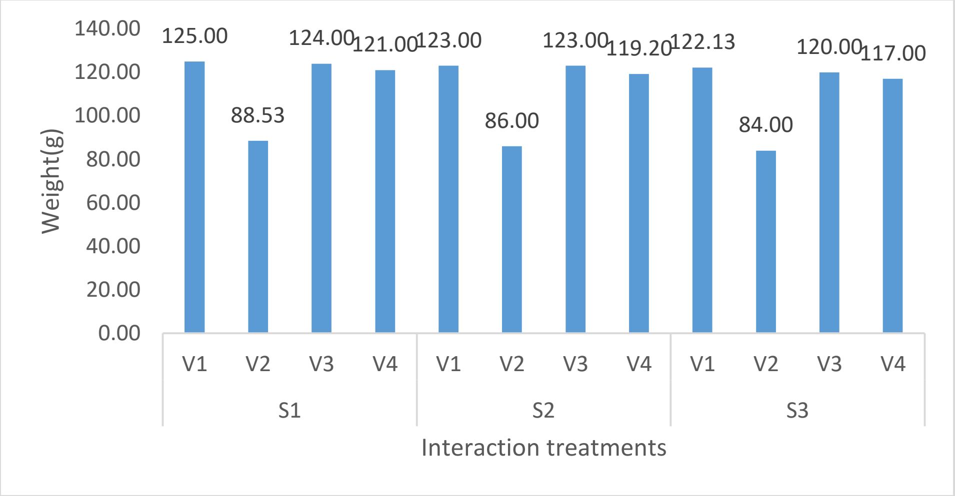


Fig.96: Stover dry weight of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% = 1.75)

### 4.1.19 Ear Weight

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on ear weight. The results are presented below in Fig. 98 to 101 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

**Effect of planting date**

Ear weight have been presented in (98 & 90). Planting date significantly affected ear weight of white maize. Crop sown on November 25 recorded the highest ear weight which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on ear weight (Fig. 54). The highest weight (144.44 and 142.76 g in $1^{st}$ and $2^{nd}$ year respectively) was recorded from $S_1$ that means November 25 planting which was not statistically similar (143.27 g) to $S_2$ in the first year. The lowest weight (142.2 117.47 g) was observed from $S_3$ that mean December 25 of the both year.

**Effect of variety**

Statistically significant variation was observed for different white maize genotypes in terms of ear weight (Fig 99 & 101). The highest ear weight was found from V1 (154.15 and 144.19 g respectively of the years) PSC-121 which was statistically similar to $V_3$ (151.40 139.75 g) Yungnuo-30 in both the years and whereas the lowest ear weight was found from $V_2$ (118.15 113.30 g) Yungnuo-7 in the both first and second seasons.

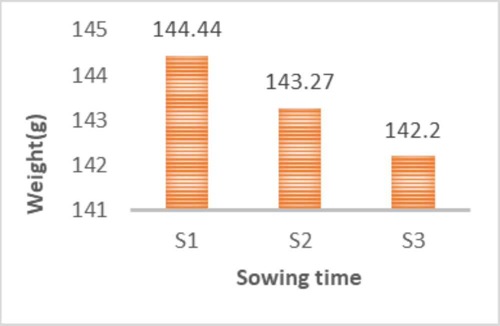


Fig.97: The average ear dry weight per plant of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =1.08)

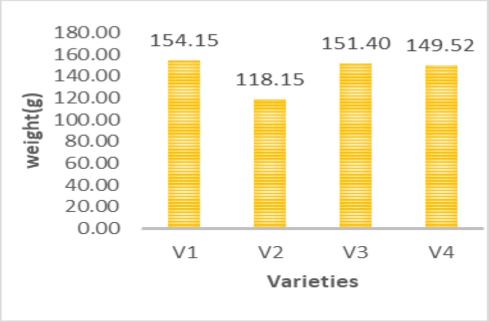


Fig.98: The average ear weight per plant of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =1.25)

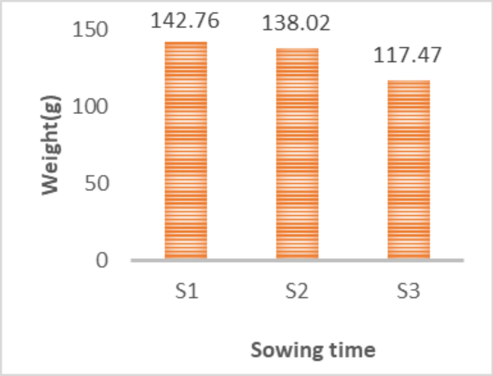


Fig.99: Ear weight of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% = 0.89)

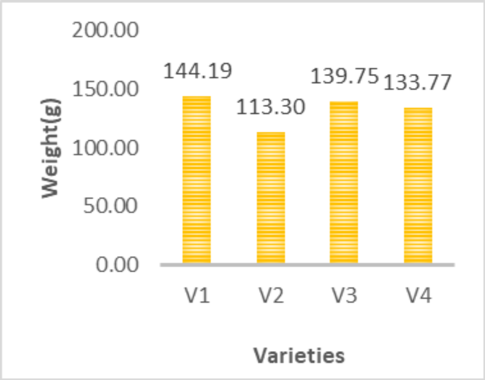


Fig.100: Ear weight of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 1.03)

**Interaction effect of planting dates and variety**

In the first season, interaction effect of white maize genotypes and planting dates sowed significant differences on ear weight (Fig. 101). The highest weight (156.07 g) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety in the first year which was then followed (153.33 g) by $V_1S_1$ from PSC-121 with December 10 planting and that was again statistically similar to the values of 153.04 g as found from $V_1S_3$ that mean December 25 planting with PSC-121 variety. While the lowest weight (117.11 g) was obtained from the treatment combination $V_2S_3$ that mean December 25 planting with Yungnuo-7 variety followed (118.34 g) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety. Higher ear weight under November 25 planting was attributed to ear weight characters.

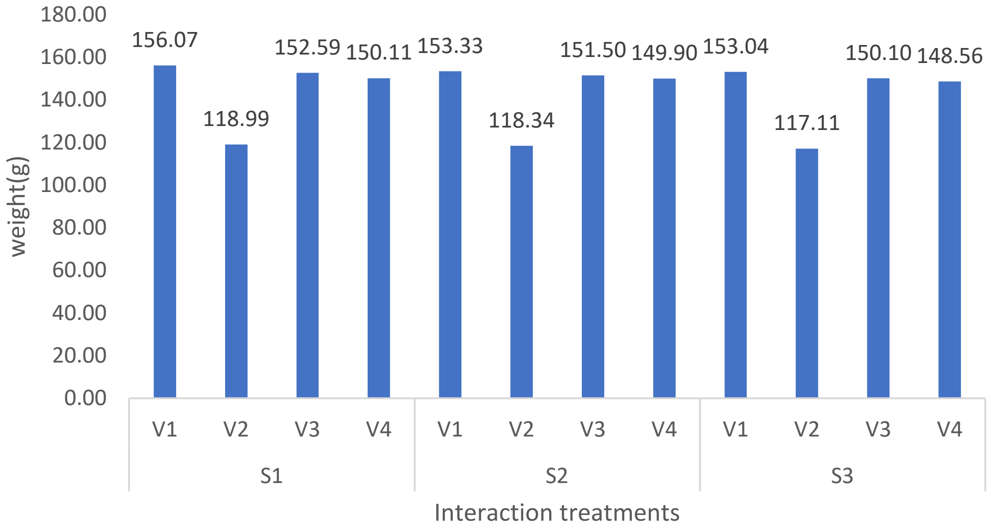


Fig.101: Bar diagram showing the average ear dry weight per plant of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =2.17)

### 4.1.20 Dry matter per plant

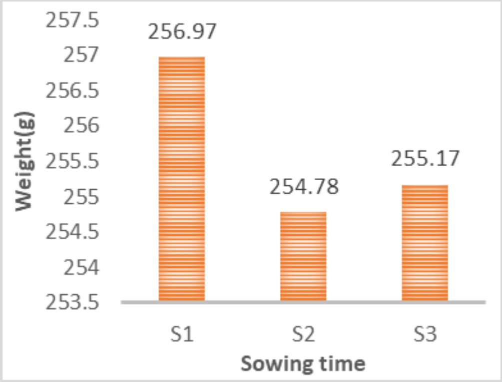
In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on DM weight. The results are presented below in Fig. 102 to 107 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

### Effect of planting date

Dry matter have been presented in (Fig. 102 & 104 ). Planting date significantly affected weight of white maize. Crop sown on November 25 recorded the highest weight which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on weight. The highest weight in 2016-17 and 2017-18 (256.97 and 269.10 g respectively) was recorded from $S_1$ that means November 25 planting which was statistically similar (255.17 g) to $S_3$ in the first year. The lowest weight (254.78 and 265.25 g) was observed respectively from $S_2$ and $S_3$.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of Dry matter (Fig. 103 & 105). The highest weight was found from $V_1$ in both the seasons (273.70 and 277.85 g respectively) which was PSC-121. This was statistically similar to $V_4$ (271,83 g) that means Changnuo-6 in the first season. The lowest weight was found in both the seasons from $V_2$ (208.74 240.65 g respectively) that is from Yungnuo-7.



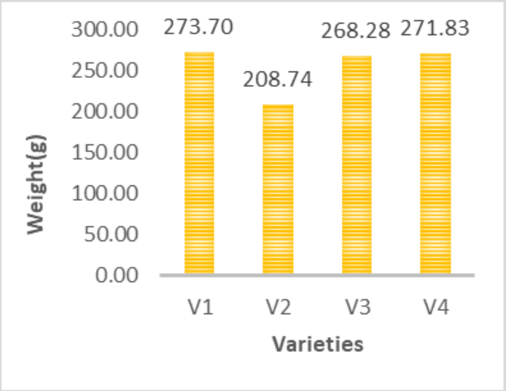
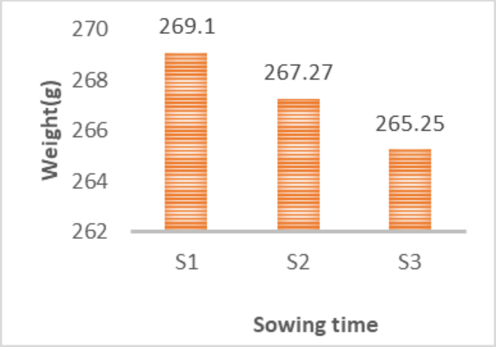


Fig.102: The average total dry matter per plant of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =14.32)

Fig.103: The average total dry matter per plant of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V^1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5%= 16.52)



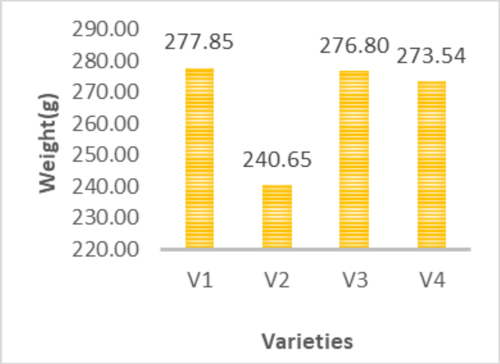


Fig.104: Per plant dry matter of white maize as influenced by varying planting dates ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) grown in Rabi 2017-2018 season (LSD5% = 0.84)

Fig.105: Dry matter per plant of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 0.97

## Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on dry matter weight (Fig. 106). The highest weight (276.02 g) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety in 2016-17. This was then followed (273.57 g) by $V_1S_3$ from PSC-121 with December 25 planting and statistically similar results (272.51 g) was also found from $V_4S_1$ that mean November 25 planting with Changnuo-6 variety. In the second season, the highest value was obtained with also $V_1S_1$. While the lowest weight in 2016-17 and 2017-18 (206.86 and 238.47 g respectively) was obtained from the treatment combination $V_2S_3$ that mean December 25 planting with Yungnuo-7.

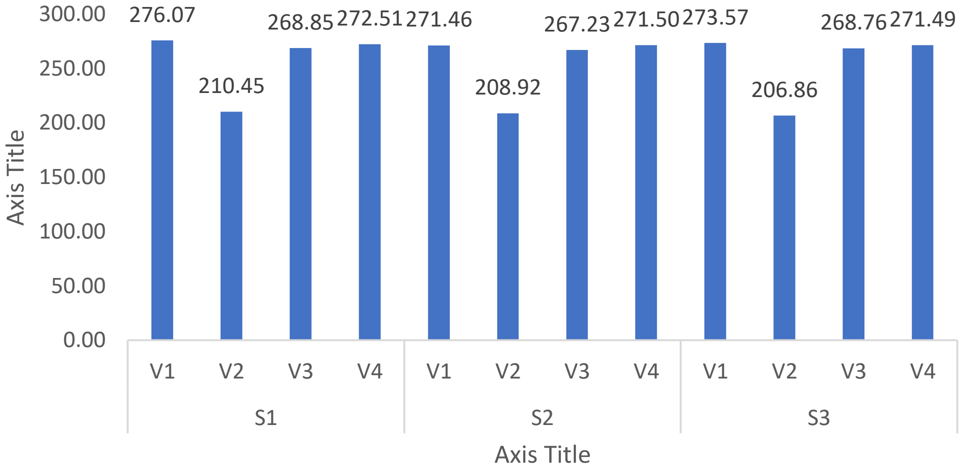


Fig.106: The average total dry weight per plant of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =28.65)

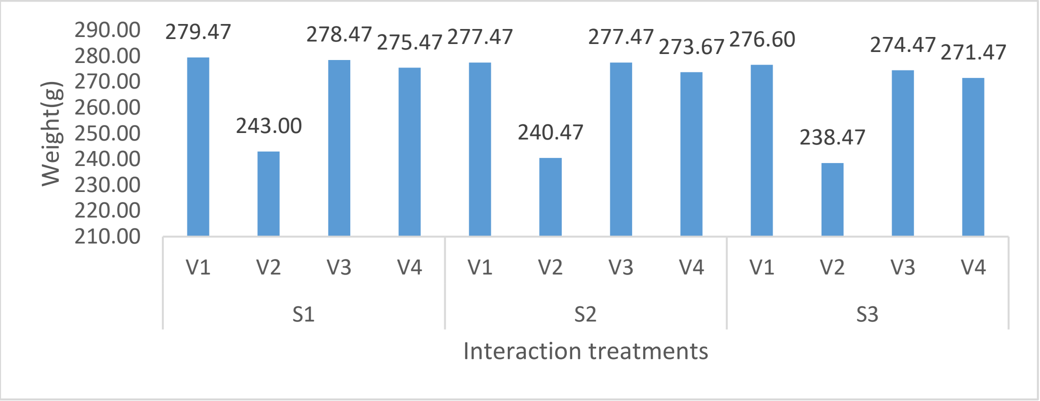


Fig.107: Per plant dry matter of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% = 1.69

### 4.1.21 Number of row

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on number of grain rows per cob. The results are presented below in Fig. 108 – 113 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

### Effect of planting date

In the first Rabi season of 2016-17, the number of row have been presented in (Fig. 108 & 110). Planting date significantly affected number of row of white maize. Crop sown on December 25 recorded the highest number of row which was statistically at per with November 25 planting. Different planting dates showed statistically significant differences on number of row (Fig 60). The highest number of row (12.92) was recorded from $S_3$ that means December 25 planting which was statistically similar (12.75) to $S_1$. The lowest number of row (12.75) was observed from $S_2$ that mean December 10.

### Effect of variety

In the first Rabi season of 2016-17, statistically significant variation was observed for different white maize genotypes in terms of Number of row (Fig. 109 & 111). The highest Number of row was found from $V_4$ (13.44) Changnuo-6 which was statistically similar to $V_1$ (13.33) whereas the lowest number of row was found from $V_2$ (11.22) Yungnuo-7 due to susceptible characters.

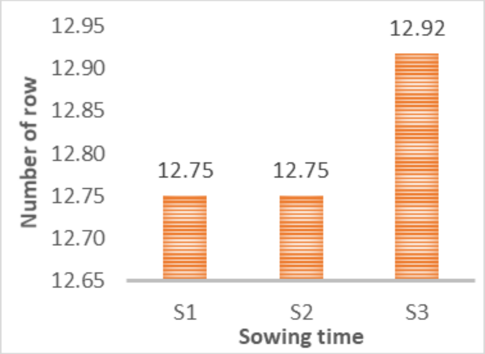


Fig.108: The average number of rows per cob of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.48)

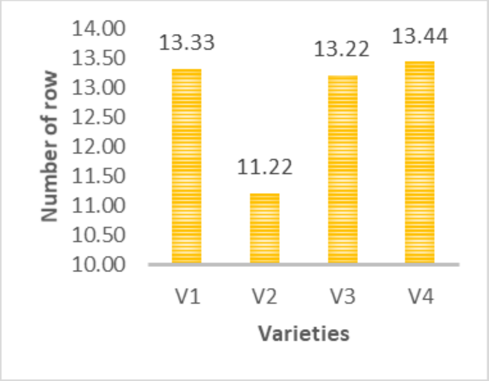
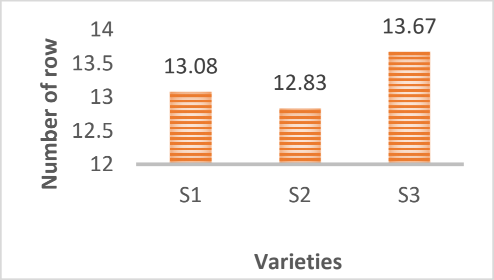


Fig.109: The average days to number of rows per cob of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.56)



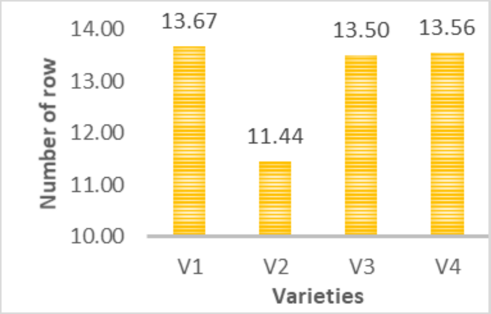


Fig. 110: Number of row per cob of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% =0.58

Fig. 111: Number of row per cob of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 0.68

**Interaction effect of planting dates and variety**

In the first Rabi season of 2016-17, interaction effect of white maize genotypes and planting dates sowed significant differences on date of Number of row (Fig. 112 & 113). The highest number of row (13.67) was observed from $V_4S_3$ that mean December 25 planting with Changnuo-6 variety followed (13.33) by $V_1S_1$ from PSC-121 with November 25 planting and statistically similar results (13.33) was also found from $V_1S_3$ that mean December 25 planting with PSC-121 variety. While the lowest number of row (11.00) was obtained from the treatment combination $V_2S_1$ that mean November 25 planting with Yungnuo-7 variety followed (11.33) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety. Higher number of row under December 25 planting was attributed to number of row characters.

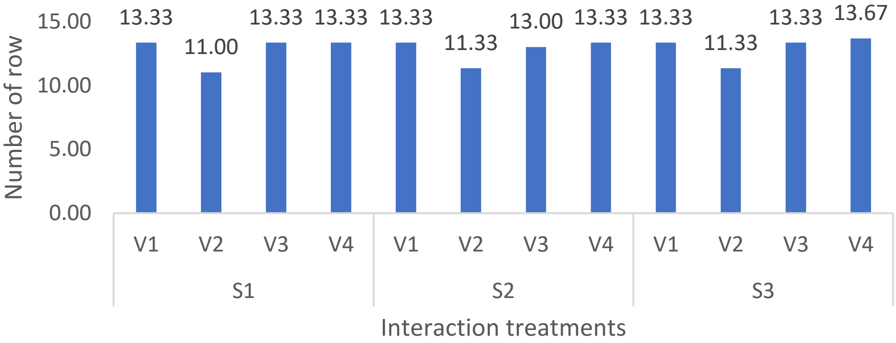


Fig.112: The average number of rows per cob of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.97)

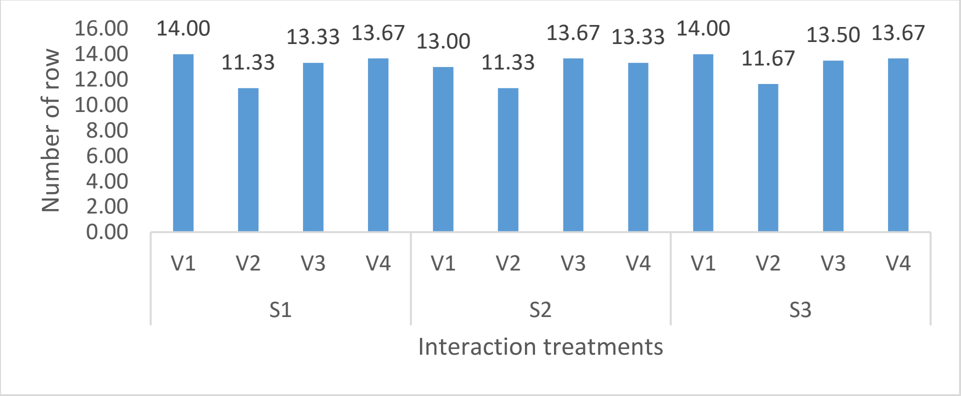


Fig.113: Number of rows per cob of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% = 1.17

### 4.1.22 Number of grain per row

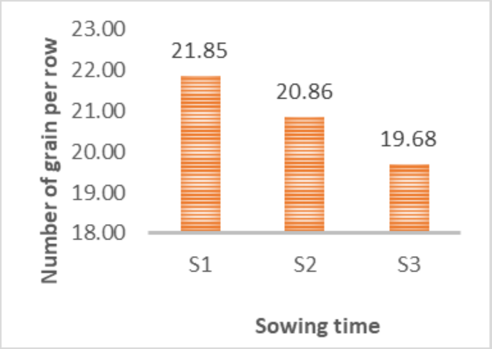
In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on number of grains per row in a cob. The results are presented below in Fig. 114 – 119 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

**Effect of planting date**

In the first Rabi season of 2016-17, number of grain per row have been presented in (Fig. 114 & 116). Planting date significantly affected number of grain per row of white maize. Crop sown on November 25 recorded the highest number of grain per row which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on number of grain per row. The highest number of grain per row (21.85) was recorded from $S_1$ that means November 25 planting which was statistically similar (20.86) to $S_2$. The lowest number of row (20.86) was observed from $S_3$ that mean December 25.

**Effect of variety**

In the first Rabi season of 2016-17, statistically significant variation was observed for different white maize genotypes in terms of Number of grain per row (Fig. 115 & 117). The highest Number of grain per row was found from $V_1$ (24.20) PSC-121 which was statistically similar to $V_3$ (23.21) Yungnuo-30 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest number of grain per row was found from $V_2$ (14.47) Yungnuo-7 due to susceptible characters.



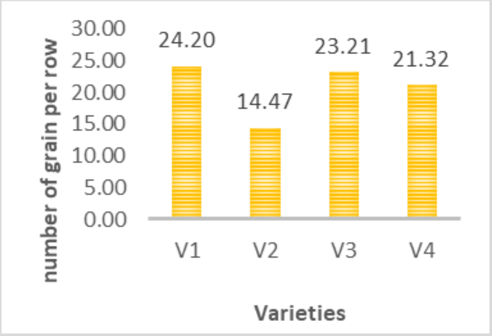
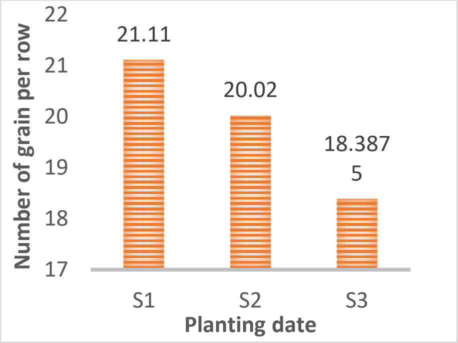


Fig 114: The average grains per row of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.48)

Fig.115: The average grains per row of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$= Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.55)



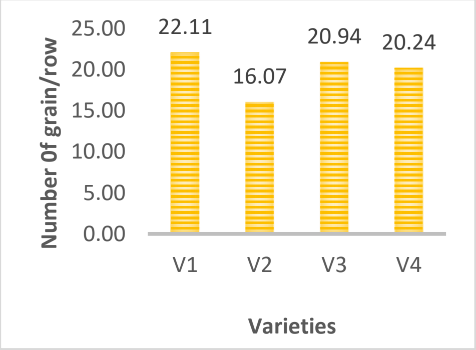


Fig 116: Number of grains per row in cob of white maize as influenced by varying planting dates ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) grown in Rabi 2017-2018 season (LSD5% = 0.75)

Fig 117: Number of grains per row in cob of white maize as influenced by varying planting dates ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) grown in Rabi 2017-2018 season (LSD5% = 0.87)

### Interaction effect of planting dates and variety

In the first Rabi season of 2016-17, interaction effect of white maize genotypes and planting dates sowed significant differences on date of Number of grain per row (Fig. 118 & 119). The highest number of grain per row (25.31) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety followed (24.62) by $V_1S_1$ from PSC-121 with December 10 planting and statistically similar results (23.45) was also found from $V_3S_1$ that mean November 25 planting with Yungnuo-30 variety. While the lowest number of grain of row (12.60) was obtained from the treatment combination $V_2S_3$ that mean December 25 planting with Yungnuo-7 variety followed (14.54) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety. Higher number of grain of row under November 25 planting was attributed to number of grain of row characters.

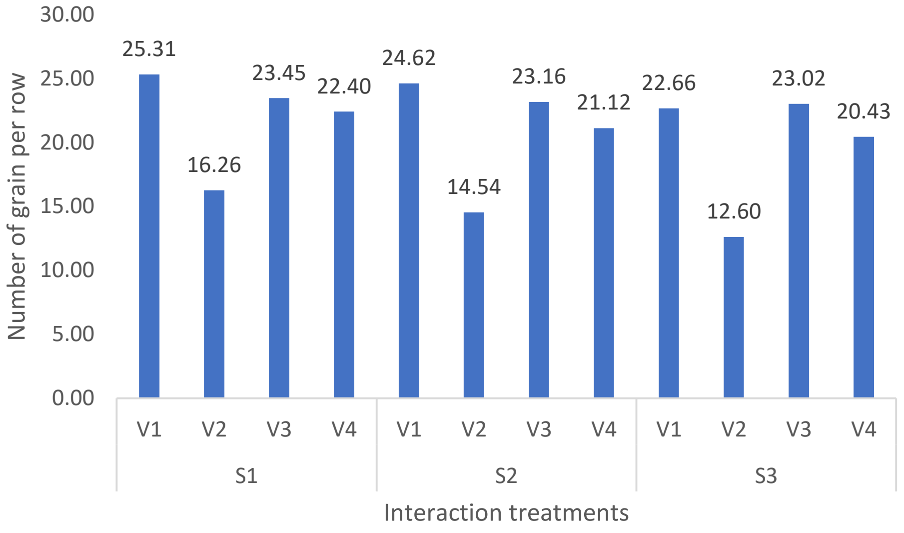


Fig.118: The average grains per row of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.96)

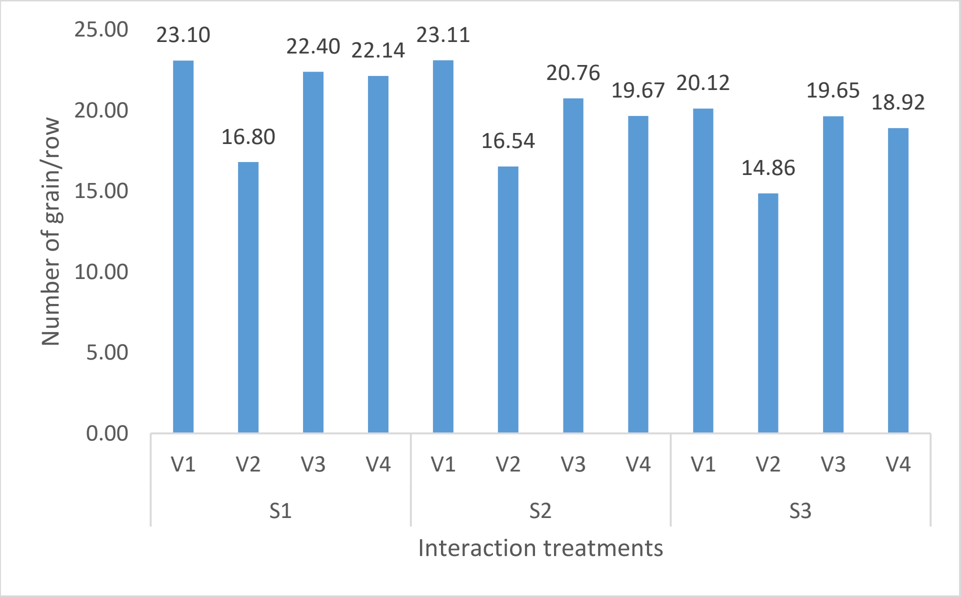


Fig.119: Number of grains per row in cob of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% = 1.51

### 5.1.23 Number of grain per cob

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on number of grains per cob. The results are presented below in Fig. 120 – 125 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

#### Effect of planting date

Number of grain per cob have been presented in (Fig. 120 & 122). Planting date significantly affected number of grain per cob of white maize. Crop sown on November 25 recorded the highest number of grain per cob in both the seasons. Different planting dates showed statistically significant differences on number of grain per cob. The highest number of grain per cob in both the seasons (281.86 and 279.47) was recorded from S1 that means November 25 planting. In the first year it was not statistically similar (268.88) to that of $S_2$. The lowest number of grain of cob in both the seasons (257.74 and 278.75 respectively) was observed from $S_3$ that mean December 25.

#### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of Number of grain per cob (Fig. 121 & 123). The highest Number of grain per cob was found from $V_1$ in both the seasons (322.54 and 301.84) which was PSC-121. In the first year this was statistically similar to $V_3$ (306.84 and 282.55 respectively in first and second year) Yungnuo-30. Whereas, the lowest number of grain per cob was found from $V_2$ (162.12 and 162.12) Yungnuo-7 in both the years.

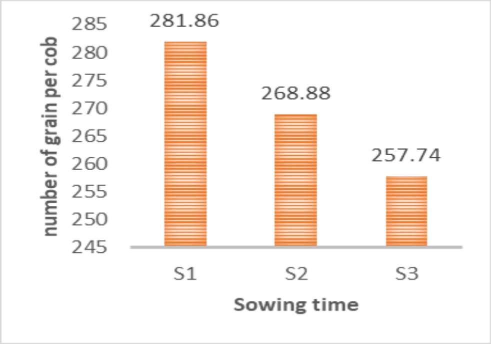


Fig 120: The average grains per cob of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =15.57)

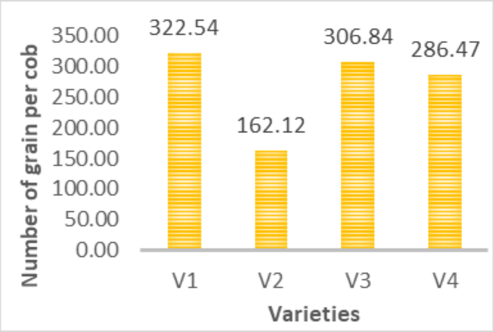
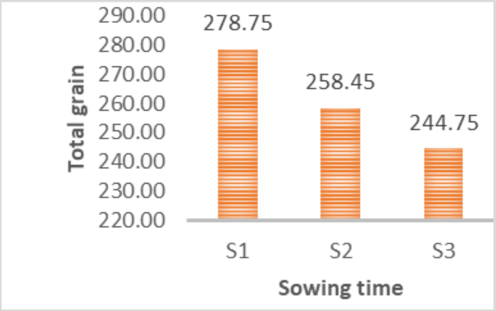


Fig 121: The average number of grains per cob of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =17.98)



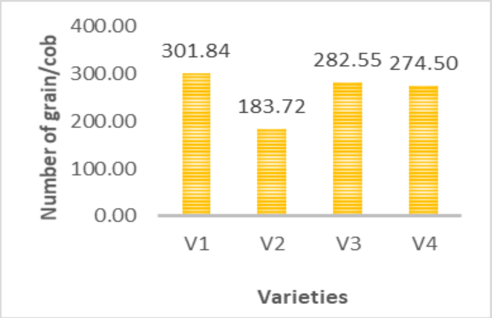


Fig 122: Number of grains per cob of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% = 0.83)

Fig 123: Number of grains per cob of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 0.96

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of Number of grain per cob (Fig. 124 & 125). The highest number of grain per cob (337.38) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety in the first season. This was then followed (328.18) by $V_1S_1$ from PSC-121 with December 10 planting but was statistically similar (312.59) which was also found from $V_3S_1$ that mean November 25 planting with Yungnuo-30 variety. In the second season of Rabi the highest value was obtained with $V_4S_1$ (302.65). While the lowest number of grain of cob (142.76173.42) was obtained from the treatment combination $V_2S_3$ in both the seasons, that means with December 25 planting with Yungnuo-7 variety followed (164.74) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety.

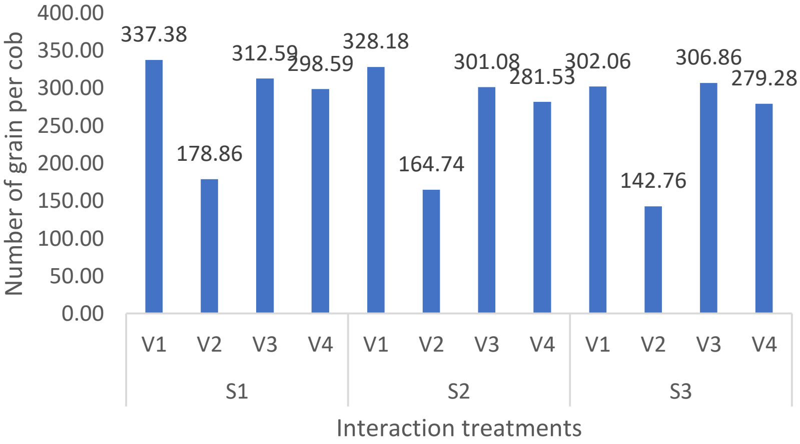


Fig 124: The average grains per cob of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =31.14)

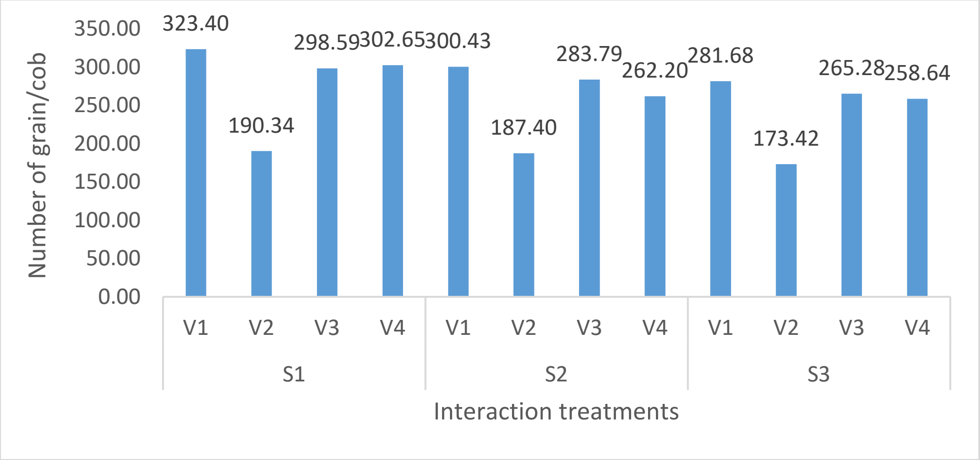


Fig 125: Number of grains per cob of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =1.66.

### 4.1.24 Grain weight per plant

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on grain weight per plant. The results are presented below in Fig. 126 – 131 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

### Effect of planting date

Grain yield have been presented in (Fig. 126 & 128). Planting date significantly affected weight of white maize. Crop sown on November 25 recorded the highest weight which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on weight. In the first season, the highest weight (148.73 g) was recorded from $S_1$ that means November 25 planting which was statistically similar (146.83 g) to $S_2$. The lowest weight (145.6 g) was observed from $S_3$ that mean December 25.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of grain weight (Fig. 127 & 129). The highest weight was found from $V_1$ in both the seasons (159.50 and 144.35 g) which was PSC-121. But in the first season it was statistically similar to that of $V_3$ (156.93 g) which was Yungnuo-30. The lowest weights were found from $V_2$ (117.37 and 104.49 g) that is Yungnuo-7 in both the seasons.

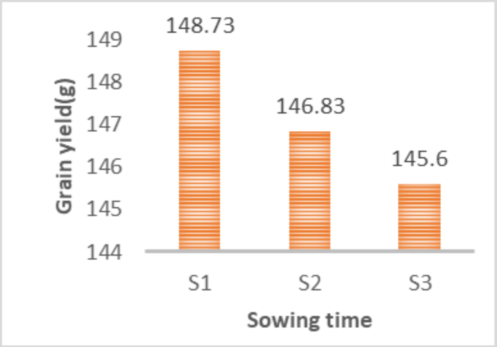


Fig. 126: The average grain weight per plant of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.65)

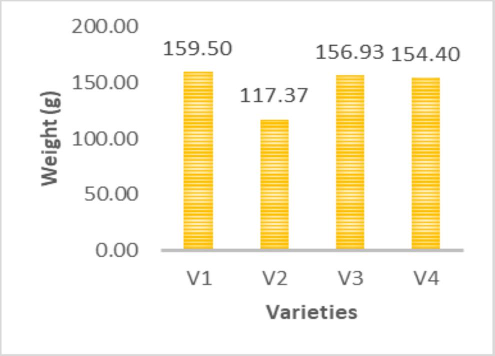


Fig.127: The average grain weight per plant of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.76)

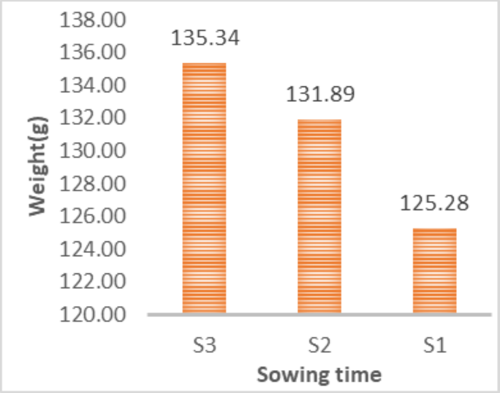


Fig.128: Grain dry weight per plant of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% = 0.83)

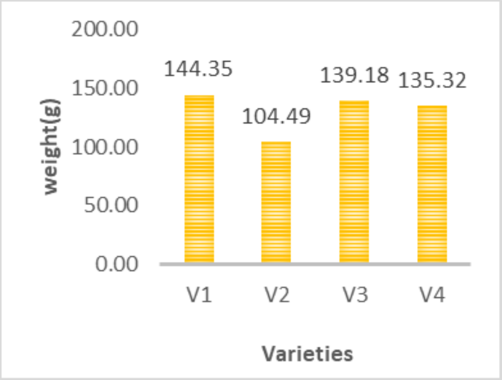


Fig.129: Per plant grain dry weight of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 0.96)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on grain weight (Fig. 130). The highest weight (161.50 g) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety followed (159.00 g) by $V_1S_1$ from PSC-121 with December 10 planting which was statistically similar to that (158.00 g) of $V_1S_3$ that mean December 25 planting with PSC-121 variety. In the second season, the highest value was found with also with $V_1S_1$ (149.50 g). While the lowest weight in both the seasons (116.00 and 99.48 g) were obtained from the treatment combination $V_2S_3$ that mean December 25 planting with Yungnuo-7 variety.

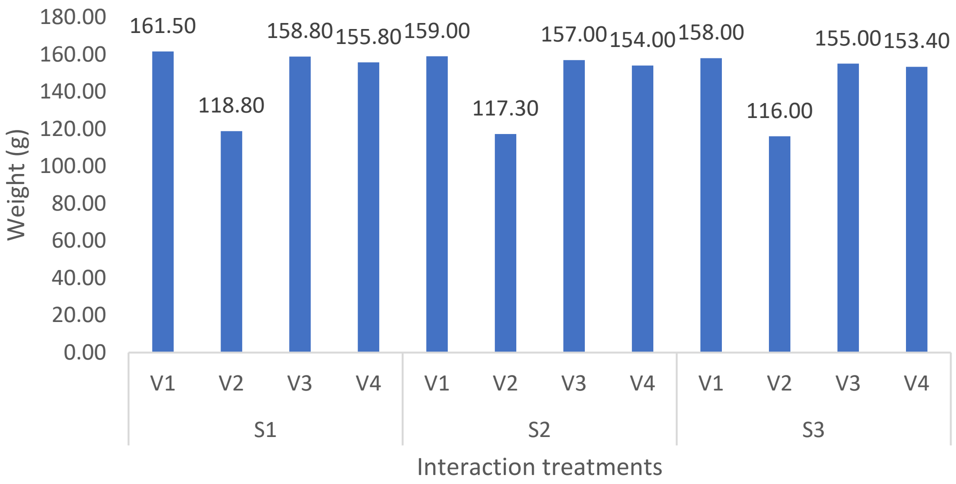


Fig.130: Bar diagram showing the average grain weight per plant of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =1.31)

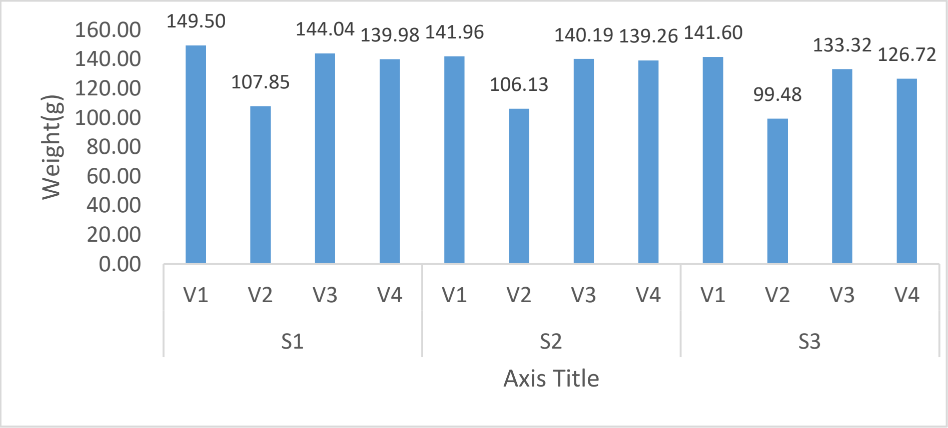


Fig. 131: Grain dry weight per plant of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% =1.66

### 4.1.25 100 seed weight

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on 100-seed weight. The results are presented below in Fig. 132 to 137 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

### Effect of planting date

100 seed weight have been presented in (Fig. 132 & 134). Planting date significantly affected 100 seed weight of white maize. Crop sown on November 25 recorded the highest number of grain per cob which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on 100 seed weight. The highest weight (32.17 and 32.38 g) was recorded from S1 in both the seasons that means November 25 planting. The highest weight in the first season was statistically similar (30.51 g) to $S_2$. The lightest (28.8 and 28.80 g) seeds were observed from $S_3$ that mean November 25 in both the seasons.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of 100 seed weight (Fig. 133 & 135). The highest 100 seed weight was found from $V_4$ (31.71g) Changnuo-6 which was statistically similar to $V_3$ (31.03g) Yungnuo-30 while from $V_4$ in 2017-18. Whereas, the lowest 100 seed weight was found from $V_2$ which were 28.71 and 26.25 g where the variety was Yungnuo-7 in both the seasons respectively.

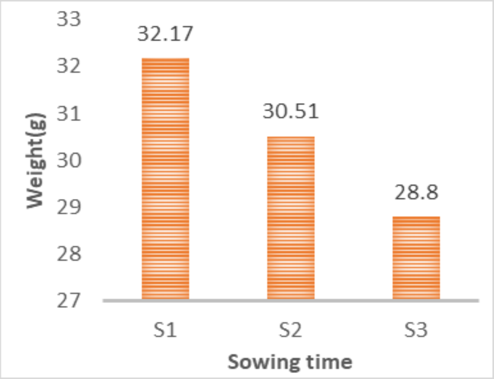


Fig. 132: The average 100-seed weight of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =1.39)

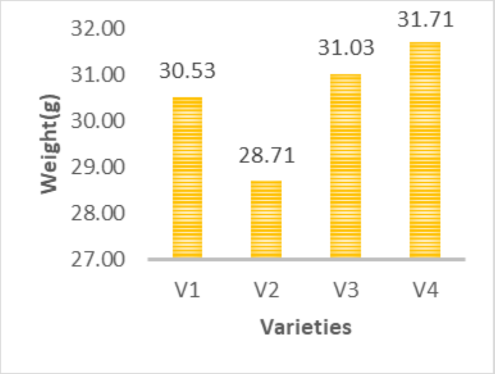
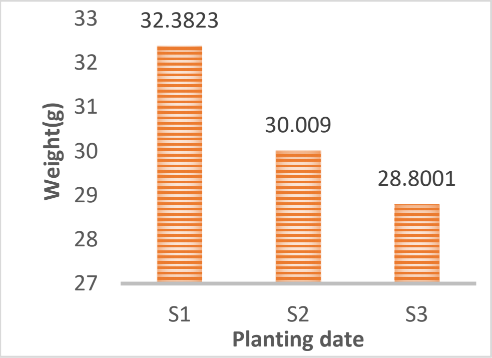


Fig.133: The 100-seed weight of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 1.60)



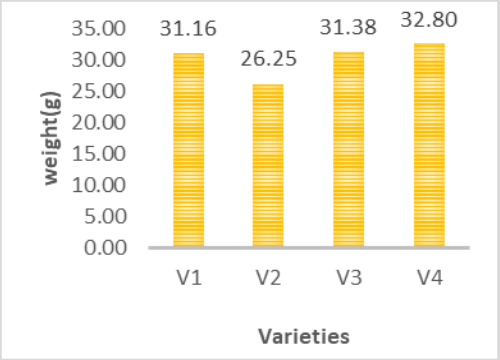


Fig. 134: 100-seed weight of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% = 0.87

Fig.135: 100-seed weight of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 1.00

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on 100 seed weight (Fig. 136 & 137). The highest weight (34.76 g) was observed from $V_4S_1$ that mean November 25 planting with Changnuo-6 variety in 2016-17 while from $V_4S_1$ (34.10) during 2017-18. In the first season it was followed by $V_3S_1$ (33.45 g) which were Yungnuo-30 with November 10 planting in 2016-17. While the lowest weight (27.86 g) was obtained from the treatment combination $V_2S_3$ that mean December 25 planting with Yungnuo-7 variety followed (28.92) by $V_2S_2$ that mean December 10 planting with Yungnuo-7 variety, while in the next season it was with $V_2S_3$ (27.86 g).

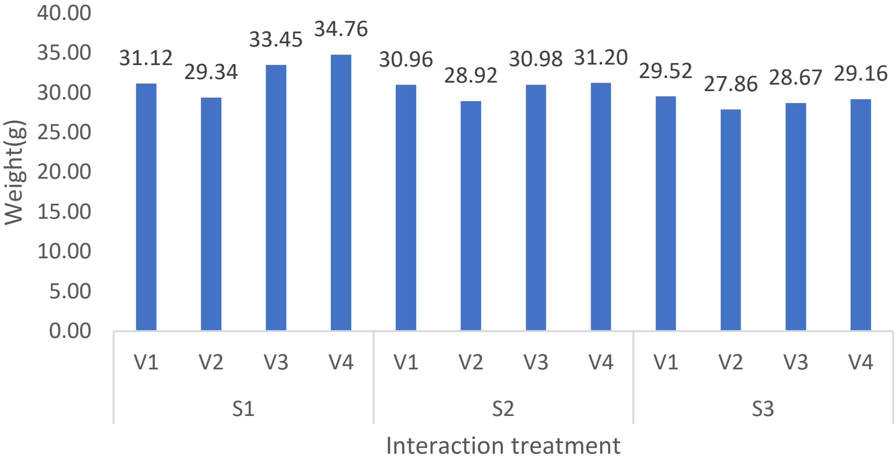


Fig.136: Bar diagram showing the average 100-seed weight of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =2.78)

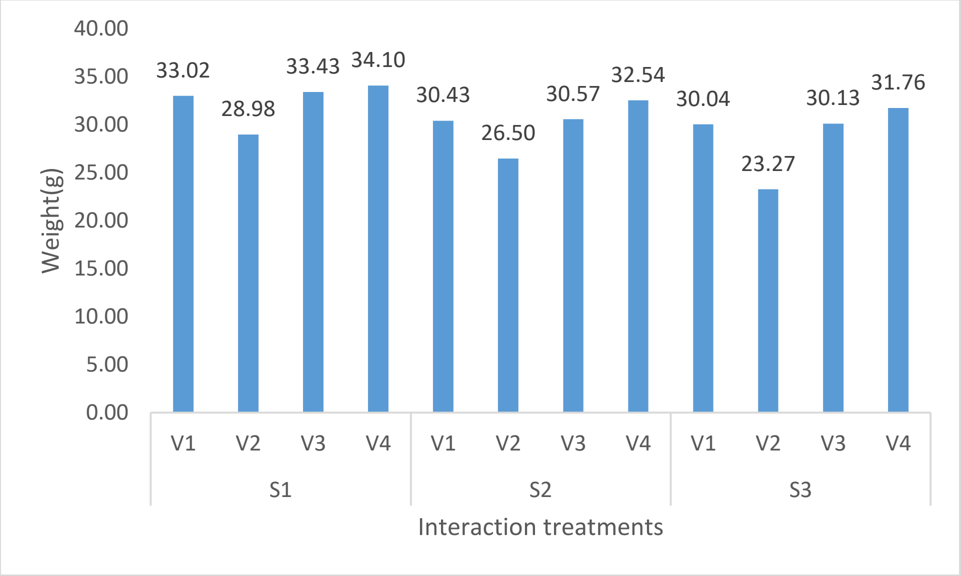


Fig.137: 100-seed weight of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% = 1.74

### 4.1.26 Yield

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on seed yield weight. The results are presented below in Fig. 138 to 143 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

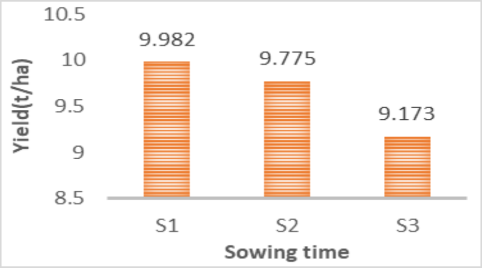
**Effect of planting date**

Yield have been presented in (Fig. 138 & 140). Planting date significantly affected weight of white maize. Crop sown on November 25 recorded the highest weight which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on weight. The highest yields of 9.982 and 10.45 t ha$^{-1}$ were recorded from $S_1$ in both the seasons respectively, that means November 25 planting which was statistically similar (9.775 t ha$^{-1}$) to $S_2$ in the first year. The lowest weight in both the years (9.173 and 9.973 t ha$^{-1}$) were observed from $S_3$ that mean December 25.

**Effect of variety**

Statistically significant variation was observed for different white maize genotypes in terms yield (Fig. 139 & 141). The highest weight was found from $V_1$ (10.59 and

11.480 t ha$^{-1}$) that is from PSC-121 in both the seasons. The seed yield of the first season was statistically similar to $V_3$ (10.50 t ha$^{-1}$) which was Yungnuo-30. Whereas, the lowest weight was found from $V_2$ (7.36 and 7.840 t ha$^{-1}$) which was Yungnuo-7 in both the years.



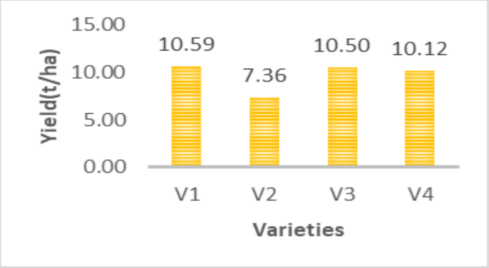
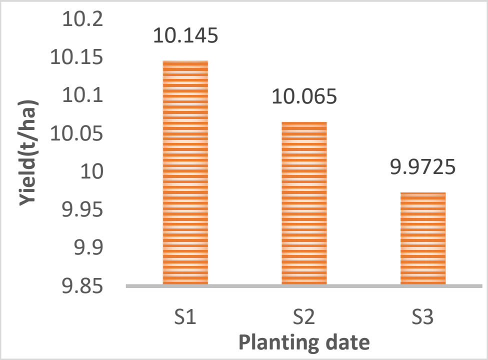


Fig.138: The average seed yield per hectare of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.08)

Fig .139: The average seed yield per hectare of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.09)



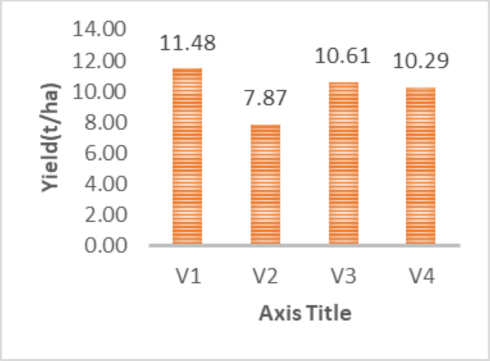


Fig.140: Per hectare seed yield of white maize as influenced by varying planting dates ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) grown in Rabi 2017-2018 season (LSD5% = 0.08

Fig 141: Per hectare seed yield of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 0.1

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on yield weight (Fig. 142 & 143). The highest grain yields (10.77 and 11.650 t ha$^{-1}$) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety in the first and second seasons respectively. The grain yield of the first year was followed (10.68 t ha$^{-1}$) by $V_3S_1$ from Yungnuo-30 with November 25 planting and statistically similar results (10.58 t $ha^{-1}$) was also found from $V_3S_2$ that mean December 10 planting with Yungnuo-30 variety. While the lowest yields in both the years (respectively 6.44 and 7.810 t $ha^{-1}$) were obtained from the treatment combination $V_2S_3$ in both the years.

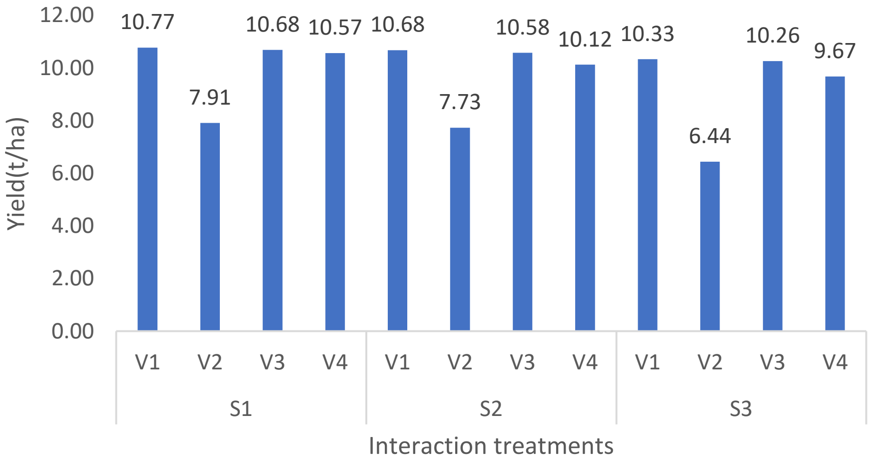


Fig.142: Bar diagram showing the average seed yield per hectare of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.16)

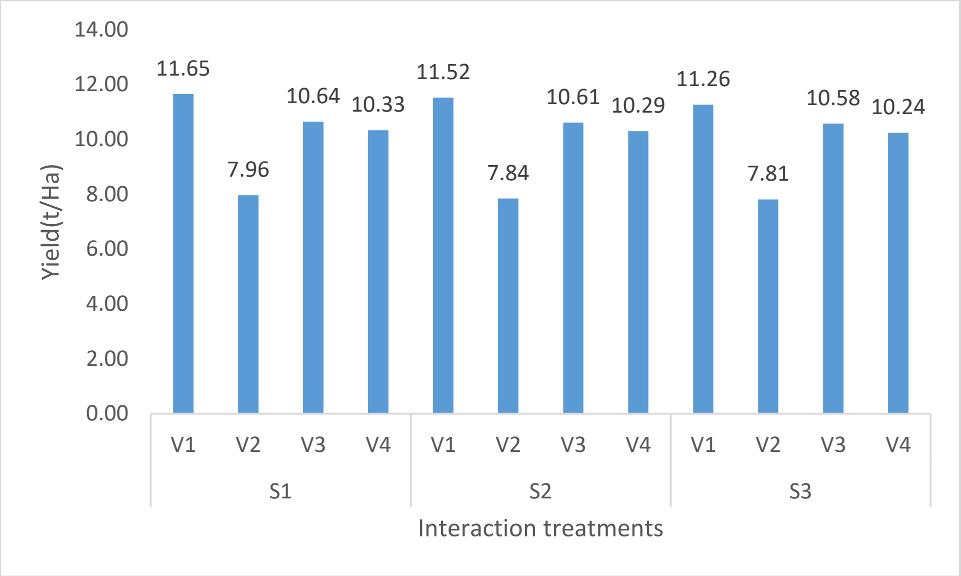


Fig.143: Per hectare seed yield of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th November 2017, 11th December 2017 and 26th December 2017; LSD5% = 0.17)

In general, changes in plant's surroundings such as fluctuation in temperature and humidity result in allocation of photosynthate to sinks (seed) (Gormus and Yucel, 2002). Unfavorable planting date causes plants subject to adverse growing conditions during germination and early seedling growth. Also, planting too late, generally results in reduced yields and increases vulneRability to insects, weeds and unsuitable weather. Whereas weather condition particularly cloudy days and intensive rains might have forced the plants to enter into reproductive phase early thus resulting in shorter growth period and the plant do not get enough time for complete maturity during delayed planting (Azadbakht *et al.*, 2012; Ramachandrudu *et al.*, 2013).

For optimization of yield, planting at an appropriate time is very critical (McCutcheon *et al.,* 2001). Ali *et al.* (2018) reported that one of the most important factors contributing to yield gap is a planting of maize on appropriate planting dates. Dekhane *et al. (*2017) contended that early planting in the spring is optimum and more efficient than delayed planting as through early planting germination occurs when days are longer and sun shines impact is more by way of an acute angel; whereas delaying planting date results in decrease in maize grain yields.

### 4.1.27 Biological yield ha$^{-1}$

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on biological weight. The results are presented below in Fig. 144 to 149 showing the effect of the showing the effect of variety, planting dates and their interactions individually.

### Effect of planting date

Dry matter have been presented in (Fig. 144 & 146). Planting date significantly affected weight of white maize. Crop sown on November 25 recorded the highest weight which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on weight. The highest weight (21.33 t ha$^{-1}$) was recorded from $S_1$ that means November 25 planting which was statistically similar (21.18 t ha$^{-1}$) to. The lowest weight (21.15 t ha $^{-1}$) was observed from $S_2$ that mean December 10.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of grain yield (Fig. 145 & 147). The highest weight was found from $V_1$ (22.72

and 22.119 t ha$^{-1}$) which was PSC-121 in both the years. The biological yield of the first year was statistically similar to that of $V_4$ (22.56 t ha$^{-1}$) which was Changnuo-6. Whereas, the lowest weight was found from $V_2$ (17.33 and 16.551 t ha$^{-1}$) which was Yungnuo-7 in both the years.

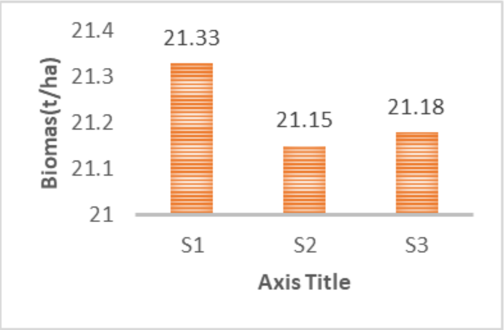


Fig. 144: The average biological yield per hectare of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =0.6)

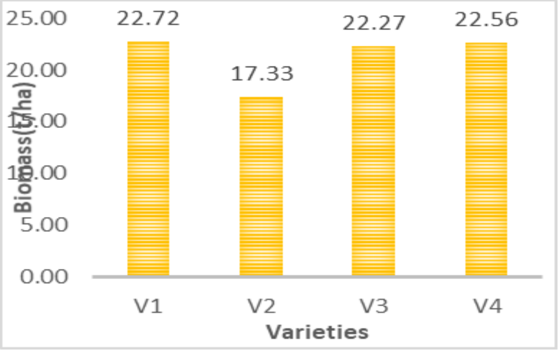


Fig.145: Biological yield of different white maize varieties grown in Rabi 2017-2018 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 0.59

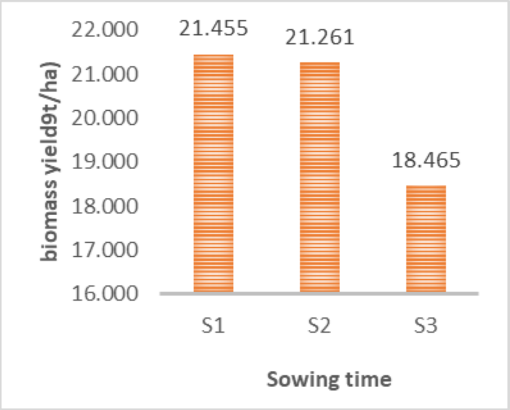


Fig. 146: Biological yield of white maize as influenced by varying planting dates ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) grown in Rabi 2017-2018 season (LSD5% = 0.51

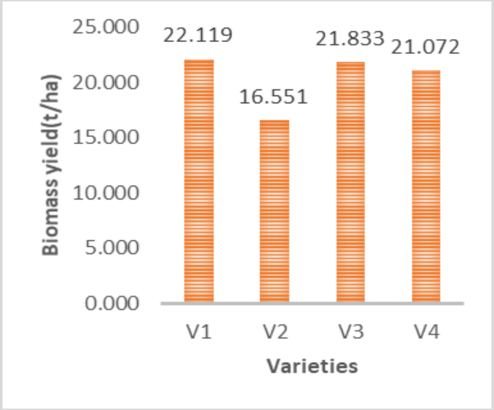


Fig. 147: Biological yield of different white maize genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% = 0.59 grown in Rabi 2017-2018 season

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on dry matter weight (Fig. 148 & 149). The highest weight (22.91 t ha$^{-1}$) was observed from $V_1S_1$ that mean November 25 planting with PSC-121 variety which was then followed by $V_1S_3$ (22.71 t ha$^{-}$1) that is from PSC-121 with December 25 planting which again was similar results to that of $V_4S_1$ (22.62 t ha$^{-1}$), that mean

November 25 planting with Changnuo-6 variety. In Rabi 2017-18 the highest biomass was obtained $V_3S_2$ (23.179 tha$^{-1}$). While the lowest weight (17.17 t ha $^{-1}$) was obtained from the treatment combination $V_2S_3$ in the first season, that mean December 25 planting with Yungnuo-7 which was also in the next season (15.836 tha$^{-1}$).

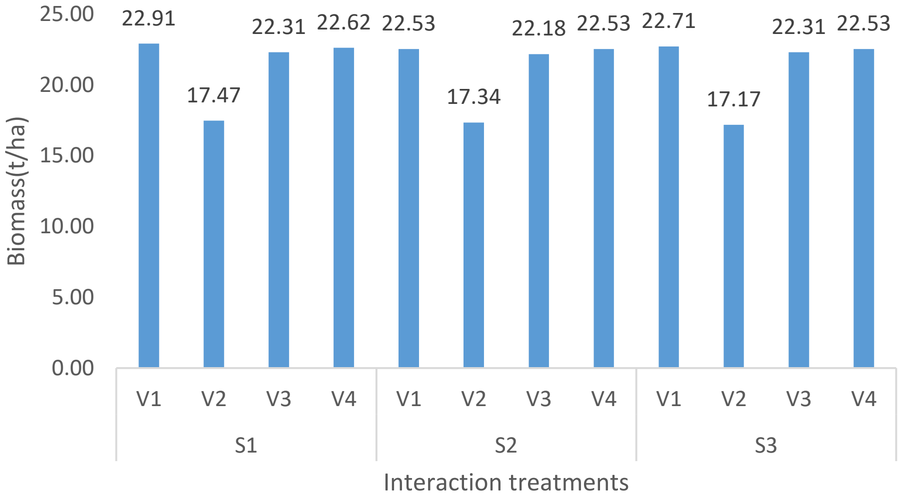


Fig. 148: Bar diagram showing the average biological yield per hectare of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th  November 2016, 10th December 2016 and 25th December 2016)

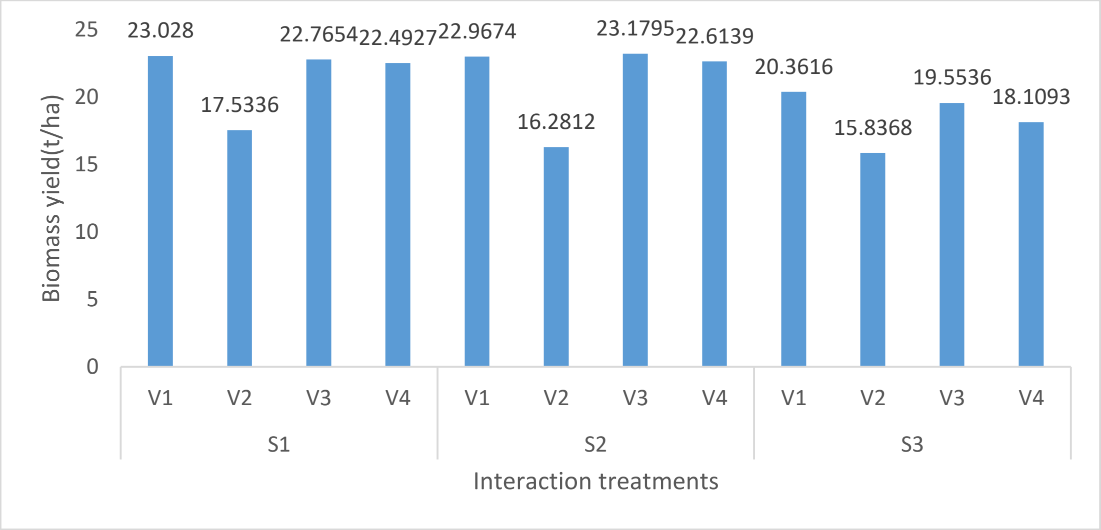


Fig.149: Biological yield of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=26th  November 2017, 11th December 2017 and 26th December 2017; LSD5% = 1.02

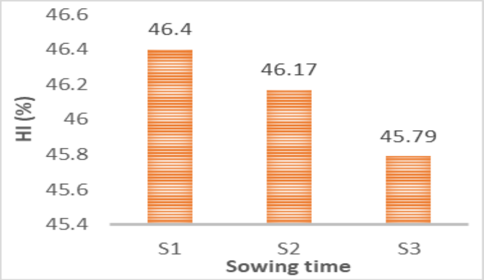
### 4.1.28 Harvest index:

Corn stover is made up of the stalk, leaves, husks and tassels left in the field after harvesting the grain with a combine. Stover can be harvested and used as a livestock feed, converted into ethanol or burned for heat or electricity (Fig. 150 – 155). The amount of stover produced each crop year depends on weather, soils and management practices like fertilizer and pest control applications. As a general rule, the amount of stover produced is about the same as the amount of grain produced. This is commonly expressed in a ratio called harvest index.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on harvest index. The results are presented below showing the effect of the showing the effect of variety, planting dates and their interactions individually.

**Effect of planting date**

HI have been presented in (Fig. 150 & 152). Planting date significantly affected weight of white maize. Crop sown on November 25 recorded the highest HI which was statistically at per with December 10 planting. Different planting dates showed statistically significant differences on HI. The highest HI (46.4 and 50.10% respectively) was recorded from $S_1$ that means November 25 planting in both the years. These were statistically similar to those of $S_2$ (46.17 and 49.18 %). The lowest HI (45.79 and 47.04%) were observed from $S_3$ that mean December 25 in both the years.



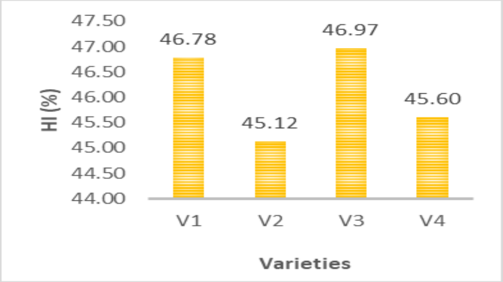
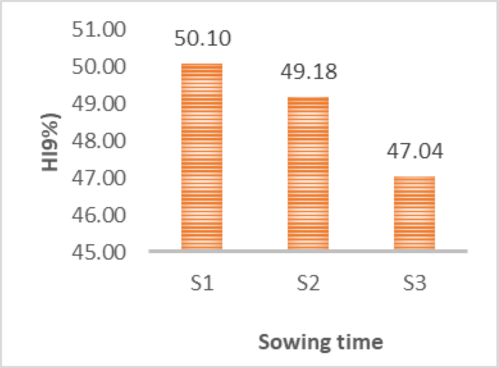


Fig. 150: Bar diagram showing the average harvest index of white maize grown in Rabi 2016-2017 season across varying genotypes (25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =.52)

Fig. 151: The average harvest index of different white maize genotypes grown in Rabi 2016-2017 season across varying planting dates ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.63)

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of HI (Fig. 151 & 153). The highest HI was found from $V_3$ (46.97 and 51.95%) which was Yungnuo-30 in both the seasons, and that of the first season was statistically similar to that of $V_1$ (46.78 %) that is PSC-121. Whereas the lowest HI was found from $V_2$ (45.12 43.41%) that is from Yungnuo-7 in the both the seasons.



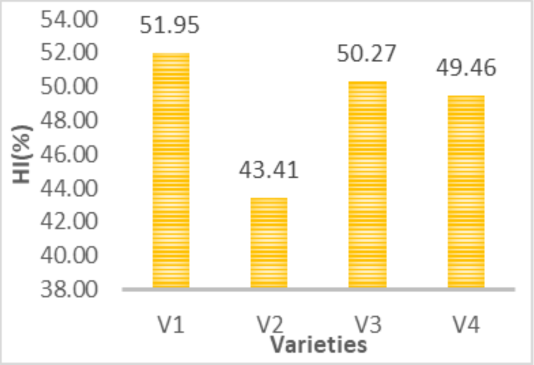


Fig. 152: Harvest index of white maize as influenced by varying planting dates grown in Rabi 2017-2018 season ($S_1$=26 November 2017, 11th December 2017 and 26th December 2017) (LSD5% = 0.53)

Fig.153: Harvest index of different white maize varieties grown in Rabi 2017-2018 season ($V^1$=PSC-121, $V^2$=Yangnuo-7, $V^3$= Yungnuo-30, $V^4$= Changnuo-6; LSD5% = 0.62

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on HI (Fig. 154 & 155). The highest weight (47.39 %) was observed from $V_3S_1$ that mean November 25 planting with Yungnuo-7 variety followed (47.21 %) by $V_3S_2$ from Yungnuo-30 with December 10 planting and statistically similar results (46.99 and 53.49 %) was also found from $V_1S_1$ that mean November 25 planting with PSC-121 variety in both the seasons. While the lowest weight (45.01and 41.72 %) was obtained from the treatment combination $V_2S_3$ that mean December 25 planting with Yungnuo-7 in both the seasons.

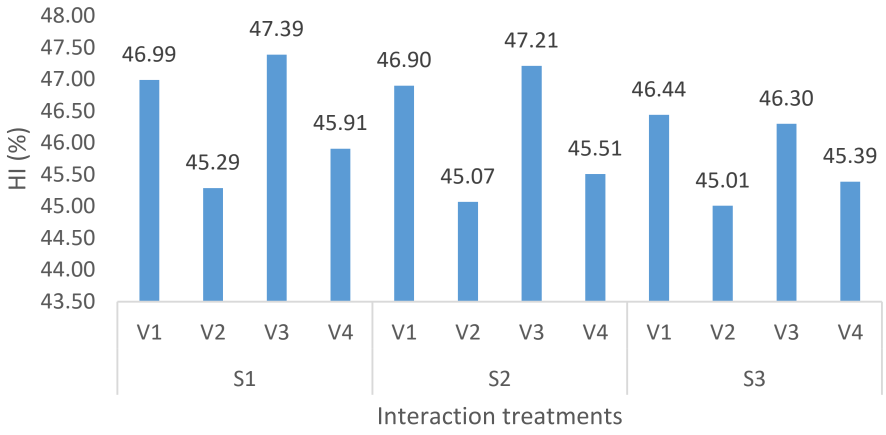


Fig. 154: Bar diagram showing the average harvest index of white maize grown in Rabi 2016-2017 season across as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; 25th November 2016, 10th December 2016 and 25th December 2016; LSD5% =1.07)

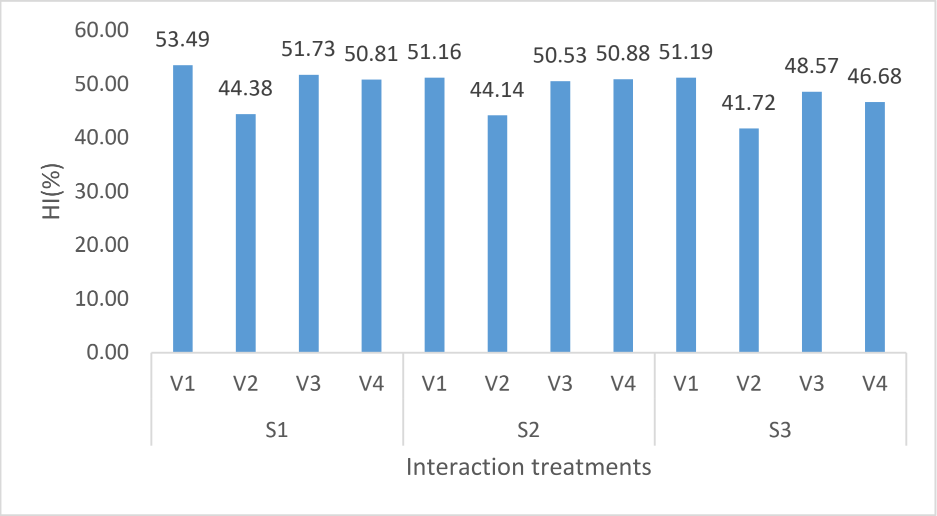


Fig.155: Harvest index of white maize grown in Rabi 2017-18 season as influenced by varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=25th November 2017, 10th December 2017 and 25th December 2017; LSD5% = 1.07)

### 4.1.29 Growing day degrees (GDD)

In this trial the variety, planting dates and their interactions seemed to have significant effect on growing day degrees.

### Effect of planting date

The GDD values increased as the phenotypic stages progressed with the passing of time. The latest planting date required the highest GDD while the earliest planting had the lowest GDD.

### Effect of genotypes

Like planting date the GDD values increased with the advancement of time and progress of the phenotypic growth stages. The variety PSC-121 required the highest GDD compared to others and the variety Yangnjuo-7 had the lowest GDD.

### Interaction effect

The interaction effect of planting dates and variety had significant effect on the GDD required. $S_3V_3$ had the highest value of GDD.

## Table 4 Growing day degree required of different phenological stages as influenced by planting dates, variety and their interactions*

| | GDD for Emergence | | GDD for Emergence to V6 | | GDD for V6-V10 | | GDD for V10-V12 | | GDD for V12-50% tasseling | | GDD for 50% tasseling to 50% silking | | GDD for silking -50% maturity | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 |
| $S_1$ | 72 | 68 | 268 | 372 | 182 | 170 | 107 | 25 | 220 | 112 | 68.9375 | 67 | 804 | 875 |
| $S_2$ | 69 | 75 | 247 | 305 | 155 | 212 | 129 | 34 | 269 | 164 | 84.025 | 88 | 881 | 962 |
| $S_3$ | 72 | 58 | 231 | 304 | 168 | 274 | 154 | 41 | 323 | 213 | 80.0875 | 97 | 954 | 997 |
| LSD (5%) | 0.36 | 0.08 | 0.37 | 1.89 | 0.49 | 6.08 | 0.46 | 1.06 | 0.56 | 6.36 | 0.63 | 2.07 | 0.55 | 9.69 |
| $V_1$ | 70 | 67 | 287 | 377 | 164 | 220 | 126 | 29 | 333 | 228 | 88.3 | 100 | 918 | 1008 |
| $V_2$ | 70 | 68 | 203 | 268 | 171 | 203 | 117 | 32 | 224 | 132 | 54.883333 | 53 | 744 | 799 |
| $V_3$ | 70 | 67 | 267 | 351 | 178 | 244 | 143 | 35 | 272 | 141 | 68.766667 | 80 | 965 | 1017 |
| $V_4$ | 73 | 67 | 237 | 312 | 161 | 207 | 134 | 37 | 255 | 149 | 98.783333 | 102 | 892 | 956 |
| LSD (5%) | 0.40 | 0.09 | 0.43 | 2.19 | 0.56 | 7.02 | 0.53 | 1.22 | 0.65 | 7.35 | 0.73 | 2.39 | 0.63 | 11.19 |
| $S_1V_1$ | 68 | 65 | 317 | 422 | 163 | 144 | 104 | 29 | 260 | 148 | 106.25 | 108 | 897 | 970 |
| $S_1V_2$ | 82 | 78 | 207 | 298 | 191 | 182 | 107 | 27 | 184 | 97 | 49.1 | 34 | 663 | 705 |
| $S_1V_3$ | 68 | 65 | 291 | 401 | 196 | 188 | 104 | 18 | 224 | 99 | 51 | 52 | 863 | 945 |
| $S_1V_4$ | 68 | 65 | 256 | 368 | 179 | 164 | 114 | 27 | 214 | 102 | 69.4 | 73 | 794 | 882 |
| $S_2V_1$ | 68 | 78 | 275 | 349 | 148 | 216 | 127 | 26 | 340 | 243 | 88 | 101 | 920 | 1025 |
| $S_2V_2$ | 57 | 67 | 213 | 260 | 159 | 193 | 108 | 31 | 220 | 129 | 54 | 54 | 740 | 815 |
| $S_2V_3$ | 68 | 78 | 265 | 329 | 158 | 234 | 150 | 40 | 276 | 138 | 71.8 | 80 | 958 | 1037 |
| $S_2V_4$ | 80 | 78 | 234 | 281 | 155 | 205 | 130 | 39 | 240 | 145 | 122.3 | 116 | 907 | 971 |
| $S_3V_1$ | 72 | 58 | 269 | 361 | 181 | 300 | 148 | 31 | 398 | 294 | 70.65 | 92 | 937 | 1030 |
| $S_3V_2$ | 72 | 58 | 188 | 247 | 161 | 233 | 135 | 38 | 268 | 170 | 61.55 | 69 | 830 | 877 |
| $S_3V_3$ | 72 | 58 | 245 | 322 | 178 | 310 | 176 | 47 | 317 | 186 | 83.5 | 108 | 1075 | 1068 |
| $S_3V_4$ | 72 | 58 | 221 | 285 | 150 | 251 | 157 | 46 | 310 | 201 | 104.65 | 117 | 974 | 1014 |
| LSD (5%) | 0.68 | 0.17 | 0.75 | 3.79 | 0.98 | 12.16 | 0.92 | 2,12 | 1.13 | 12.73 | 1.27 | 4.14 | 1.10 | 19.39 |
| CV (%) | | 1.77 | 0.17 | 0.65 | 0.33 | 3.12 | 0.40 | 3.61 | 0.24 | 4.37 | 0.93 | 2.77 | 0.07 | 1.15 |

*V1=PSC-121, V2=Yangnuo-7, V3= Yungnuo-30, V4= Changnuo-6; S1=25th November, 10th December and 25th December

The second highest total GDD (2000) were obtained $S_3$, $V_1$ and $V_3$. The GDD increased with the delay of planting date having the highest with $S_3$ (2000). The variety $V_1$ had also GDD the highest (2000) which was then followed by $V_3$ and $V_4$. The variety $V_2$ required the lowest GDD (1584). In respect of interaction of the planting date and variety, the total GDD was obtained with the $V_3S_3$ and $S_3V_1$ which were over 2000. $S_1V_2$ had GDD below 1500. The GDD in the 2017-18 followed that as was observed in 2016-18.

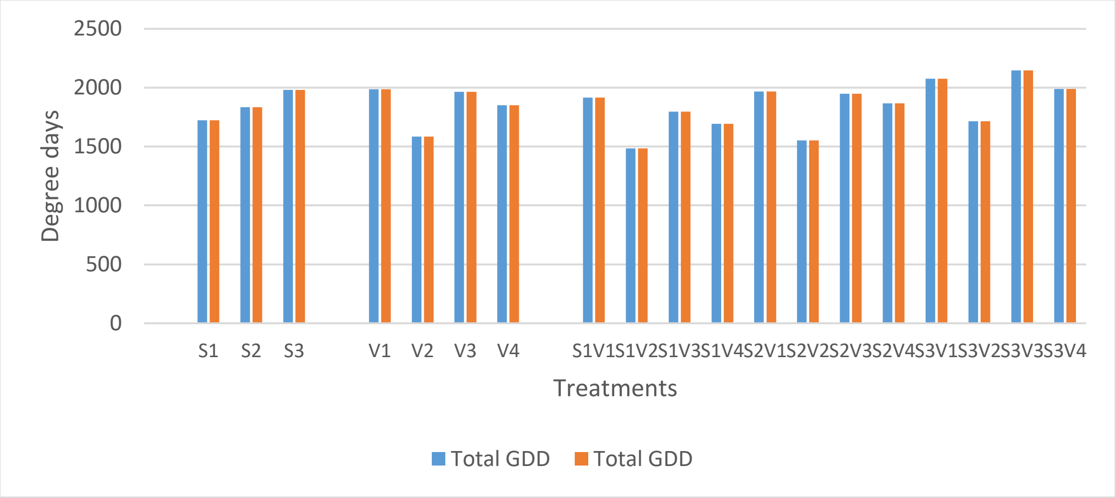


Fig.156: Total GDD as required for the whole life of white maize up to maturity under varying planting dates and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=25th November, 10th December and 25th December).

### Relations of growing day degrees with different yield attributes and yield of white maize

Regression analysis was made between growing day degree (GDD) with the yield and yield attributes using both linear and polynomial regression models. It was observed that a positive relationship was existed in both regression analysis models (Table- 4, Fig. 158 to 163). But a stronger dependency was observed while polynomial regression was fitted with the GDD, that is higher regression coefficient values were observed at polynomial regression model than those at the linear model. The regression coefficients in linear regression has not been presented. The polynomial regression were 0.1688 with plant height, 0.6726 with stover weight, 0.7073 with ear weight, 0.7014 with dry weight per plant, 0.5025 with yield per hectare; and 0.7014 with the biological yield per hectare in the 2016-17 season which were more or less similar in 2017-18 with some wider deviation in the biological yield. It signified that these parameters were highly dependent on the accumulated growing day degrees and the curve was best fitted in polynomial or quadratic functions showing a stronger positive curvilinear relationship rather than a linear relationship with the regression model $Y = a + bX + bX^2$.

**Table-5 Polynomial Regression coefficient values under linear and polynomial regression analysis of GDD with the yield attributes and yield of white maize**

| **Season** | **Plant height** | **Stover wt.plant$^{-1}$** | **Ear wt.plant$^{-1}$** | **Dry wt.plant$^{-1}$** | **Yieldha$^{-1}$** | **Biological yieldha$^{-1}$** |
|---|---|---|---|---|---|---|
| 2016-17 | 0.1688 | 0.6726 | 0.7073 | 0.7014 | 0.5025 | 0.7014 |
| 2017-18 | 0.0720 | 0.6726 | 0.2144 | 0.637 | 0.6844 | 0.3599 |
| Average | 0.1204 | 0.6726 | 0.46085 | 0.6692 | 0.59345 | 0.53065 |

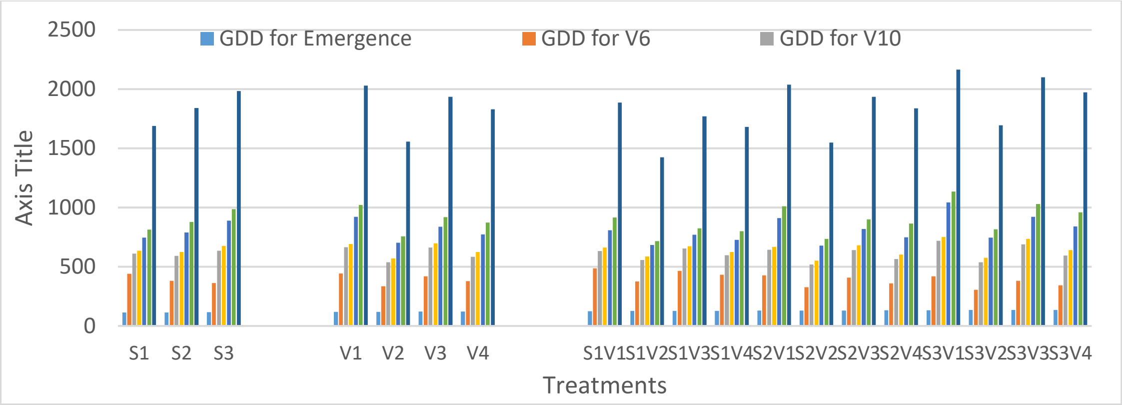


Fig. 157: Cumulative GDD from emergence to maturity of of white maize as affected by the planting date and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; $S_1$=25th November, 10th December and 25th December of rabi 2016-17

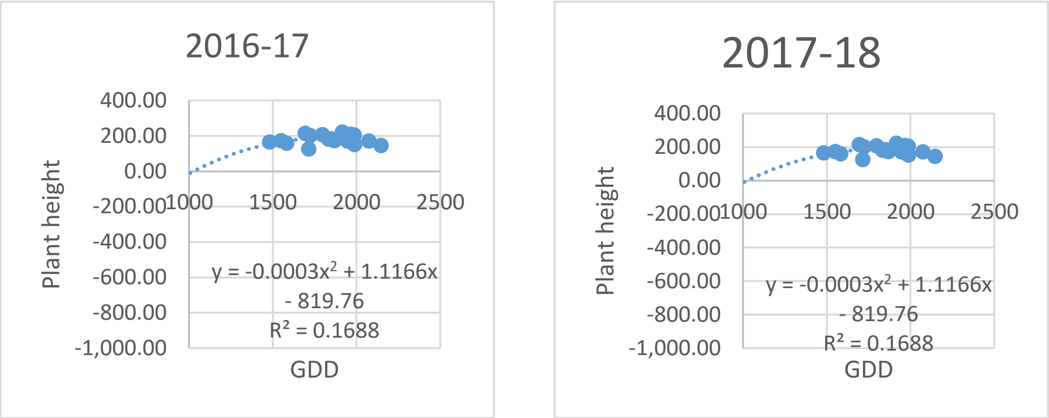


Fig. 158: Polynomial regression analyses of accumulated GDD for plant height from planting to maturity in 2016-17 and 2017-18 Rabi seasons

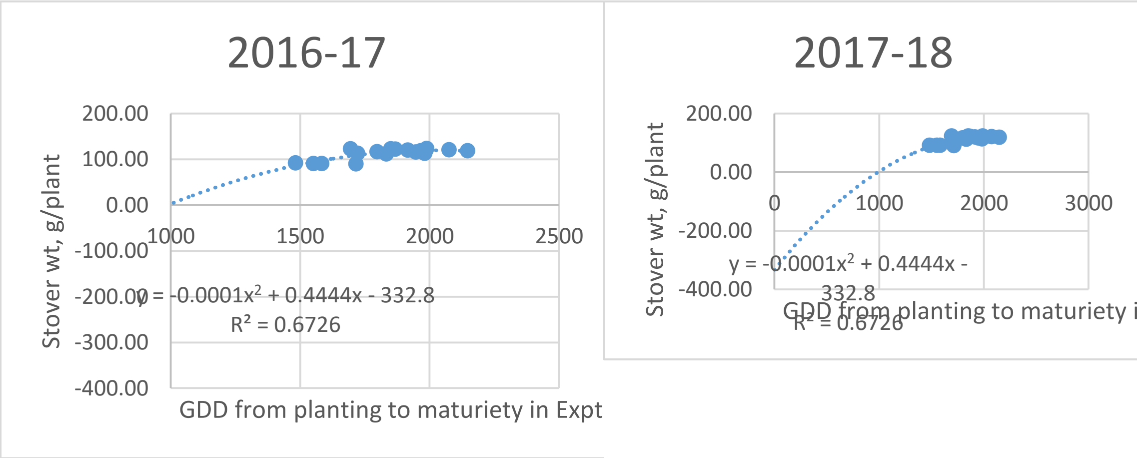


Fig.159 : Polynomial regression analyses of accumulated GDD for per plant stover weight from planting to maturity in 2016-17 and 2017-18 Rabi seasons

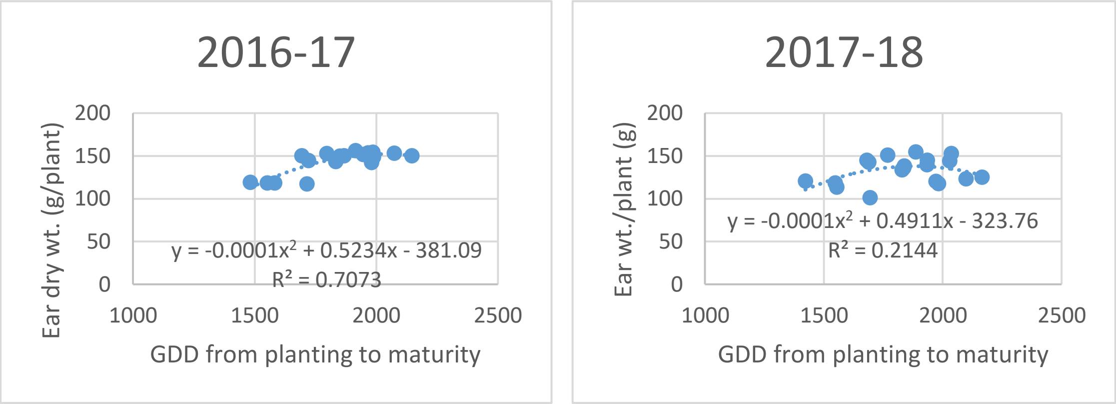


Fig.160: Polynomial regression analyses of accumulated GDD for ear dry weight from planting to maturity in 2016-17 and 2017-18 Rabi seasons

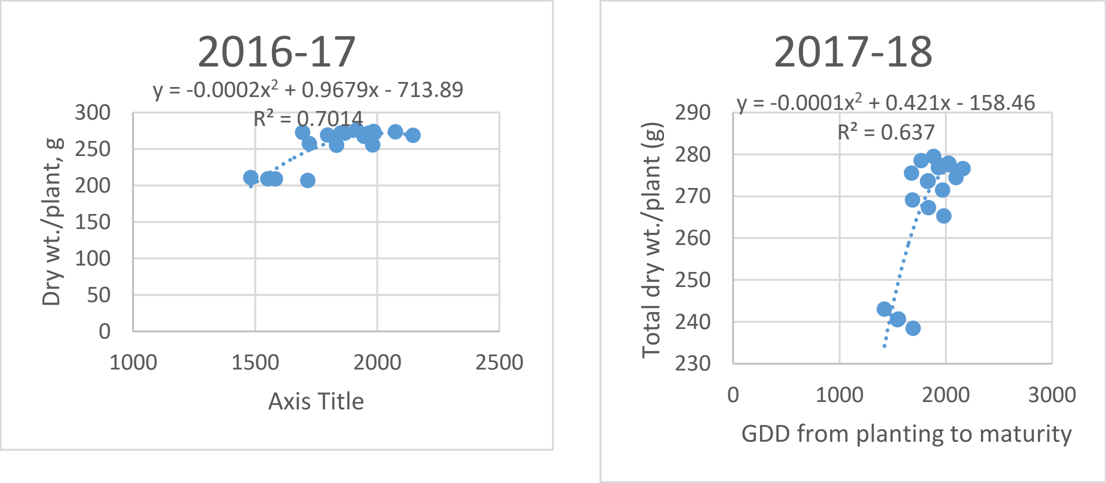


Fig.161: Polynomial regression analyses of accumulated GDD for per plant dry weight from planting to maturity in 2016-17 and 2017-18 Rabi seasons

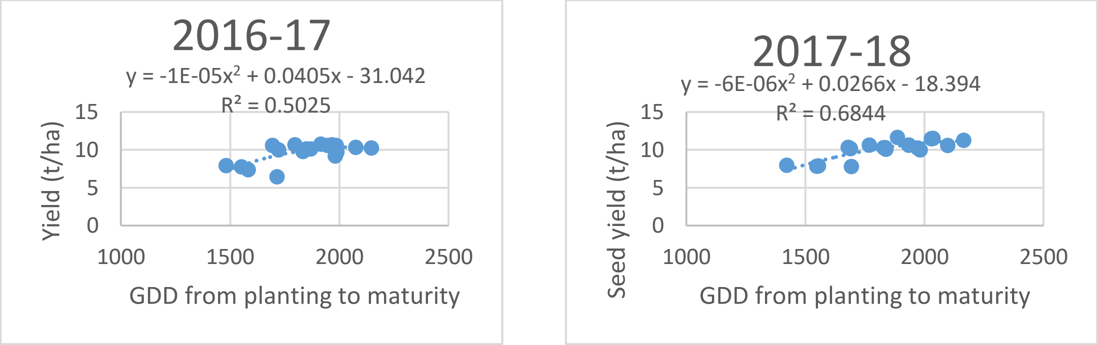


Fig.162: Polynomial regression analyses of accumulated GDD for per hectare grain yield from planting to maturity in 2016-17 and 2017-18 Rabi seasons

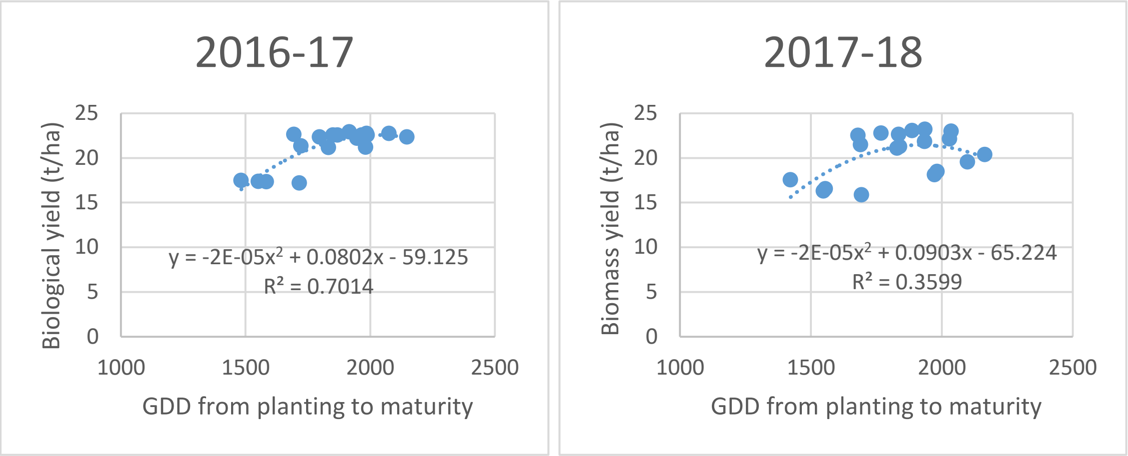


Fig.163: Polynomial regression analyses of accumulated GDD for per hectare grain yield from planting to maturity in 2016-17 and 2017-18 Rabi seasons

Effect of temperature was pronounced in maize cultivars and at different dates of planting. Maize yield was significantly high in PSC-121 over Yangnuo-7. Early planting also resulted in significantly higher yield compared to planting at later dates. Total growing degree days (GDD) was less in PSC-121 (1747) than Yangnuo-7 (1915.20) at first date of planting i.e., in late November sown crop during 2016; followed by subsequent days sown at 30 days interval. The effect of temperature in reducing the length of growing cycle especially the grain filling phase is the most important factor in explaining reduced yields at warmer temperatures (White and Reynolds, 2003).

The extreme temperatures have an adverse effect on the yield of major crops in different parts of the world. K. K. Murari *et al*. (2018) finds an inverse linear relationship between yield and extreme degree days. The impact of extreme temperature on yields (EDD) was greater than the impact of rainfall and GDD and suggests that the inverse relationship between EDD and crop yield holds for the different quantile levels. It focuses on climate and climate variability, and clearly shows that exposure to extreme heat is the most important effect of climate change on agriculture that can be currently observed in Karnataka.

As delay in planting date can lead to a linear decrease in grain yields (Anapalli *et al*., 2005). There was negative correlation between heat units and cob yield. By accelerating crop development, elevated temperatures limit the amount of solar radiation received by the plant during each developmental stage. GDD increased with the delay planting might be the increase temperature caused more respiration leading to low yield. Aggregated over the entire growing period, less interception of solar energy is problematic.

The increased temperature caused more respiration leading to low yield. G. N. Al-Karaki (2011) found that grain yield was negatively correlated with growing degree days (GDDs) to maturity, while positively correlated with GDD to heading. Increasing GDD to heading resulted in higher grain yield, while increasing grain fill duration had little effect. Rapid grain fill rate was positively correlated with grain weight and negatively correlated with grain fill duration in Jordan.

Table-6. Correlation coefficient showing the relationships among the total dry matter accumulation per plant of maize at different days after planting across varying genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6) and planting dates (25th November 2016, 10th December 2016 and 25th December 2016) in Rabi seasons 2016-17 and 2017-18)

| | **30 d dm pl$^{-1}$** | | **45 d dm pl$^{-1}$** | | **60 d dm pl$^{-1}$** | | **75 d dm pl$^{-1}$** | | **90 d dm pl$^{-1}$** | | **Harvesting dm pl$^{-1}$** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 |
| **30 d dmpl$^{-1}$** | 1.00 | 1.00 | | | | | | | | | | |
| **45 d dmpl$^{-1}$** | 0.65 | 0.16 | 1.00 | 1.00 | | | | | | | | |
| **60 d dmpl$^{-1}$** | 0.70 | 0.70 | 0.03 | 0.05 | 1.00 | 1.00 | | | | | | |
| **75 d dmpl$^{-1}$** | 0.47 | -0.16 | 0.85 | -0.10 | -0.11 | 0.22 | 1.00 | 1.00 | | | | |
| **90 d dmpl$^{-1}$** | 0.69 | -0.61 | 0.56 | -0.16 | 0.43 | -0.58 | 0.55 | 0.05 | 1.00 | 1.00 | | |
| **Harvesting dmpl$^{-1}$** | -0.05 | 0.04 | 0.21 | 0.14 | -0.05 | 0.10 | 0.23 | 0.23 | -0.03 | -0.65 | 1.00 | 1.00 |

d= day; dm=dry matter

## Experiment 2. Phenology, growth, yield attributes and yield of white maize genotypes as influenced by varying planting dates in Kharif season 2017

### 4.2.1. Days to Emergence

Corn emergence (VE stage) is achieved when the coleoptiles reach and break through the soil surface. Normally corn emerge under favourable conditions can be 4 to 5 days after planting. If cool or dry conditions exist, emergence may be delayed several weeks. At the VE stage, the nodal root system begins to grow.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to emergence. The results are presented below in.

### Effect of planting date

Date of emergence is the function of effective germination time. Data on date of emergence have been presented in (Fig. 164). Planting date significantly affected date of emergence of white maize. Crop sown on May 29 recorded the highest date of emergence which was statistically at per with May 29 planting. Different planting dates showed statistically significant differences on date of emergence. The highest date of emergence (5.82 days) was recorded from S1 that means May 29 planting which was statistically similar (5.7 days) to $S_3$. The lowest date of emergence (5.68 days) was observed from $S_2$ that mean June 21.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to emergence (Fig. 165. The highest date of emergence was found from $V_3$ (5.79 days) Yungnuo-30 which was statistically similar to $V_1$ (5.77 days) PSC-121 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest date of emergence was found from $V_2$ (5.57 days) Yungnuo-7 due to susceptible characters.

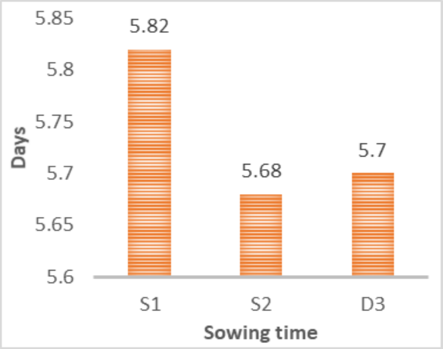


Fig 164: Days to emergence of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =0.09)

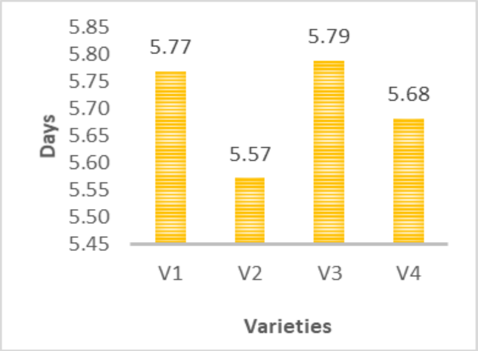


Fig 165: Days to emergence of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.1)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of emergence (Fig. 166). The highest date of emergence (5.97 days) was observed from $V_3S_1$ that mean May 29 planting with Yungnuo-30 variety followed (5.87 days) by $V_1S_1$ from PSC-121 with May 29 planting and statistically similar results (5.8 days) was also found from $V_4S_1$ that mean May 29 planting with Changnuo-6 variety. While the lowest grain yield (5.5 days) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (5.55 days) by $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety. Higher date of emergence under May 29 planting was attributed to higher date of emergence characters.

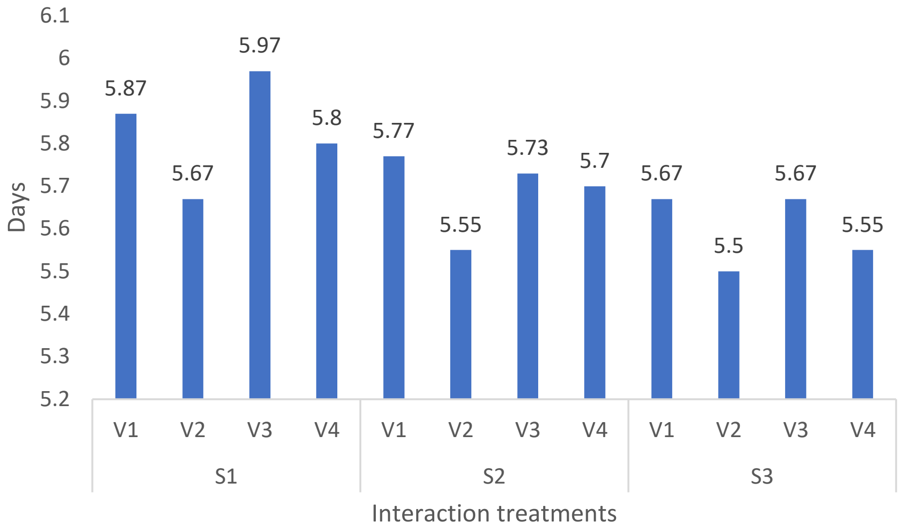


Fig.166: Days to emergence of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =0.19

According to Banotra *et al*., (2017) significant effect of planting times was noticed on days to emergence of sweet corn. March 29 planted crop took significantly higher days (5.77 days) to emerge as compared to other planting times. It was followed by the crop planted on 30 of May which took statistically similar days to emergence (5.22 days) with that of crop sown on April 15 with 5.00 days and this in turn was found statistically at par with the crop sown on 30th of April which took 4.66 days. The June 19 sown crop took significantly less (4.44days) but statistically similar days to emergence as recorded with the crops sown on May15 with 4.33 days and 30 of April.

### 4.2.2 Days to 6-collar leaf stage ($V_6$)

During these stages the uppermost ear and tassel is initiated and kernel row numbers are determined. The growing point of the corn plant is near the surface. In order to minimized negative effect of some abiotic and biotic stress on plant, planting date can play a major role in determining the seed yield, quality, seed germination and understanding whole phenological stages in many regions (Koca and Canavar, 2014).

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to 6-collar leaf stage. The results are presented below in Fig. 167 – 169.

### Effect of planting date

Data on date to 6-collar leaf stagehave been presented in (Fig. 167). Planting date significantly affected date to 6-collar leaf stageof white maize. Crop sown on May 29 recorded the highest date to 6-collar leaf stagewhich was statistically at per with May 29 planting. Different planting dates showed statistically significant differences on date to 6-collar leaf stage. The highest date to 6-collar leaf stage (21.37 days) was recorded from $S_1$ that means May 29 planting which was statistically similar (18.88 days) to $S_2$. The lowest 6-colar leaf (16.95 days) was observed from $S_3$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to 6-collar leaf stage(Fig 168). The highest date to 6-collar leaf stagewas found from $V_1$ (21.59 days) PSC-121 which was statistically similar to $V_4$ (19.22 days) Changnuo-6 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest 6-colar leaf was found from $V_2$ (17.06 days) Yungnuo-7 due to susceptible characters.

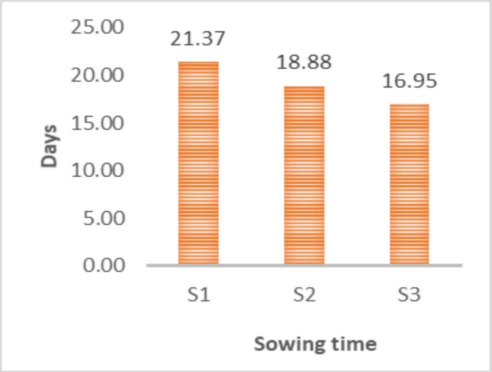


Fig 167: Days to 6-collar leaf stage of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =1.66)

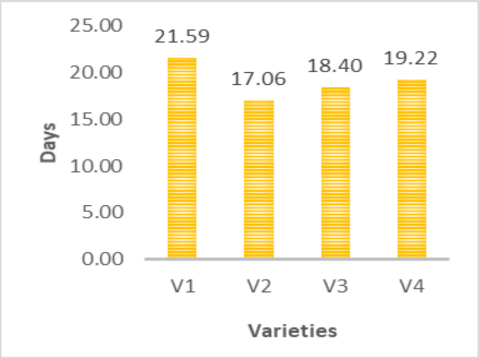


Fig.168: Days to 6-collar leaf stage of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =1.91)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date to 6-collar leaf stage (Fig. 169). The highest date to 6-collar leaf stage (24.97 days) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (21.11 days) by $V_4S_1$ from Changnuo-6 with May 29 planting and statistically similar results (20.92 days) was also found from $V_1S_1$ that mean June

21 planting with PSC-121 variety. While the lowest date to 6-collar leaf stage (15.14 days) was obtained from the treatment combination $V_2S_3$ that mean July 29 planting with Yungnuo-7 variety followed (16.02 days) by $V_3S_3$ that mean July 29 planting with Yungnuo-30 variety. Higher date to 6-collar leaf stageunder May 29 planting was attributed to higher date to 6-collar leaf stagecharacters.

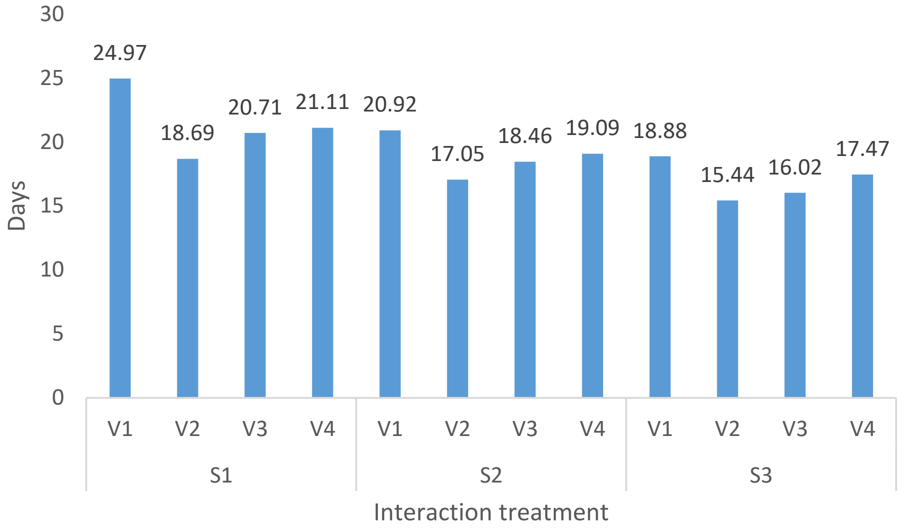


Fig.169: Days to 6-collar leaf stage of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =3.3)

### 4.2.3 Day to 10-collar leaf stage ($V_{10}$)

These stages begin the rapid growth phase. If the corn plant is stressed, lower leaves may die. During the $V_{10}$ growth stages, any management practice that helps reduce plant stress and allows for adequate nutrient levels can help maximize yield potential. 10 leaves have formed, the corn stalk elongates, and the tassel rapidly grows during this phase.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to 10-collar leaf stage. The results are presented below in Fig 170 - 172.

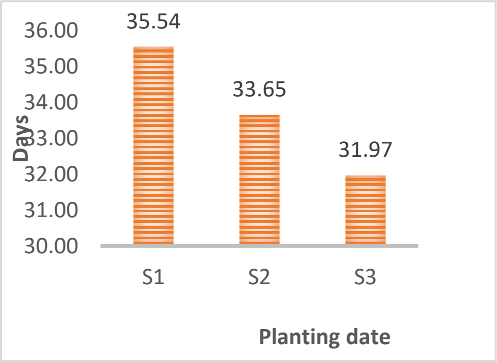
#### Effect of planting date

Data on date to 10-collar leaf stagehave been presented in fig. 170. Planting date significantly affected date to 10-collar leaf stageof white maize. Crop sown on May 29 recorded the highest date to 10-collar leaf stagewhich was statistically at per with

May 29 planting. Different planting dates showed statistically significant differences on date to 10-collar leaf stage (Fig. 170). The highest date to 10-collar leaf stage (35.54 days) was recorded from $S_1$ that means May 29 planting which was statistically similar (33.65 days) to. The lowest date of emergence (31.97 days) was observed from $S_3$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to 10-collar leaf stage (Fig. 171). The highest date to 10-collar leaf stagewas found from $V_1$ (36.26 days) PSC-121 which was statistically similar to $V_3$ (35.91 days) Yungnuo-30 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest date 10-cpllar leaf was found from $V_2$ (33.11 days) Yungnuo-7 due to susceptible characters.



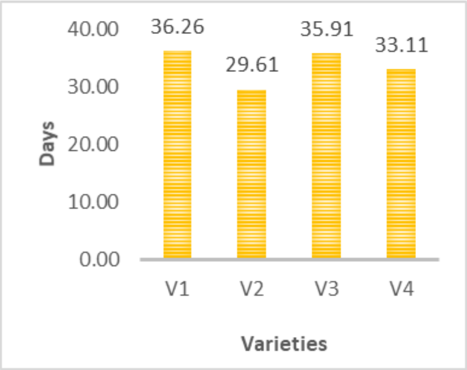


Fig. 170: Days to 10-collar leaf stage of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =2.71)

Fig.171: Days to 10-collar leaf stage of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =3.13)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date to 10-collar leaf stage (Fig. 172). The highest date to 10-collar leaf stage (38.01 days) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (37.59 days) by $V_3S_1$ from Yungnuo-30 with May 29 planting and statistically similar results (36.33 days) was aslo found from $V_1S_1$ that mean june 21 planting with PSC-121 variety. While the lowest date to 10-collar leaf stage (27.72 days) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (29.40 days) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher date to 10-collar leaf stageunder May 29 planting was attributed to higher date to 10-collar leaf stagecharacters.

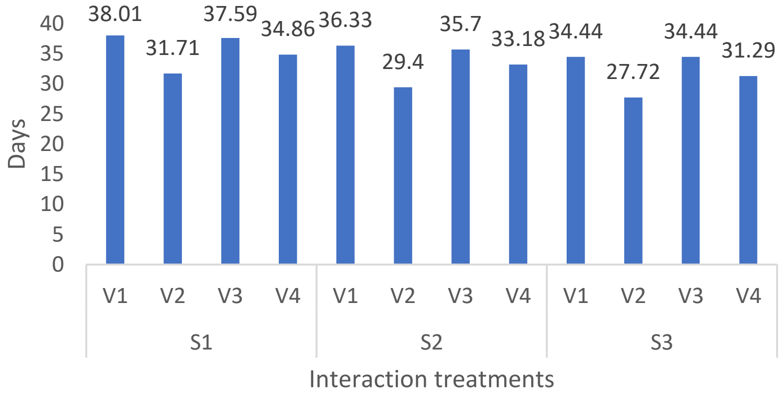


Fig. 172: Days to 10-collar leaf stage of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =5.43)

### 4.2.4 Days to 12-collar leaf stage ($V_{12}$)

At $V_{12}$, kernel row determination is almost complete. As the plant nears pollination, soil moisture and nutrient availability becomes increasingly critical for yield determination. The phenology of corn has been described as the appearance of leaves or leaf collars during the vegetative stage and accumulation of material in the grain during the reproductive stage.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to 12-collar leaf stage. The results are presented below in Fig. 173-175.

### Effect of planting date

Data on date to 12-collar leaf stagehave been presented in (Fig. 173). Planting date significantly affected date to 12-collar leaf stageof white maize. Crop sown on May 29 recorded the highest date to 12-collar leaf stagewhich was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on date to 12-collar leaf stage. The highest date to 12-collar leaf stage (38.05 days) was recorded from $S_1$ that means May 29 planting which was statistically similar

(35.71 days) to $S_2$. The lowest date of emergence (34.22 days) was observed from $S_3$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days to 12-collar leaf stage (Fig 174). The highest date to 12-collar leaf stagewas found from $V_1$ (40.30 days) PSC-121 which was statistically similar to $V_3$ (38.64 days) Yungnuo-30 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest date of emergence was found from $V_2$ (35.41 days) Yungnuo-7 due to susceptible characters.

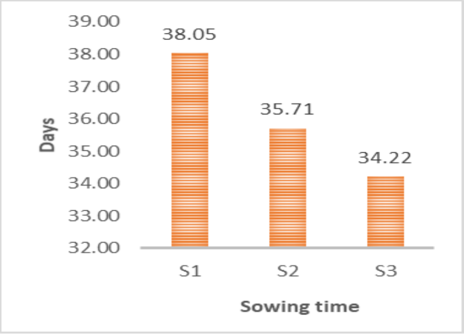


Fig.173: Days to 12-collar leaf stage of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =4.19)

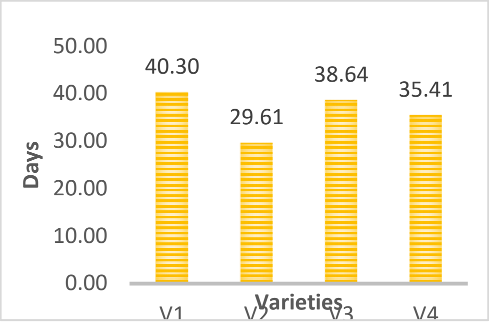


Fig.174: Days to 12-collar leaf stage of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =4.84)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date to 12-collar leaf stage (Fig. 175). The highest date to 12-collar leaf stage (42.19 days) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (40.83 days) by $V_3S_1$ from Yungnuo-30 with May 29 planting and statistically similar results (40.37 days) was aslo found from $V_1S_1$ that mean June 21 planting with PSC-121 variety. While the lowest date to 12-collar leaf stage (27.72 days) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (29.40 days) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher date to 12-collar leaf stageunder May 29 planting was attributed to higher date to 12-collar leaf stagecharacters.

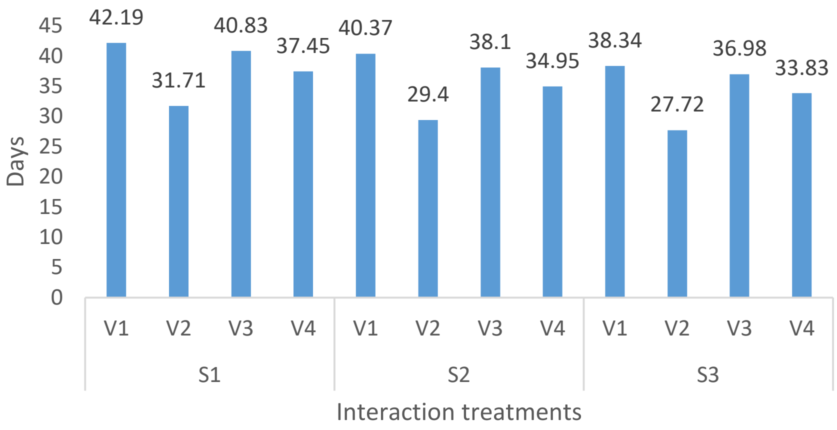


Fig.175: Days to 12-collar leaf stage of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =8.38)

### 4.2.5 Days to First tasseling

Pollination begins around 9 or 10 weeks after corn emergence. Moisture and heat stress during pollination may cause the greatest yield reduction, which can result in barren tips or loss of entire ears. Tassel stage begins when the last branch of the tassel is visible, but silks have not emerged. Tassels normally appear 2 to 3 days before silk emergence. Pollen shed typically occurs in the morning or evening.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to first tasseling. The results are presented below in Fig. 176-178.

### Effect of planting date

Date of tasseling have been presented in (Fig. 176). Planting date significantly affected date of tasselingof white maize. Crop sown on May 29 recorded the highest date of tasseling which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on date of tasseling. The highest date of tasseling (55.5 days) was recorded from $S_1$ that means May 29 planting which was statistically similar (53.33 days) to $S_2$. The lowest date of emergence (51.75 days) was observed from $S_3$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days of tasseling (Fig 177). The highest date of tasseling was found from $V_1$ (57.70 days) PSC-121 which was statistically similar to $V_3$ (55.70 days) Yungnuo-30 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest date of tasseling was found from $V_2$ (47.80 days) Yungnuo-7 due to susceptible characters.

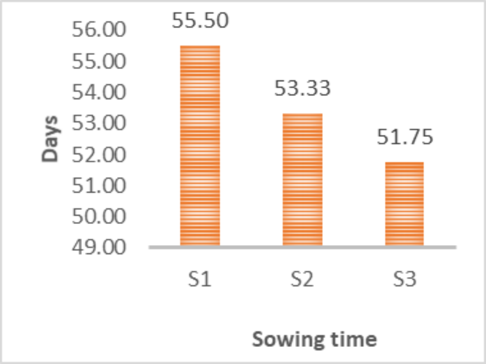


Fig.176: First tasseling of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =3.77)

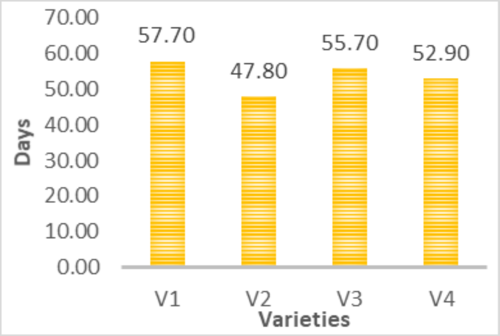


Fig. 177: Days to first tasseling of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =4.35)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of tasseling (Fig. 178). The highest date of tasseling (59.40 days) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (58.20 days) by $V_3S_1$ from Yungnuo-30 with May 29 planting and statistically similar results (57.90 days) was aslo found from $V_1S_1$ that mean June 21 planting with PSC-121 variety. While the lowest date of tasseling (45.90 days) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (47.40 days) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher date of tasseling under May 29 planting was attributed to higher date of tasseling characters.

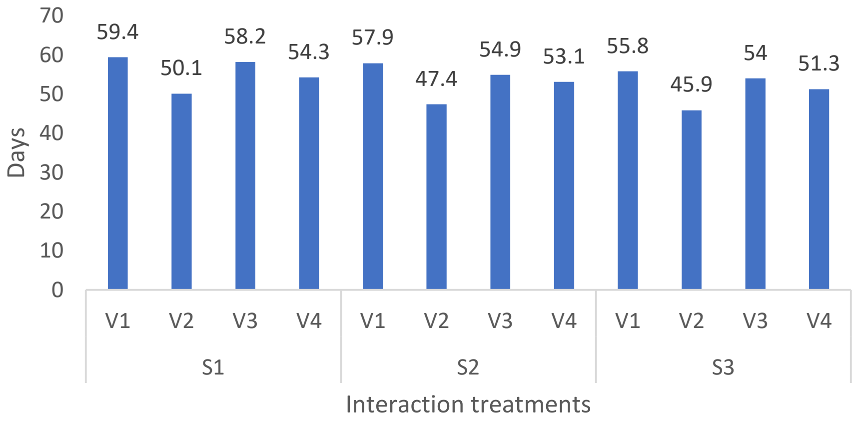


Fig.178: Days of first tasseling of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =7.54

Photoperiod and temperature can influence the timing of development events in maize (Aitken, 1977; Allison and Daynard, 1979) and influence days to tasseling in maize with appreciable genetic differences in relative sensitivity to these factors (Ellis *et al.*, 1992). These results are also supported by Khan *et al. (*2009).

At Kharif-2017 required less days to reach the tasseling stages as compared with other two season. Banotra *et al.*(2017) found 29 March sown crop took maximum days (56.31 days) to acquire 50 per cent tasselling and this was statistically at par in days taken by the crop with April 15 (55.62 days) and April 30 (55.45 days) sown crops to get to this stage. Maize variety azam belongs to medium maturity group (Khan *et al.*, 2004) hence it took significantly less days to tasseling. Days to tasseling decreased with delay in planting from March to July.

### 4.2.6 Days to 50% tasseling

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to 50% tasseling. The results are presented below in Fig. 179-181.

### Effect of planting date

Date of 50% tasseling have been presented in (Fig. 179). Planting date significantly affected date of 50% tasselingof white maize. Crop sown on May 29 recorded the highest date of 50% tasseling which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on date of 50% tasseling (Fig. 179). The highest date of tasseling (60.90 days) was recorded from $S_1$

that means May 29 planting which was statistically similar (57.68 days) to $S_2$. The lowest date of emergence (55.50 days) was observed from $S_3$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days of 50% tasseling (Fig 180). The highest date of 50% tasseling was found from $V_3$ (60.90 days) Yungnuo-30 which was statistically similar to $V_1$ (60.70 days) PSC-121 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest date of 50% tasseling was found from $V_2$ (51.90 days) Yungnuo-7 due to susceptible characters.

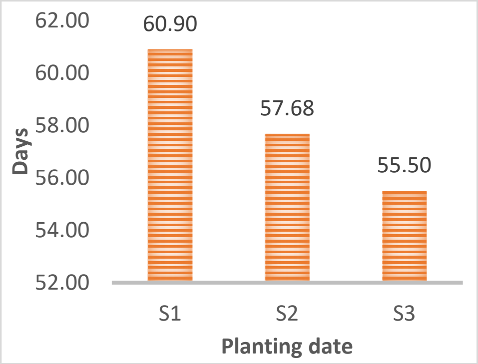


Fig. 179: Days to 50% tasseling of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =3.9

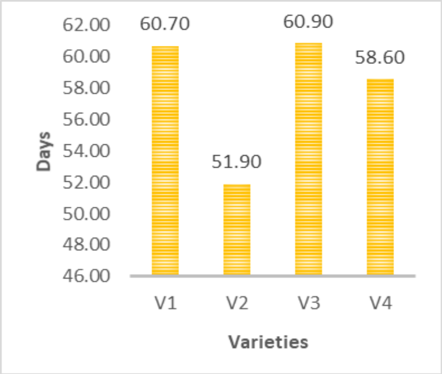


Fig.180: Days to 50% tasseling of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$= Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =4.51)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of 50% tasseling (Fig. 181). The highest date of 50% tasseling (63.90 days) was observed from $V_3S_1$ that mean May 29 planting with Yungnuo-30 variety followed (63.30 days) by $V_1S_1$ from PSC-121 with May 29 planting and statistically similar results (60.60 days) was aslo found from $V_1S_1$ that mean June 21 planting with PSC-121 variety. While the lowest date of 50% tasseling (49.50 days) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (51.30 days) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher date of 50% tasseling under May 29 planting was attributed to higher date of 50% tasseling characters.

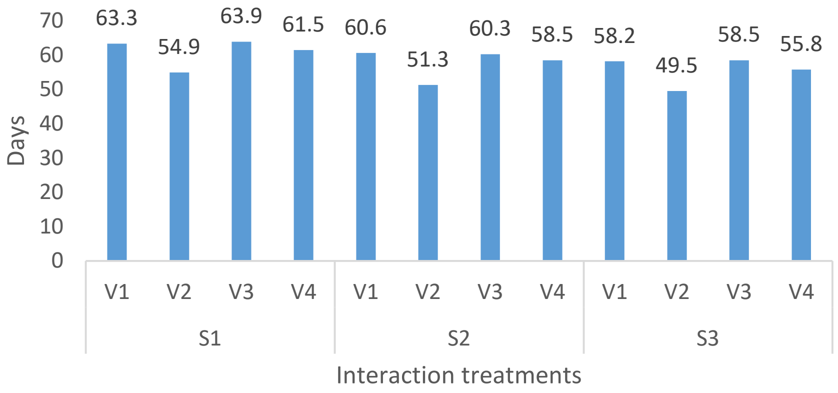


Fig. 181: Days to 50% tasseling of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =7.81)

Days to 50% tasseling was significantly by genotypes, planting time and their interactions between PSC-121 and Yungnuo-30 at Kharif-2017 It was also revealed that late planting of maize caused reduction in these attributes. Prasad *et al.(*2017) studied four planting dates of maize (15th June, 25th June, 5th July and 15th July) on five maize (*Zea mays* L.) hybrids of different maturity group{HQPM-1 (long), HM-4 (medium), HM-5 (long), HM-6 (early) and HM-7 (extra early)] and revealed that days to 50% tasseling, 50% silking and maturity were delayed in last date of planting.

Kharazmshahi *et al.* (2015) conducted a study with planting date in two levels (15 and 30 May) and they found significant difference of planting date and sweet maize hybrids on number of days to emergence tassel, number of days to anthesis, number of days to emergence spikelet, per plant.

### 4.2.7 Days to First silking

The silking stage begins when the silk is visible outside the husk. Pollen falls onto the silks to potentially fertilize the ovules. Each ovule can produce an individual kernel. Moisture stress at this time can cause the desiccation of silks and/or pollen grains, which could reduce seed set.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to first silking. The results are presented below in Fig. 182- 184.

### Effect of planting date

Date of first silking have been presented in (Fig. 182). Planting date significantly affected date of first silkingof white maize. Crop sown on May 29 recorded the highest date of first silking which was statistically at per with June 21 planting.

Different planting dates showed statistically significant differences on date of first silking (Fig. 182). The highest date of tasseling (64.42 days) was recorded from $S_1$ that means May 29 planting which was statistically similar (62.17 days) to $S_2$. The lowest date of emergence (60.42 days) was observed from $S_3$ that mean July 6.

## Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days of first silking (Fig 183). The highest date first silking was found from $V_1$ (66.11 days) PSC-121 which was statistically similar to $V_3$ (63.78 days) Yungnuo-30 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest date of first silking was found from $V_2$ (57.11 days) Yungnuo-7 due to susceptible characters.

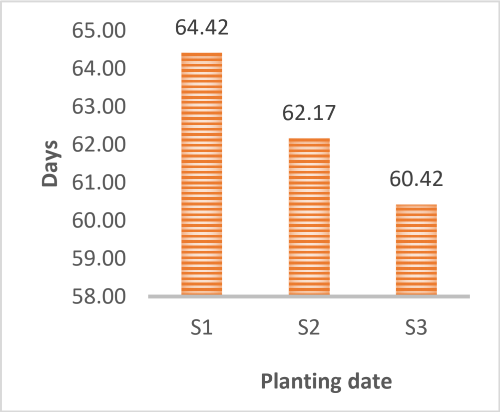


Fig. 182: Days to first silking of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =3.37)

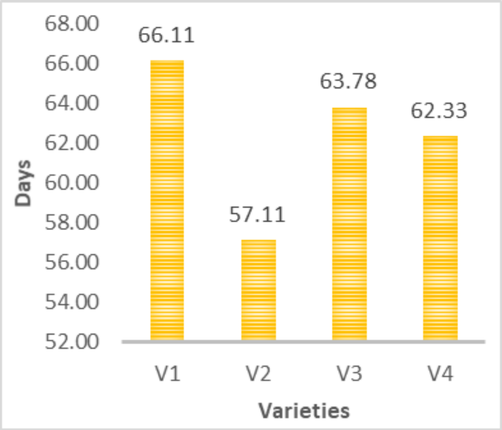


Fig. 183: Days to first silking of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =3.9)

## Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of first silking (Fig. 184). The highest date of first silking (68.33 days) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (66.00 days) by $V_1S_1$ from PSC-121 with June 21 planting and statistically similar results (64.00 days) was also found from $V_1S_3$ that mean July 6 planting with PSC-121 variety. While the lowest date of first silking (55.00 days) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (57.00 days) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher date of first silking under May 29 planting was attributed to higher date of first silking characters.

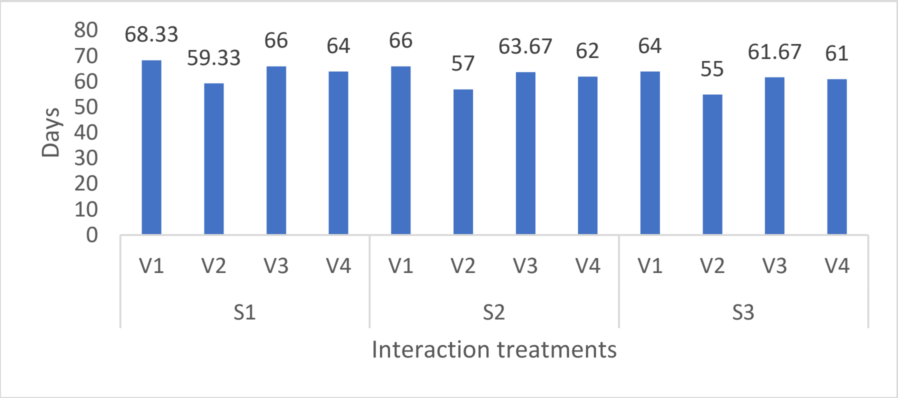


Fig. 184: Days to first silking  of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) and genotypes ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =6.75)

Determination of planting dates for maize genotypes is crucial for better crop yield. Significant effects of planting date and landraces on days to silking in corn are reported Khan *et al*. (2009) and Shafi *et al.(*2006). Planting date and variety treatments were statistically significant on variety of PSC-121, Yungnuo-7, Yungnuo-30, and Changnuo-6 at the days to tasseling.

At Kharif-2017 required less days to reach the silking stages as compared with other two season As planting date was delayed, growth occurred under greater temperatures, with associated reductions in duration of growing cycles (Otegui *et al.*, 1995). Zaki *et al. (*1994) also reported decrease in number of days to maturity when planting date was enhanced from April to June.

### 4.2.8 Days to 50% silking

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to 50% silking. The results are presented below in Fig. 185-187.

### Effect of planting date

Date of 50% silking have been presented in (Fig. 185). Planting date significantly affected date of 50% silkingof white maize. Crop sown on May 29 recorded the highest date of 50% silking which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on date of 50%

silking. The highest date of tasseling (69.50 days) was recorded from $S_1$ that means May 29 planting which was statistically similar (67.00 days) to $S_2$. The lowest date of emergence (65.50 days) was observed from S3 that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days of 50% silking (Fig 186). The highest date 50% silking was found from $V_1$ (72.33 days) PSC-121 which was statistically similar to $V_3$ (68.33 days) Yungnuo-30 due to its tolerance, decrease resistant and yield potentiality and whereas the lowest date of 50% silking was found from $V_2$ (62.33 days) Yungnuo-7 due to susceptible characters.

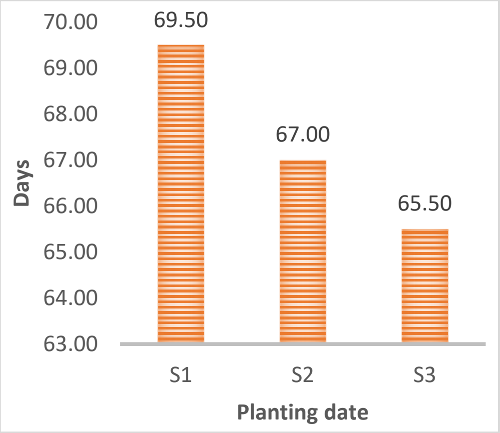


Fig. 185: Days to 50% silking of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =3.6)

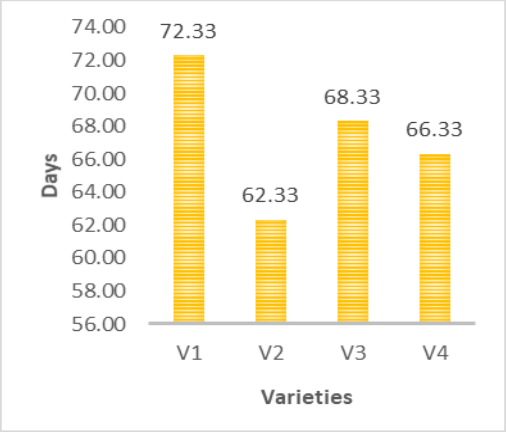


Fig.186: Days to 50% silking of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =4.16)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of 50% silking (Fig. 187). The highest date of 50% silking (75.00 days) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (72.00 days) by $V_1S_1$ from PSC-121 with June 21 planting and statistically similar results (70.00 days) was aslo found from $V_1S_3$ that mean July 6 planting with PSC-121 variety. While the lowest date of 50% silking (60.00 days) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (62.00 days) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher date of 50% silking under May 29 planting was attributed to higher date of 50% silking characters.

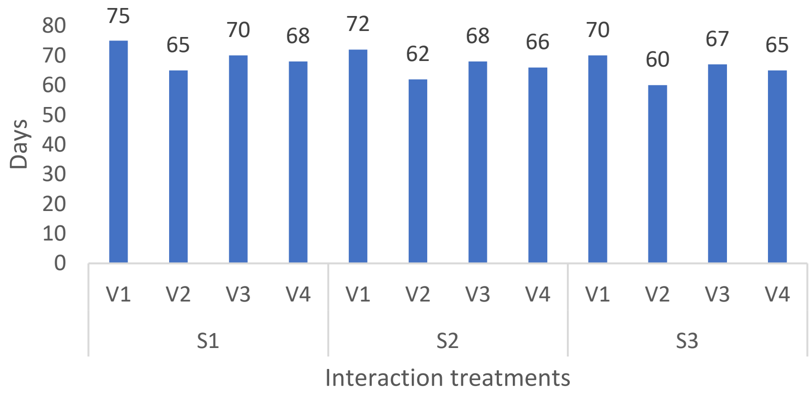


Fig.187: Days to 50% silking of white maize as influenced by varying sowing dates in Kharif 2017 season and varieties ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =7.2)

Late planting of maize caused elongation of silking to physiological maturity period due to adverse effect of low temperature on pace of maturity period as well as proper grain black layer filling was also affected (Tollenaar and Bruulsema, 1998). Daynard, (1972) observed that time interval requirement of thermal condition during planting to mid – silking stage in maize crop was lengthen whereas requirement of thermal exposure interval by mid – silking to grain black layer formation stage was shorten as a result of late seed planting.

At Kharif-2017 required less days to reach the 50% silking stages as compared with other two season because of the cumulative temperature is comparatively low than Kharif season and variety also showed variability with different temperature range. A field experiment was conducted by Verma *et al. (*2012) during *Rabi* season to study the effect of planting dates and integrated nutrient management on growth, yield and quality of winter maize. The significantly more number of days to maturity was observed in 25 Oct planting followed by 15 Oct and 5 Nov dates of planting and the average number of days to maturity were also more in 25 Oct planting as compared to other dates of planting, also supported by Andrew *et al.(*2006).

### 4.2.9 Days to Physiological Maturity

Grain fill is the last set of stages of the corn growth cycle. The plant now directs nutrients for reproductive growth instead of vegetative growth. While the number of kernels has already been determined in earlier stages, the size of the kernels is set during grain fill stages.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on days to physiological maturity. The results are presented below in Fig. 188-190.

### Effect of planting date

Date of physiological maturity have been presented in (Fig. 188). Planting date significantly affected date of physiological maturity of white maize. Crop sown on May 29 recorded the highest date of physiological maturity which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on date of physiological maturity. The highest physiological maturity (110.25 days) was recorded from $S_1$ that means May 29 planting which was statistically similar (110.25 days) to $S_2$. The lowest physiological maturity (109.75 days) was observed from $S_3$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of days of physiological maturity (Fig 189). The highest date physiological maturity was found from $V_3$ (116.22 days) Yungnuo-30 which was statistically similar to V1 (115.33 days) PSC-121 due to its tolerance, disease resistant and yield potentiality and whereas the lowest date of physiological maturity was found from $V_2$ (95.56 days) Yungnuo-7 due to susceptible characters.

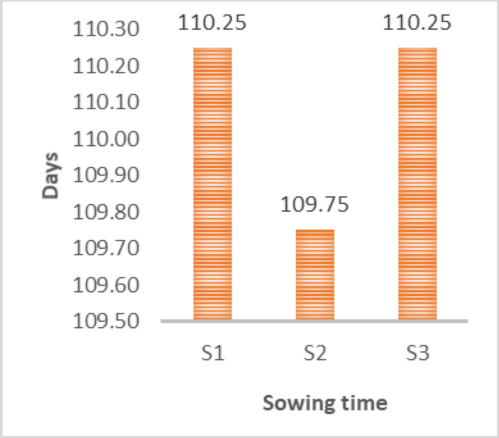


Fig.188: Days to physiological maturity of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =8.71)

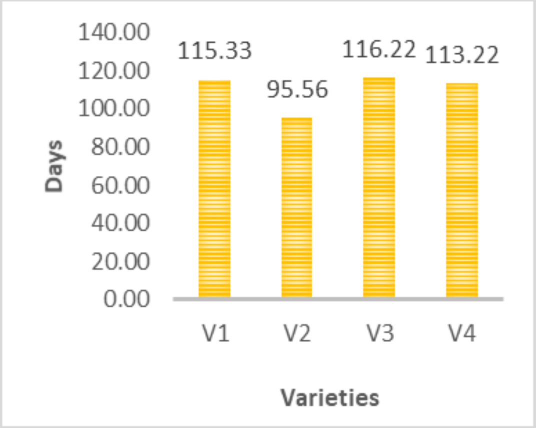


Fig.189: Days to physiological maturity of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =10.06)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of physiological maturity (Fig. 190). The highest date of physiological maturity (116.67 days) was observed from $V_3S_1$ that mean May 29 planting with Yungnuo-30 variety followed (115.67 days) by $V_1S_1$ from PSC-121 with May 29 planting and statistically similar results (116 days) was also found from $V_3S_2$ that mean June 21 planting with Yungnuo-30 variety. While the lowest date of physiological maturity (95.33 days) was obtained from the treatment combination $V_2S_1$ that mean May 29 planting with Yungnuo-7 variety followed (95.67 days) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher date of physiological maturity under May 29 planting was attributed to higher date of physiological maturity characters.

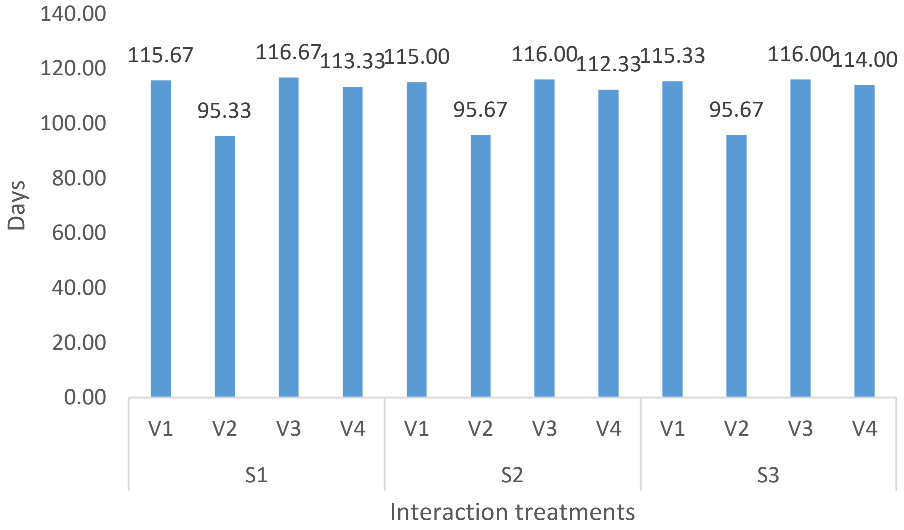


Fig.190: Days to physiological maturity of white maize as influenced by varying sowing dates in Kharif 2017 season and varieties ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =17.43)

Khan *et al.* (2011) reported that days to maturity decreased when planting was delayed from March to June, however further delay in planting increased number of days to maturity. These results are supported by Khan *et al. (*2009) and Zaki *et al. (*1994) who reported decrease in days to maturity with delaying of planting from April to July. As planting date was delayed, growth occurred under greater temperatures, with associated reductions in duration of growing cycles (Otegui *et al.*, 1995). Zaki *et al. (*1994) also reported decrease in number of days to maturity when planting date was enhanced from April to June. While further delay in planting to August, they noted an increase in number of days to maturity.

### 4.2.10 Plant height

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on plant height. The results are presented below in Fig. 191-193.

### Effect of planting date

Date of plant height have been presented in (Fig. 191). Planting date significantly affected date of plant height of white maize. Crop sown on May 29 recorded the highest plant height which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on date of plant height. The highest plant height (201.48 cm) was recorded from $S_1$ that means May 29 planting which was statistically similar (180.88 cm) to $S_2$. The lowest plant height (157.44 days) was observed from $S_3$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of plant height (Fig 192). The highest height was found from $V_1$ (204.53 cm) PSC-121 which was statistically similar to $V_4$ (183.72 cm) Changnuo-6 due to its tolerance, disease resistant and yield potentiality and whereas the lowest height was found from $V_2$ (157.42 cm) Yungnuo-7 due to susceptible characters.

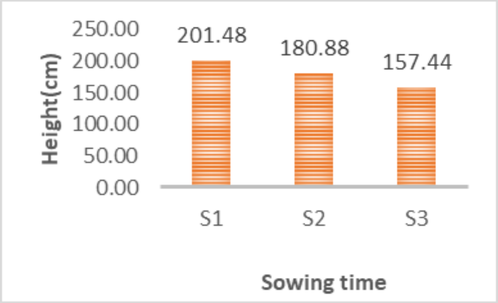


Fig. 191: Days to plant height of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =17.14)

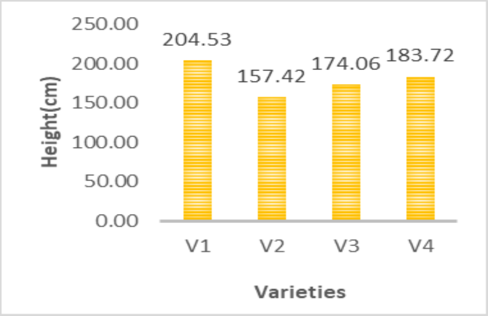


Fig.192: The plant height of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =19.84)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of plant height (Fig. 193). The highest plant height (221.07cm) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (215.33 cm) by $V_4S_1$ from Changnuo-6 with May 29 planting and statistically similar results (209.67cm) was also found from $V_1S_1$ that mean June 21 planting with PSC-121 variety. While the lowest date of plant height (136.27 cm) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (146.70 cm) by $V_3S_3$ that mean July 6 planting with Yungnuo-30 variety. Higher date of plant height under May 29 planting was attributed to higher date of plant height characters.

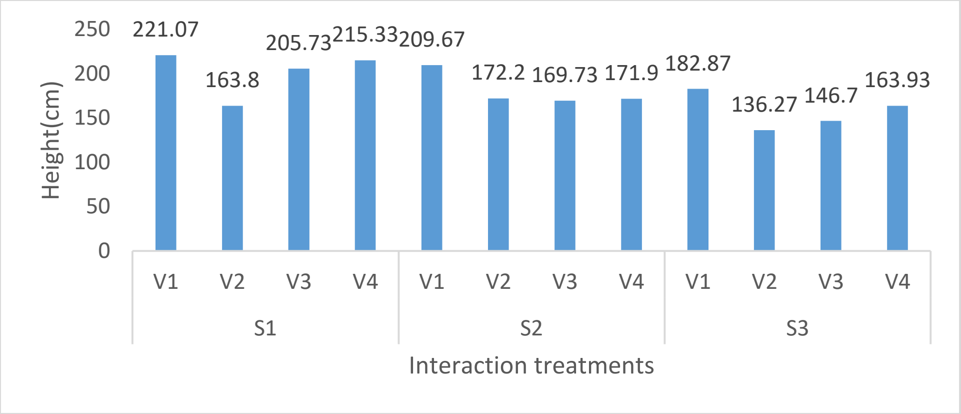


Fig.193: The plant height of white maize as influenced by varying sowing dates in Kharif 2017 season and varieties ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =-34.36)

### 4.2.11 Number of leaves per plant at maturity

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on number of leaf per plant. The results are presented below in Fig. 31-33.

### Effect of planting date

Date of number of leaf have been presented in (Fig. 194). Planting date significantly affected number of leaf of white maize. Crop sown on May 29 recorded the highest number of leaf which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on date of number of leaf. The highest number (14.88) was recorded from $S_1$ that means May 29 planting which was statistically similar (14.6) to $S_2$. The lowest plant height (14.32) was observed from $S_3$ that mean July 6.

**Effect of variety**

Statistically significant variation was observed for different white maize genotypes in terms of number of leaf (Fig 195). The highest number was found from $V_4$ (15.47) Changnuo-6 which was statistically similar to $V_1$ (15.04) PSC-121 due to its tolerance, disease resistant and yield potentiality and whereas the lowest number was found from $V_2$ (13.13) Yungnuo-7 due to susceptible characters.

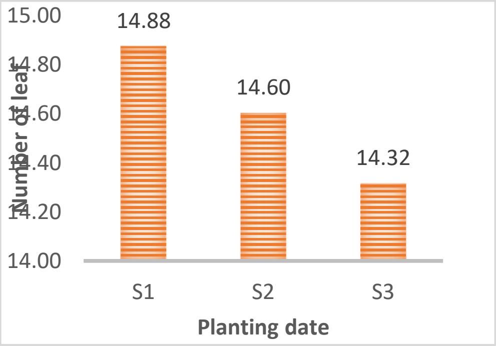


Fig. 194: The number of leaves per plant of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017; LSD5% =1.06)

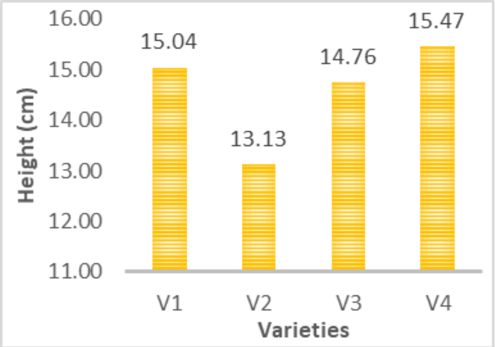


Fig.195: The number of leaves of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =1.23)

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of number of leaf (Fig. 196). The highest number of leaf (16) was observed from $V_4S_1$ that mean May 29 planting with Changnuo-6 variety followed (15.60) by $V_1S_1$ from PSC-121 with June 21 planting and statistically similar results (15.40) was aslo found from $V_4S_2$ that mean June 21 planting with Changnuo-6 variety. While the lowest date of number of leaf (12.92) was obtained from the treatment combination $V_2S_1$ that mean May 29 planting with Yungnuo-7 variety followed (13.13) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher date of number of leaf under May 29 planting was attributed to higher number of leaf characters.

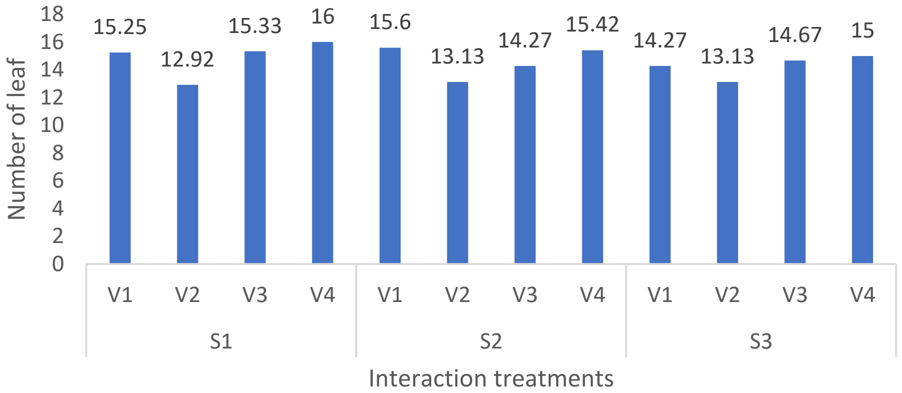


Fig.196: The number of leaves per plant of white maize as influenced by varying sowing dates in Kharif 2017 season and varieties ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =2.13)

### 4.2.12 Leaf area per plant

Leaf area per plant varied depending upon the growth stages, the smallest (0.017-0.032 $m^2$ at 30 DAS while the greatest (0.596-0.707 $m^2$ at 90 DAS. That is with the advancement of plant age the leaf area of the individual plant progressively increased. At the earlier stages the leaf area of the treatments were inconsistent while at the later stages the effect of the treatments were found to be conspicuous.

### Effect of planting dates

At the 90 DAS the leaf area in most of the cases was found to be greater with the second planting which at the latest stage ranged from 0.670-0.672 $m^2$.

### Effect of genotypes

At the maturity the leaf area in most of the cases was found to be greater with the Changnuo-6 which at the latest stage 0.533-0.648 $m^2$. Leaf area was the greatest with the at 90 DAS showing the highest with Changnuo-1 and at this stage the leaf area ranged from 0.599-0.697.

### Interaction effect of planting dates and genotypes

At the maturity the leaf area in most of the cases was found to be greater with the interaction effect of $S_3$ an Changnuo-1 and at this stage the leaf area per plant ranged 0.533-0.564 $m^2$. Leaf area was the greatest at 90 DAS showing the highest with the $V_1S_1$ and $V_3S_1$; and at this stage the leaf area ranged from 0.590-0.705, the highest with $V_3S_1$.

Table-7: Leaf area per plant of white maize as influenced by varying sowing dates in Kharif 2017 season and varieties ($S_1$= sown on 29/05/2017, $S_2$= sown on 21/06/2017, $S_3$= sown on 06/07/2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =0.049)

| Leaf area/plant ($m^2$) | | | | | | |
|---|---|---|---|---|---|---|
| | 30 | 45 | 60 | 75 | 90 | harvesting |
| Treat | | | | | | |
| $S_1$ | 0.025 | 0.061 | 0.255 | 0.445 | 0.670 | 0.609 |
| $S_2$ | 0.023 | 0.059 | 0.254 | 0.444 | 0.672 | 0.614 |
| $S_3$ | 0.025 | 0.062 | 0.254 | 0.438 | 0.671 | 0.611 |
| LSD (0.05) | 0.49 | 0.46 | 0.32 | 0.22 | 0.29 | 0.32 |
| $V_1$ | 0.022 | 0.061 | 0.238 | 0.440 | 0.695 | 0.623 |
| $V_2$ | 0.026 | 0.062 | 0.247 | 0.414 | 0.599 | 0.533 |
| $V_3$ | 0.023 | 0.060 | 0.241 | 0.433 | 0.693 | 0.648 |
| $V_4$ | 0.026 | 0.059 | 0.292 | 0.483 | 0.697 | 0.642 |
| LSD (0.05) | 0.5 | 0.05 | 0.37 | 0.25 | 0.34 | 0.37 |
| $v_1s_1$ | 0.017 | 0.054 | 0.202 | 0.401 | 0.698 | 0.621 |
| $V_1S_2$ | 0.027 | 0.071 | 0.279 | 0.450 | 0.707 | 0.627 |
| $v_1s_3$ | 0.023 | 0.059 | 0.232 | 0.469 | 0.680 | 0.620 |
| $v_2s_1$ | 0.035 | 0.059 | 0.308 | 0.435 | 0.590 | 0.532 |
| $v_2s_2$ | 0.016 | 0.055 | 0.189 | 0.371 | 0.596 | 0.540 |
| $v_2s_3$ | 0.027 | 0.072 | 0.244 | 0.437 | 0.612 | 0.526 |
| $v_3s_1$ | 0.022 | 0.056 | 0.225 | 0.437 | 0.704 | 0.635 |
| $v_3s_2$ | 0.027 | 0.056 | 0.297 | 0.452 | 0.681 | 0.654 |
| $v_3s_3$ | 0.019 | 0.069 | 0.201 | 0.410 | 0.696 | 0.654 |
| $v_4s_1$ | 0.024 | 0.073 | 0.284 | 0.507 | 0.690 | 0.646 |
| v4s2 | 0.021 | 0.055 | 0.253 | 0.504 | 0.705 | 0.636 |
| v4s3 | 0.032 | 0.049 | 0.338 | 0.437 | 0.695 | 0.645 |
| LSD (0.05) | 0.09 | 0.09 | 0.64 | 0.44 | 0.59 | 0.64 |
| CV (5%) | 36.39 | 13.64 | 22.42 | 8.85 | 7.91 | 9.31 |

## Leaf Area Index (LAI) at different stages

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on leaf area index. The results are presented below in Fig. 197-200 variety wise showing the effect under different planting dates at 30, 45, 60, 75, 90 and harvesting stages.

### Effect of planting date

LAI have been presented in (Fig. 197-200). Planting date significantly affected LAI of white maize. Crop sown on May 29 recorded the highest LAI which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on LAI. The highest number (4.36) was recorded from $S_1$ that means May 29 planting which was statistically similar (4.36) to $S_2$ and closely followed (4.31) by $S_3$. The lowest LAI (0.11) was observed from $S_1$ that mean May 29.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of Leaf area index (Fig 197-200). The LAI was found from $V_3$ (4.36) Yungnuo-30 which was statistically similar to $V_3$ (4.36) Yungnuo-30 due to its tolerance, disease resistant and yield potentiality and whereas the lowest number was found from $V_1$ (0.11) PSC-121 due to susceptible characters.

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of LAI (Fig. 197-200). The highest LAI (4.36) was observed from $V_3S_1$ that mean May 29 planting with Yungnuo-30 variety followed (4.36) by $V_3S_2$ from Yungnuo-30 with June 21 planting and statistically similar results (4.31) was also found from $V_3S_3$ that mean July 6 planting with Yungnuo-30 variety. While the lowest LAI (0.11) was obtained from the treatment combination $V_1S_1$ that mean May 29 planting with Yungnuo-7 variety followed (0.11) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher LAI under December 25 planting was attributed to LAI characters.

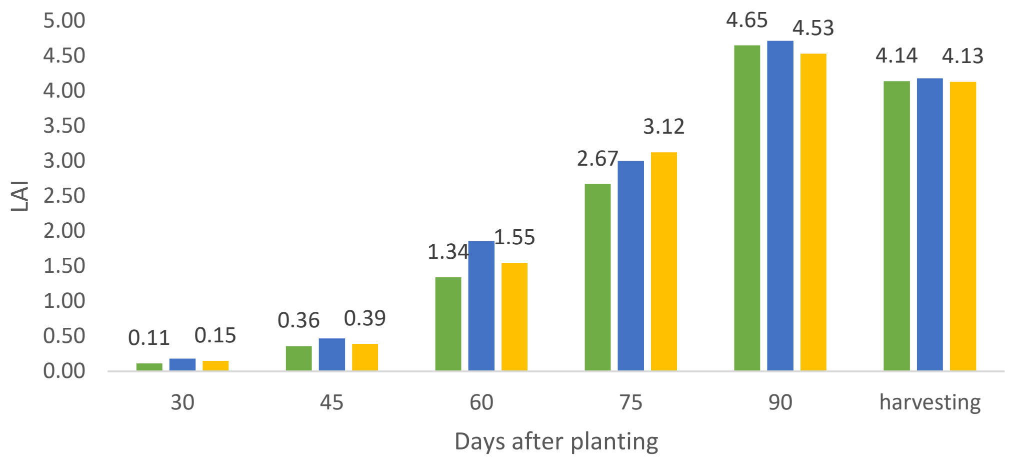


Fig. 197: Leaf area index of a white maize variety ($V_1$=PSC-121) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017).

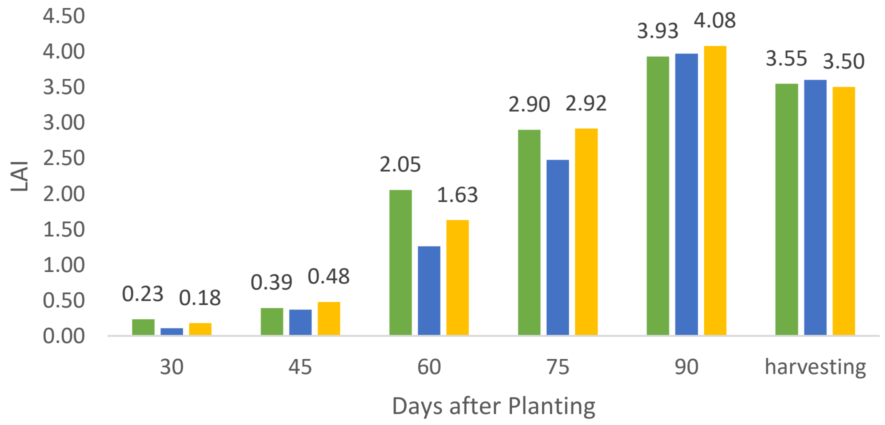


Fig. 198: Leaf area index of a white maize variety ($V_2$=Yangnuo-7) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017)

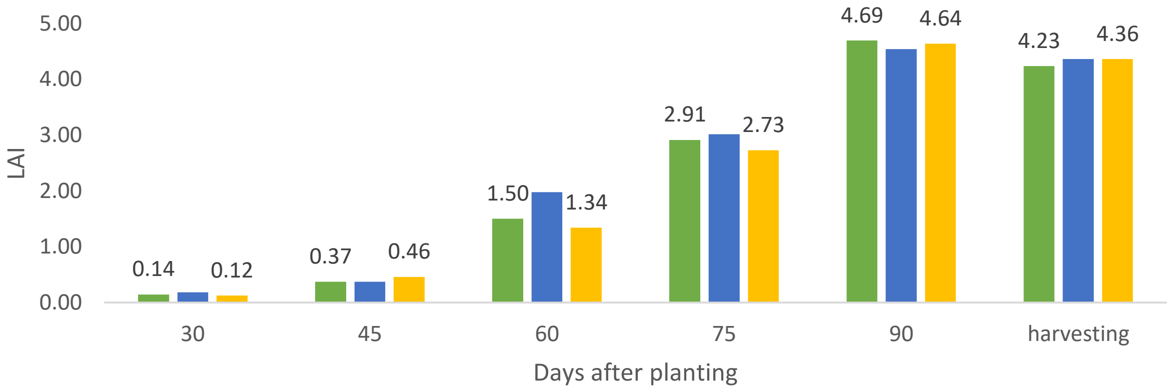


Fig.199: Leaf area index of a white maize variety ($V_3$=Changnuo-1) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017).

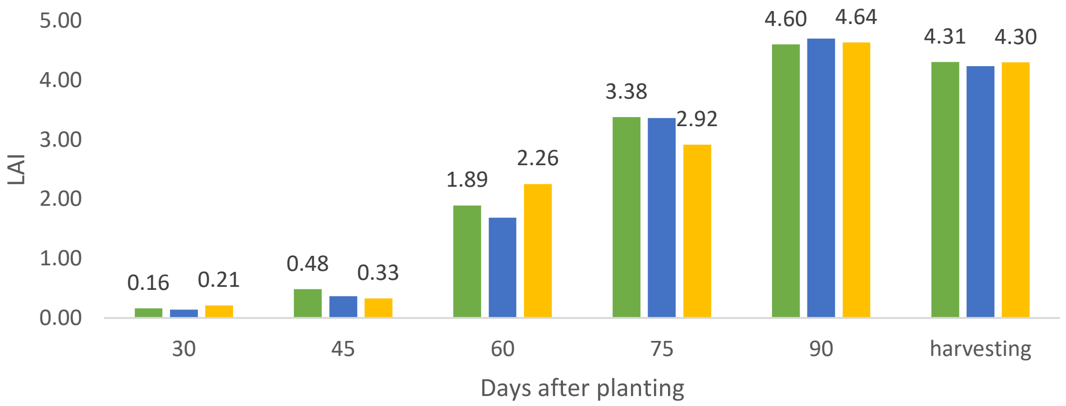


Fig.200: Leaf area index of a white maize variety ($V_4$=Changnuo-6) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017)

### 4.2.13 Dry weight per plant from 30 to 90 DAS

Dry weight per plant increased progressively with the advancement of growth stages from 30 days after planting up to maturity.

### Effect of planting dates

At 30 DAS each plant accumulated dry weight at around 19 and 20 g which at Rabi season was found to be higher (30 g) in the previous Rabi season. The dry weight gradually increased and attained 79-80 g at 75 (almost flowering) and then finally reached at around 118.08 g at 90 DAS. It was apparent that the dry weight decreased with the delay of planting date although the second planting in some of the growth stages had higher dry weight compared to other planting dates, but this was not significantly higher than others.

### Effect of genotypes

The variety had significant effect on the dry weight per plant of white maize. The variety Yangnuo-7 had the least dry weight compared to others among which either the variety Changnuo-1 or Changnuo-6 had the highest dry weight at certain growth stages although they seemed having no significant difference.

### Interaction effect

The interaction effect of the planting dates and variety was significant on the dry weight per plant. It ranged from 18.74 to 19.87 g at the 30 DAS while increasing progressively throughout the phenological stages showed dry matter range 107.46-122.45 g at 90 DAS. Yangnuo-7 at all the growth stages had lower dry weight per plant (107.46-108.71g) which were significantly lower than other interaction treatments. Other three genotypes had had almost invariable data although the highest dry weight was observed with Changnuo-1 under first and second planting (123.70g).

**Table-8 Dry weight per plant at different growth stages of white maize genotypes under varying planting dates in experiment 2.**

| Growth stages | | | | | |
|---|---|---|---|---|---|
| Treatments | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 90 DAS |
| $S_1$ | 19.44 | 28.74 | 46.86 | 79.97 | 116.52 |
| $S_2$ | 19.43 | 29.36 | 47.79 | 80.28 | 118.08 |
| $S_3$ | 19.50 | 28.74 | 46.86 | 79.03 | 114.33 |
| LSD (0.05%) | 0.89 | 0.99 | 1.12 | 0.96 | 1.24 |
| $V_1$ | 19.47 | 27.49 | 46.65 | 80.80 | 118.29 |
| $V_2$ | 19.35 | 24.57 | 38.73 | 72.47 | 107.87 |
| $V_3$ | 19.40 | 32.07 | 52.48 | 81.63 | 119.54 |
| $V_4$ | 19.60 | 31.65 | 50.81 | 84.13 | 119.54 |
| LSD (0.05%) | 0.56 | 1.23 | 2.12 | 2.34 | 1.24 |
| $v_1s_1$ | 18.99 | 27.49 | 46.23 | 79.97 | 118.70 |
| $V_1S_1$ | 19.74 | 27.49 | 47.48 | 81.22 | 117.45 |
| $v_1s_3$ | 19.68 | 27.49 | 46.23 | 81.22 | 118.70 |
| $v_2s_1$ | 19.87 | 24.99 | 38.73 | 72.47 | 107.46 |
| $v_2s_2$ | 18.74 | 24.99 | 38.73 | 72.47 | 108.71 |
| $v_2s_3$ | 19.43 | 23.74 | 38.73 | 72.47 | 107.46 |
| $v_3s_1$ | 19.37 | 31.24 | 52.48 | 82.47 | 118.70 |
| $v_3s_2$ | 19.80 | 32.49 | 53.73 | 81.22 | 123.70 |
| $v_3s_3$ | 19.04 | 32.49 | 51.23 | 81.22 | 116.20 |
| $v_4s_1$ | 19.52 | 31.24 | 49.98 | 84.97 | 121.20 |
| $v_4s_2$ | 19.43 | 32.49 | 51.23 | 86.22 | 122.45 |
| $v_4s_3$ | 19.85 | 31.24 | 51.23 | 81.22 | 114.95 |
| LSD (0.05%) | 0.78 | 0.65 | 0.78 | 1.23 | 2.21 |
| CV(5%) | 10.02 | 10.61 | 11.91 | 10.50 | 10.69 |

### Relations of dry matter with the leaf area

Irrespective of planting dates and genotypes, there was a positive relations of dry weight per plant at maturity with the leaf area per plant at 90 DAS Fig. 201).

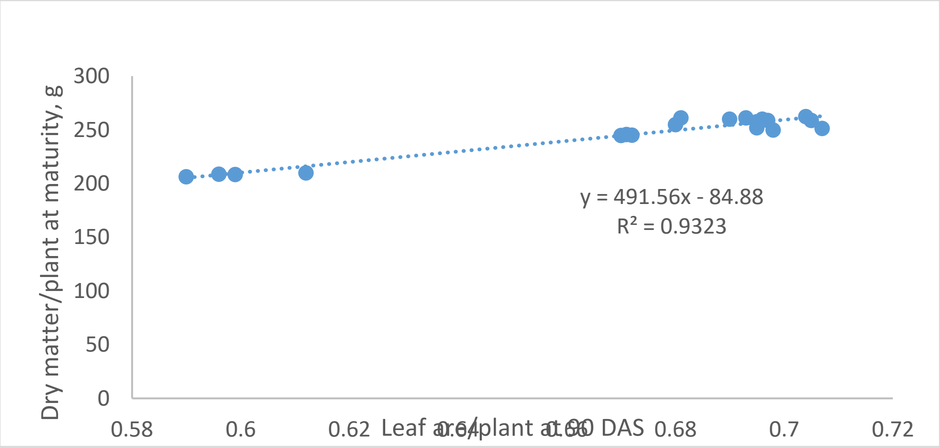


Fig.201: Relations of dry matter with leaf area

### 4.2.14Crop Growth Rate (CGR)

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on crop growth rate. The results are presented below in Fig. 201-204 variety wise showing the effect under different planting dates at 30, 45, 60, 75, 90 and harvesting stages.

### Effect of planting date

CGR have been presented in (Fig. 201). Planting date significantly affected CGR of white maize. Crop sown on July 6 recorded the highest CGR which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on CGR (Fig 201-204). The highest CGR (23.74) was recorded from $S_3$ that means May 29 planting which was statistically similar (23.12) to $S_1$ and closely followed (22.70) by S2. The lowest CGR (1.92) was observed from $S_3$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of CGR (Fig 201-204). The highest CGR was found from $V_4$ (23.74) Changnuo-6 which was statistically similar to $V_4$ (23.12) Changnuo-6 due to its tolerance, disease resistant and yield potentiality and whereas the lowest CGR was found from $V_2$ (1.92) Yungnuo-7 due to susceptible characters.

## Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of CGR (Fig. 201-204). The highest CGR (23.74) was observed from $V_4S_3$ that  mean July 6 planting with Changnuo-6 variety followed (23.12) by $V_4S_1$ from Changnuo-6 with May 29 planting and statistically similar results (22.70) was aslo found from $V_4S_2$ that mean June 21 planting with Changnuo-6 variety. While the lowest  CGR (1.92) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yangnuo-7 variety followed (2.28) by $V_2S_1$ that mean May 29 planting with  Yangnuo-7 variety. Higher CGR under July 6 planting was attributed to CGR characters.

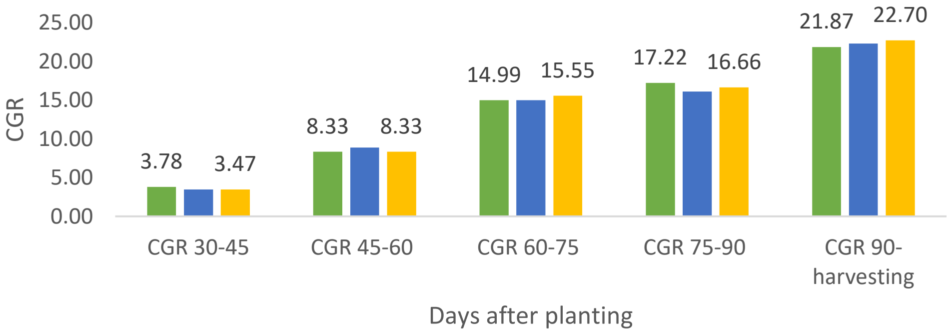


Fig 202: Crop growth rate of a white maize variety ($V_1$=PSC-121) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017)

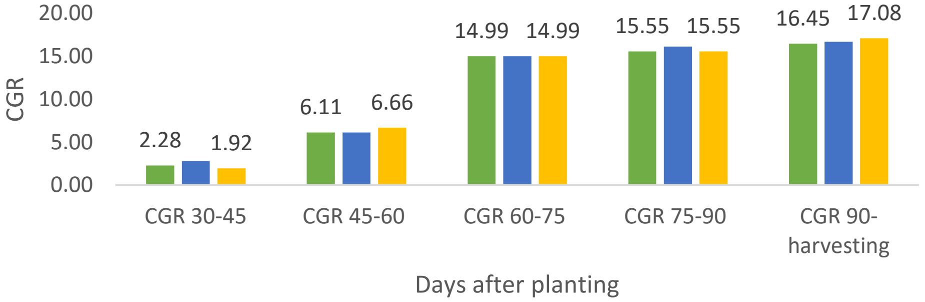


Fig.203: Crop growth rate of a white maize variety ($V_2$=Yangnuo-7) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017)

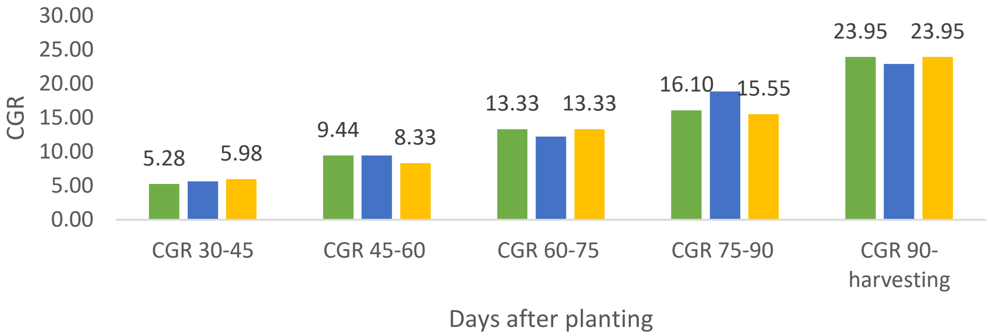


Fig.204: Crop growth rate of a white maize variety ($V_3$=Changnuo-1) at different growth stages as influenced by varying planting dates ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) in Kharif-2017 season

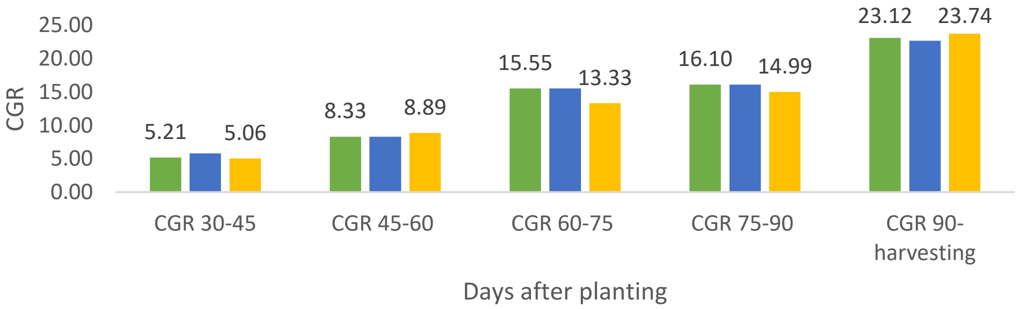


Fig.205: Crop growth rate of a white maize variety ($V_4$=Changnuo-6) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017)

### 4.2.15 Relative Growth Rate (RGR)

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on relative growth rate. The results are presented below in Fig. 205 variety wise showing the effect under different planting dates at 30, 45, 60, 75, 90 and harvesting stages.

#### Effect of planting date

RGR have been presented in (Fig. 205-208). Planting date significantly affected RGR of white maize. Crop sown on June 21 recorded the highest RGR which was statistically at per with July 6 planting. Different planting dates showed statistically significant differences on RGR. The highest RGR (0.21) was recorded from $S_2$ that means June 21 planting which was statistically similar (0.20) to $S_3$ and closely followed (0.19) by $S_1$. The lowest RGR (0.0) was observed from $S_1$ that mean May 29.

**Effect of variety**

Statistically significant variation was observed for different white maize genotypes in terms of RGR (Fig 205-208). The highest RGR was found from $V_2$ (0.21) Yungnuo-7 which was statistically similar to $V_3$ (0.20) Yungnuo-30 due to its tolerance, disease resistant and yield potentiality and whereas the lowest CGR was found from $V_1$ (0.0) PSC-121 due to susceptible characters.

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of RGR (Fig. 205-208). The highest RGR (0.21) was observed from $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety followed (0.20) by $V_3S_3$ from Yungnuo-30 with July 6 planting and statistically similar results (0.19) was aslo found from $V_1S_1$ that mean May 29 planting with PSC-121 variety. While the lowest RGR (0.0) was obtained from the treatment combination $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (0.0) by $V_1S_1$ that mean June 21 planting with PSC-121 variety. Higher RGR under June 21 planting was attributed to RGR characters.

Total crop dry matter is the spatial and temporal integration of all plant processes and therefore, crop dry matter is the most relevant parameter in the study of crop canopies. Rate of dry matter accumulation varies across the life cycle of a crop and dry matter and leaf area are sampled at intervals ranging from days to weeks to quantify effects of environmental influences or to analyze genotypic differences between crop cultivars. In growth analysis two basic measurements are made, dry weight and leaf area and a large number of parameters are derived from these measurements such as LAI, CGR, RGR and NAR. LAI reached its maximum value at harvesting stage days.

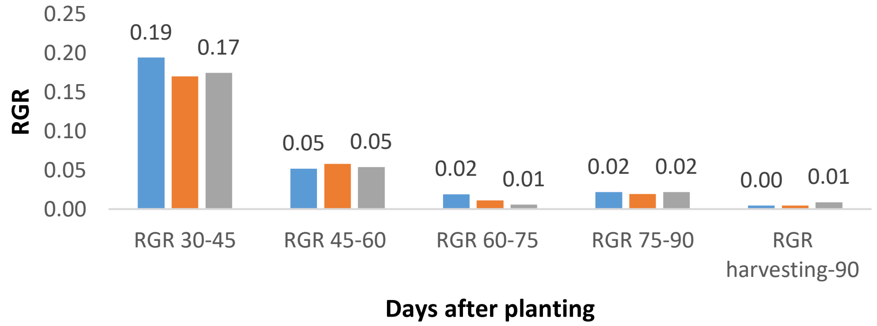


Fig 206: Relative growth rate of a white maize variety ($V_1$=PSC-121) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017)

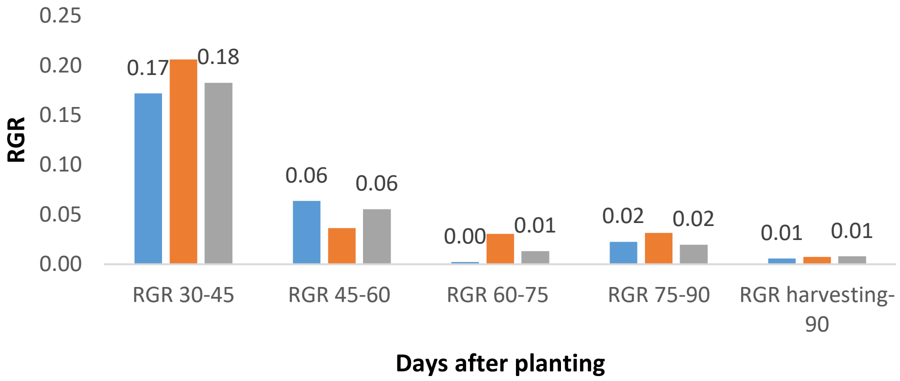


Fig 207: Relative growth rate of a white maize variety ($V_2$=Yangnuo-7) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017)

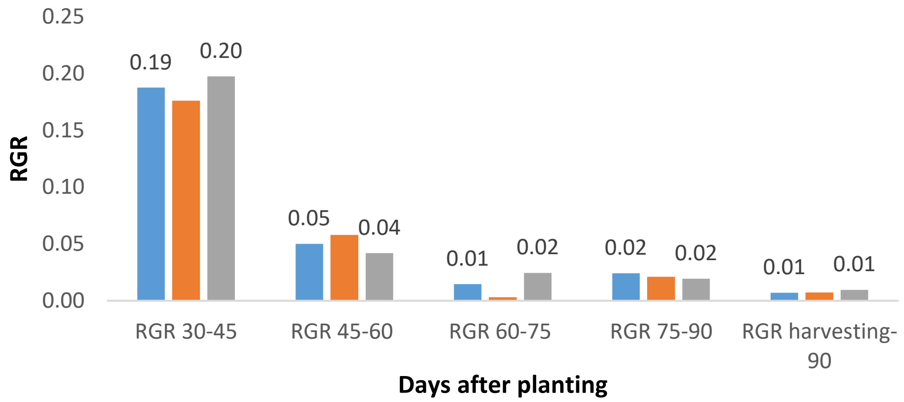


Fig 208: Relative growth rate of a white maize variety ($V_3$=Changnuo-1) at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017).

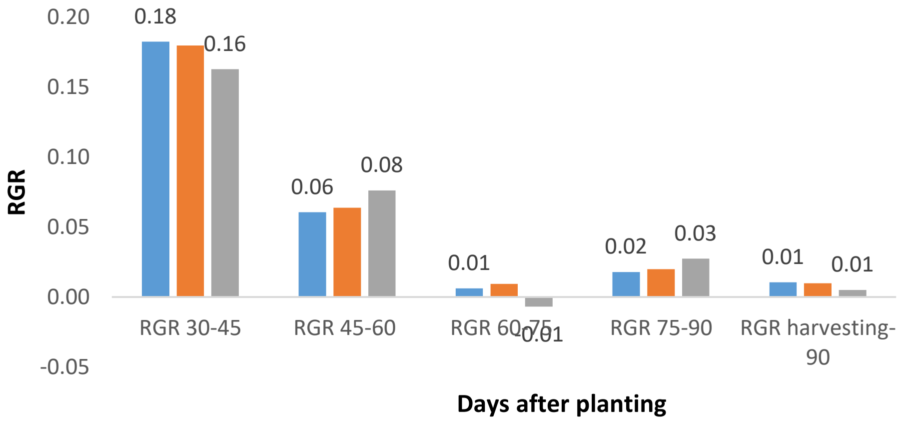


Fig 209: Relative growth rate of a white maize variety ($V_4$=Changnuo-6) at different growth stages as influenced by varying planting dates ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) in Kharif-2017 season.

### 4.2.16 Net Assimilation Rate (NAR)

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on net assimilation rate. The results are presented below in Fig. 209-212 variety wise showing the effect under different planting dates at 30, 45, 60, 75, 90 and harvesting stages.

#### Effect of planting date

NAR have been presented in (Fig. 209). Planting date significantly affected NAR of white maize. Crop sown on May 29 recorded the highest NAR which was statistically at per with July 6 planting. Different planting dates showed statistically significant differences on NAR (Fig. 209-212). The highest NAR (0.005) was recorded from $S_1$ that means May 29 planting which was statistically similar (0.005) to $S_3$ and closely followed (0.004) by $S_2$. The lowest NAR (0.00) was observed from $S_1$ that mean May 29.

#### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of NAR (Fig. 209-212). The highest NAR was found from $V_1$ (0.005) PSC-121 which was statistically similar to $V_1$ (0.005) PSC-121 due to its tolerance, disease resistant and yield potentiality and whereas the lowest NAR was found from $V_2$ (0.000) Yungnuo-7 due to susceptible characters.

#### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of NAR (Fig. 209-212). The highest NAR (0.005) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (0.005) by $V_1S_3$ from PSC-121 with July 6 planting and statistically similar results (0.004) was aslo found from $V_1S_1$ that mean June 21 planting with PSC-121 variety. While the lowest NAR (0.00) was obtained from the treatment combination $V_2S_1$ that mean May 29 planting with Yungnuo-7 variety followed (0.00) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher NAR under May 29 planting was attributed to NAR characters.

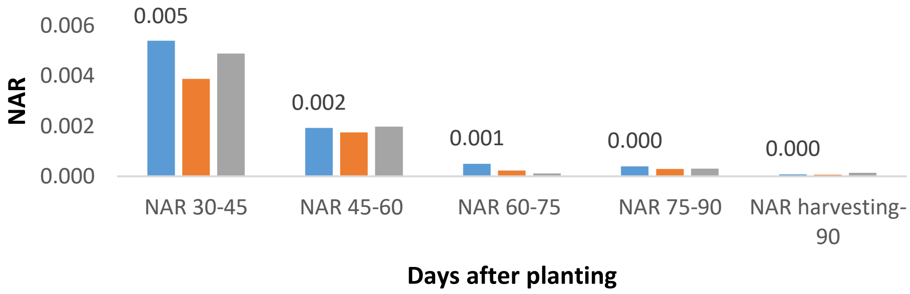


Fig.210: Net assimilation rate of a white maize variety at different growth stages as influenced by varying planting dates in Kharif-2017 season ($V_1$=PSC-121) ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017).

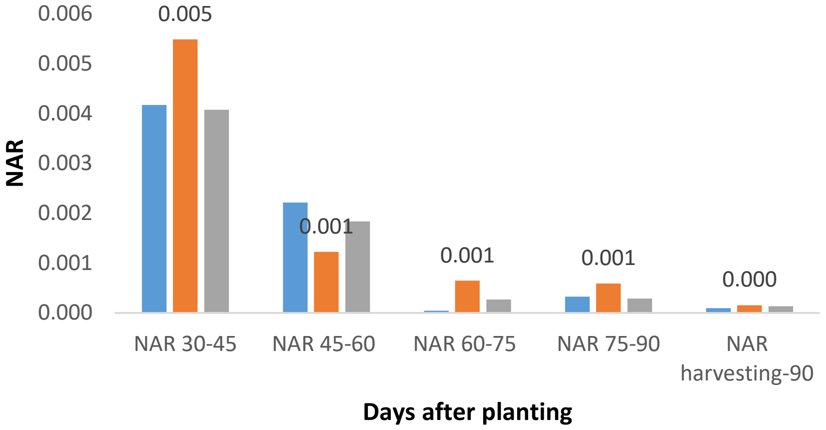


Fig.211: Net assimilation rate of a white maize variety at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) ($V_2$=Yangnuo-7).

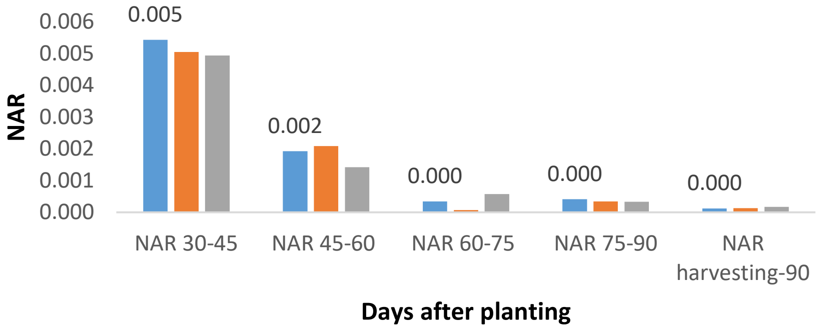


Fig.212: Net assimilation rate of a white maize variety at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) ($V_3$=Changnuo-1).

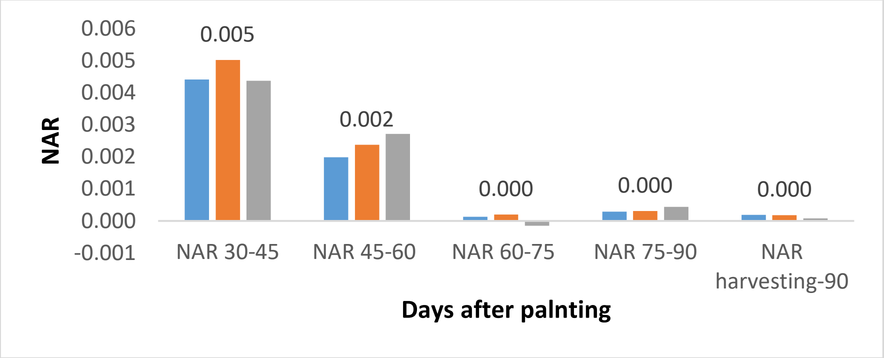


Fig.213: Net assimilation rate of a white maize variety at different growth stages as influenced by varying planting dates in Kharif-2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) ($V_4$=Changnuo-6).

### 4.2.17 Stover weight per plant at maturity

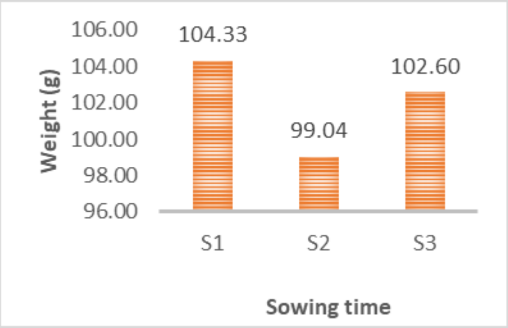
In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on stover weight per plant. The results are presented below in Fig. 213-215.

### Effect of planting date

Stover weight have been presented in (Fig. 213). Planting date significantly affected stover weight of white maize. Crop sown on July 6 recorded the highest stover weight which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on stover weight (Fig. 213). The highest weight (104.33g) was recorded from $S_1$ that means May 29 planting which was statistically similar (102.6g) to $S_2$. The lowest number of row (99.04g) was observed from $S_2$ that mean June 21.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of stover weight (Fig 214). The highest stover weight was found from $V_1$ (112.94 g) PSC-121 which was statistically similar to $V_3$ (108.19 g) Yungnuo-30 due to its tolerance, disease resistant and yield potentiality and whereas the lowest stover weight was found from $V_2$ (85.51 g) Yungnuo-7 due to susceptible characters.



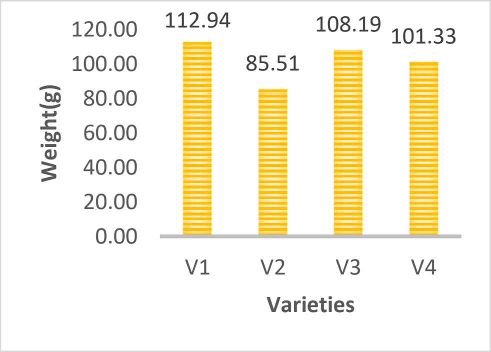


Fig 214: Stover dry weight per plant of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% = 11.06)

Fig.215: Stover dry weight per plant of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =12.76)

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on stover weight (Fig. 215). The highest weight (120.23g) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed ( 110.27g) by $V_1S_3$ from PSC-121 with July 6 planting and statistically similar results (109.58g) was also found from $V_3S_3$ that mean July 6 planting with Yungnuo-30 variety. While the lowest weight (80.65g) was obtained from the treatment combination $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety followed (85.45) by $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety. Higher stover weight under July 6 planting was attributed to stover weight characters.

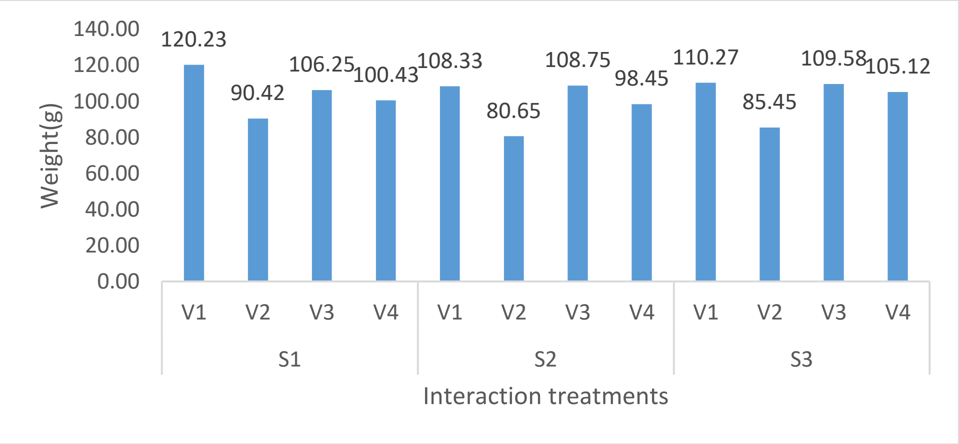


Fig.216: Stover dry weight of white maize as influenced by varying sowing dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) and varieties ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, V4= Changnuo-6;; LSD5% =22.11

### 4.2.18 Ear Weight per plant

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on ear weight per plant. The results are presented below in Fig. 216-218.

### Effect of planting date

Ear weight have been presented in (Fig. 216). Planting date significantly affected ear weight of white maize. Crop sown on May 29recorded the highest ear weight which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on ear weight (Fig. 216). The highest weight (102.54g) was recorded from $S_1$ that means May 29 planting which was statistically similar (98.73g) to $S_3$. The lowest weight (73.87g) was observed from $S_2$ that mean June 21.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of ear weight (Fig. 217). The highest ear weight was found from $V_1$ (98.01g) PSC-121 which was statistically similar to $V_3$ (95.36g) Yungnuo-30 due to its tolerance, disease resistant and yield potentiality and whereas the lowest ear weight was found from $V_2$ (79.52g) Yungnuo-7 due to susceptible characters.

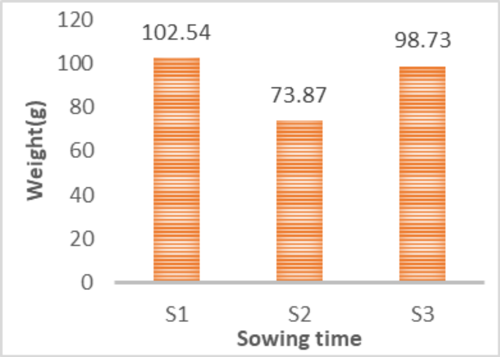


Fig.217: Ear dry weight per plant of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =12.99)

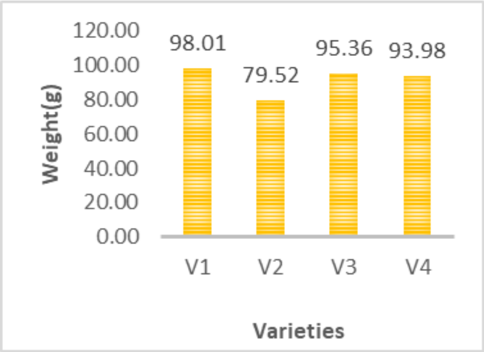


Fig.218: Ear dry weight per plant of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =15.00)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on ear weight (Fig. 218). The highest weight (108.43g) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (106.56g) by $V_3S_1$ from Yungnuo-30 with May 29 planting and statistically similar results (105.58g) was also found from $V_4S_1$ that mean May planting with Changnuo-6 variety. While the lowest weight (61.11g) was obtained from the treatment combination $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety followed (77.24g) by $V_3S_2$ that mean June 21 planting with  Yungnuo-30 variety. Higher ear weight under May 29 planting was attributed to ear weight characters.

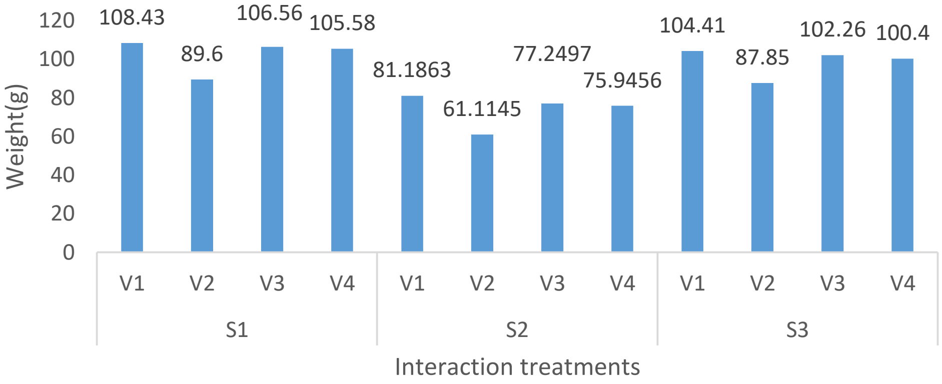


Fig.219: Ear dry weight of white maize as influenced by varying sowing dates ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) and varieties in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =12.53).

### 4.2.19 Dry Matter per plant

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on dry weight per plant. The results are presented below in Fig. 219-221.

#### Effect of planting date

Dry matter have been presented in (Fig. 219). Planting date significantly affected weight of white maize. Crop sown on June 21 recorded the highest weight which was statistically at per with July 6 planting. Different planting dates showed statistically significant differences on weight. The highest weight (206.87g) was recorded from $S_1$ that means May 29 planting which was statistically similar (201.33g) to $S_3$. The lowest weight (172.91g) was observed from $S_2$ that mean June 21.

#### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of grain yield (Fig 220). The highest weight was found from $V_1$ (210.95g) PSC-121 which was statistically similar to $V_3$ (203.55g) Yungnuo-30 due to its tolerance, disease resistant and yield potentiality and whereas the lowest weight was found from $V_2$ (165.03g) Yungnuo-7 due to susceptible characters.

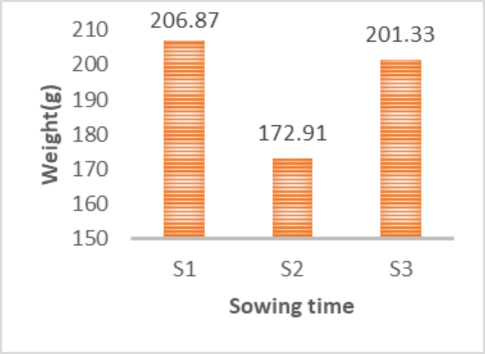


Fig.220: Total dry weight per plant of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =20.09)

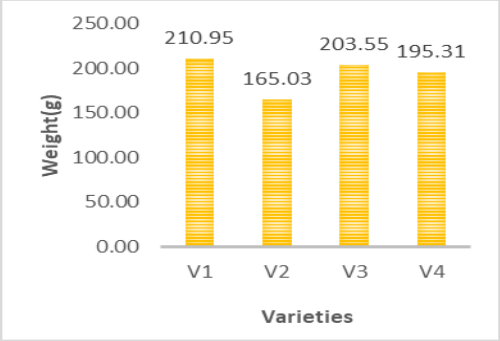


Fig.221: Total dry weight per plant of different white maize varieties grown across varying sowing dates in Kharif 2017 season; ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =25.51)

**Interaction effect of planting dates and variety**

Interaction effect of white maize genotypes and planting dates sowed significant differences on dry matter weight (Fig. 221). The highest weight (228.66g) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (214.68g) by $V_1S_3$ from PSC-121 with July 6 planting and statistically similar results (212.81g) was also found from $V_3S_1$ that mean May 29 planting with Yungnuo-30 variety. While the lowest weight (141.76g) was obtained from the treatment combination $V_2S_2$ that mean June 21 planting with Yungnuo-7.

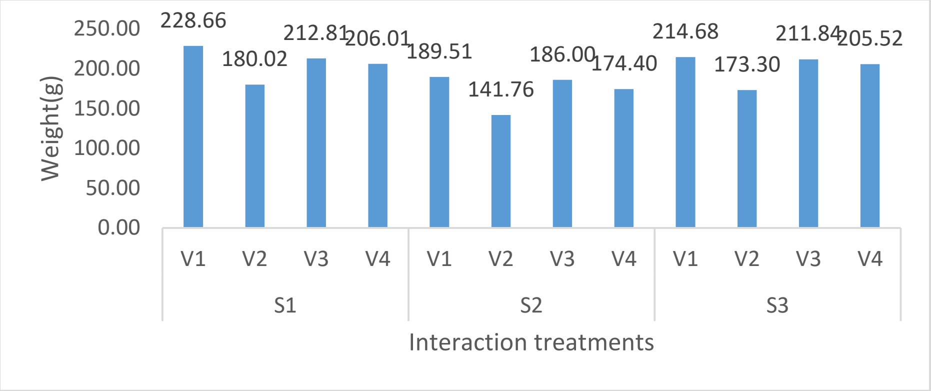


Fig.222: Total dry weight of white maize as influenced by varying sowing dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) and varieties ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6;; LSD5% =44.19)

### 4.2.20 Number of grain rows per cob

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on number of grain rows per cob. The results are presented below in Fig. 222-224.

### Effect of planting date

Number of row have been presented in (Fig. 222). Planting date significantly affected number of row of white maize. Crop sown on May 29 recorded the highest number of row which was statistically at per with July 6 planting. Different planting dates showed statistically significant differences on number of row. The highest number of row (13.23) was recorded from $S_1$ that means July 6 planting which was statistically similar (13.08) to $S_1$. The lowest number of row (12.83) was observed from $S_1$ that mean June 21.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of Number of row (Fig. 223). The highest Number of row was found from $V_1$ (13.67) PSC-121 which was statistically similar to $V_4$ (13.57) Changnuo-6 due to its tolerance, disease resistant and yield potentiality and whereas the lowest number of row was found from $V_2$ (11.43) Yungnuo-7 due to susceptible characters.

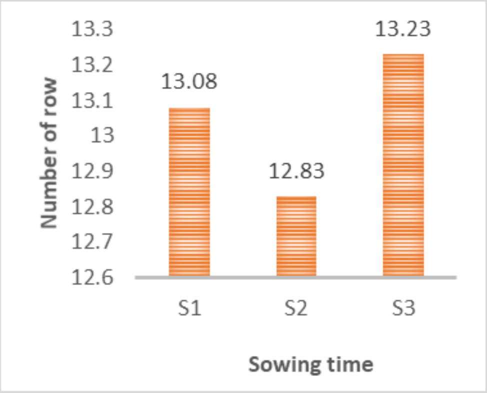


Fig. 223: Number of row per cob of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =0.94)

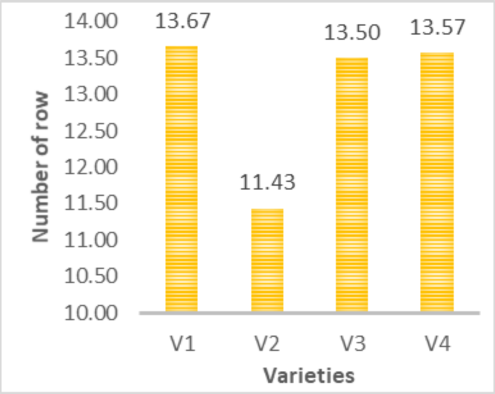


Fig. 224: Number of row per cob of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =1.09)

## Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of Number of row (Fig. 224). The highest number of row (14) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (14) by $V_1S_3$ from PSC-121 with July 6 planting and statistically similar results (13.7) was also found from $V_4S_1$ that mean May 29 planting with Changnuo-6 variety. While the lowest number of row (11.3) was obtained from the treatment combination $V_2S_1$ that mean May 29 planting with Yungnuo-7 variety followed (11.33) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher number of row under May 29 planting was attributed to number of row characters.

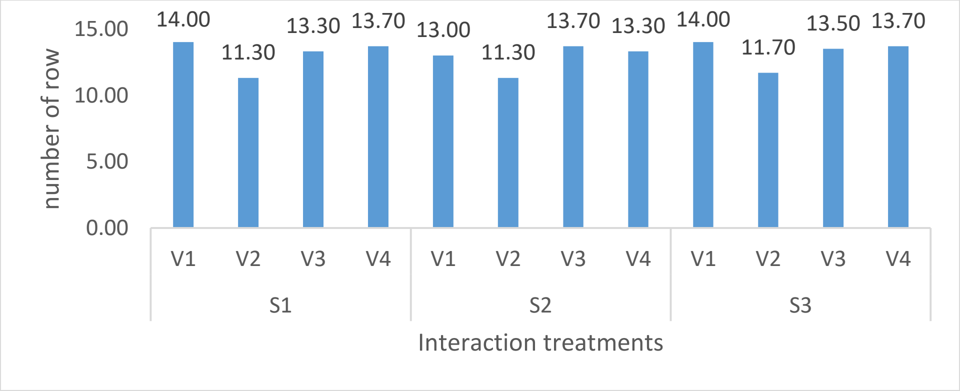


Fig. 225: Number of rows per cob of white maize as influenced by varying sowing dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) and varieties ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =1.89).

### 4.2.21 Number of grains per row on a cob

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on number of grains per row on a cob. The results are presented below in Fig. 225-227.

### Effect of planting date

Number of grain per row have been presented in (Fig. 225). Planting date significantly affected number of grain per row of white maize. Crop sown on May 29 recorded the highest number of grain per row which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on number of grain per row. The highest number of grain per row (18.06) was recorded from $S_1$ that means May 29 planting which was statistically similar (17.02) to $S_2$. The lowest number of row (15.78) was observed from $S_2$ that mean June 21.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of Number of grain per row (Fig 226). The highest Number of grain per row was found from $V_1$ (22.79) PSC-121 which was statistically similar to $V_3$ (17.38) Yungnuo-30 due to its tolerance, disease resistant and yield potentiality and whereas the lowest number of grain per row was found from $V_2$ (15.05) Yungnuo-7 due to susceptible characters.

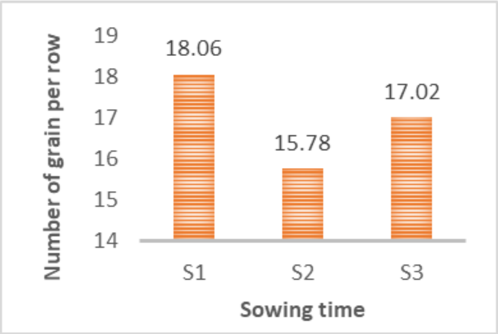


Fig.226: Number of grain per row of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =3.00)

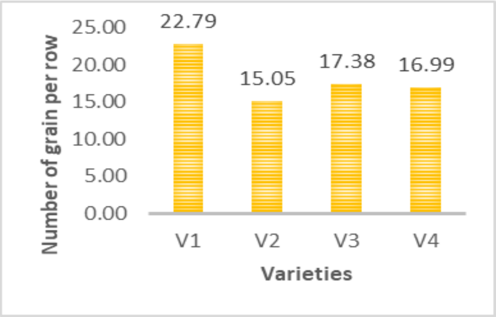


Fig.227: Number of grains per row in a cob of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =3.47)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of Number of grain per row (Fig. 227). The highest number of grain per row (23.76) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (22.35) by $V_1S_3$ from PSC-121 with July 6 planting and statistically similar results (22.24) was also found from $V_1S_1$ that mean June 21 planting with PSC-121 variety. While the lowest number of grain of row (14.4) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (15.29) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher number of grain of row under May 29 planting was attributed to number of grain of row characters.

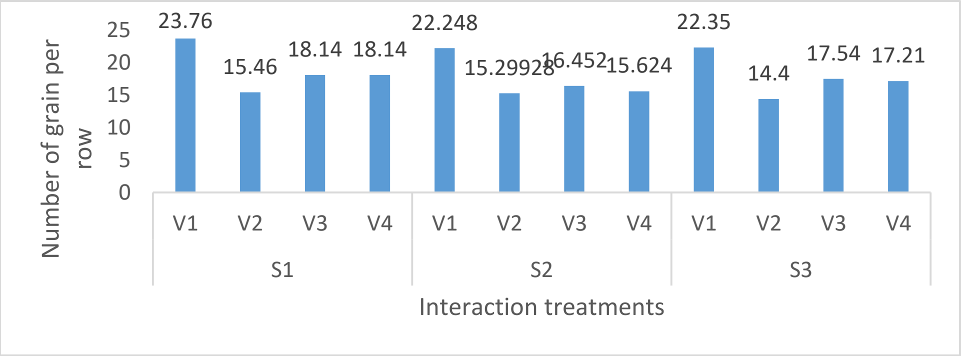


Fig.228: Number of grain per row in a cob of white maize as influenced by varying sowing dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) and varieties ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =6.01).

### 4.2.22 Number of grains per cob

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on number of grains per cob. The results are presented below in Fig 228-230.

### Effect of planting date

Number of grain per cob have been presented in (Fig. 228). Planting date significantly affected number of grain per cob of white maize. Crop sown on May 29 recorded the highest number of grain per cob which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on number of grain per cob. The highest number of grain per cob (249.27) was recorded from $S_1$

that means May 29 planting which was statistically similar (238.48) to $S_3$. The lowest number of row (223.82) was observed from $S_2$ that mean June 21.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of Number of grain per cob (Fig. 229). The highest Number of grain per cob was found from $V_3$ (309.28) Yungnuo-30 which was statistically similar to $V_1$ (307.53) PSC-121 due to its tolerance, disease resistant and yield potentiality and whereas the lowest number of grain per cob was found from $V_2$ (217.11) Yungnuo-7 due to susceptible characters.

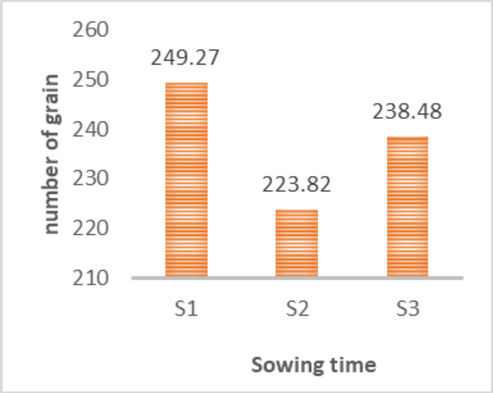


Fig.229: Number of grains per cob of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =52.62).

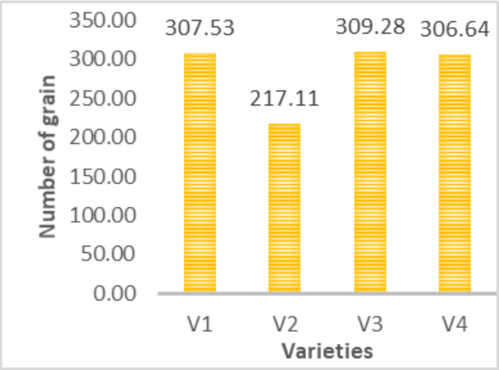


Fig. 230: Number of grains per cob of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD 5% -=60.77).

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on date of Number of grain per cob (Fig. 230). The highest number of grain per cob (332.64) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (312.90) by $V_1S_3$ from PSC-121 with July 6 planting and statistically similar results (289.22) was also found from $V_1S_1$ that mean June 21 planting with PSC-121 variety. While the lowest number of grain of cob (168.48) was obtained from the treatment combination $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety followed (172.88) by $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety. Higher number of grain of cob under May 29 planting was attributed to number of grain of cob characters.

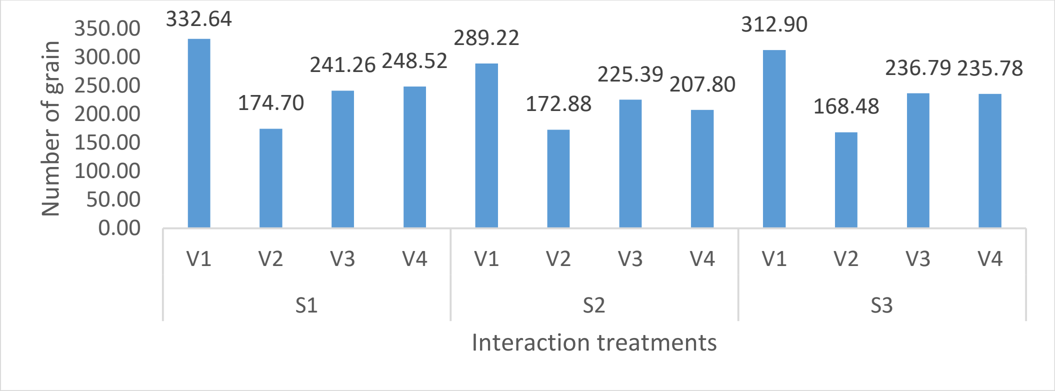


Fig. 231: Number of grains per cob of white maize as influenced by varying sowing dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) and varieties ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =105.26).

### 4.2.23 Total grain weight per plant

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on grain weight per plant. The results are presented below in Fig. 231-233.

### Effect of planting date

Grain yield have been presented in (Fig. 231). Planting date significantly affected weight of white maize. Crop sown on May 29 recorded the highest weight which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on weight. The highest weight (95.14g) was recorded from $S_1$ that means May 29 planting which was statistically similar (86.52g) to $S_2$. The lowest weight (71.7g) was observed from $S_2$ that mean June 21.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of grain yield (Fig. 232). The highest weight was found from $V_1$ (91.52g) PSC-121 which was statistically similar to $V_3$ (88.47g) Yungnuo-30 due to its tolerance, disease resistant and yield potentiality and whereas the lowest weight was found from $V_2$ (74.15g) Yungnuo-7 due to susceptible characters.

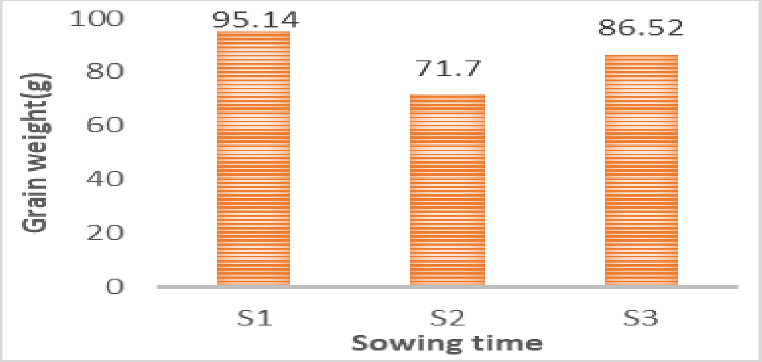


Fig.232: Grain weight per plant of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =7.3)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on grain weight (Fig. 233). The highest weight (102g) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (100.8g) by $V_3S_1$ from Yungnuo-30 with May 29 planting and statistically similar results (93.75g) was also found from $V_1S_3$ that mean July 6 planting with PSC-121 variety. While the lowest weight (59.56g) was obtained from the treatment combination $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety followed (77.59g) by $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety.

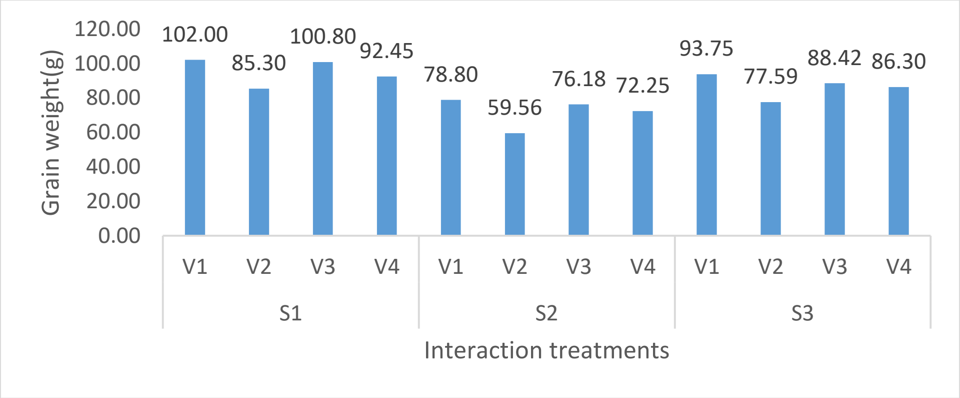


Fig. 233: Grain weight per plant white maize as influenced by varying sowing dates and varieties in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =14.61).

### 4.2.24 100 seed weight

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on 100-seed weight per plant. The results are presented below in Fig. 233-235.

### Effect of planting date

100 seed weight have been presented in (Fig. 233). Planting date significantly affected 100 seed weight of white maize. Crop sown on June 21 recorded the highest number of grain per cob which was statistically at per with July 6 planting. Different planting dates showed statistically significant differences on 100 seed weight. The highest weight (20.87g) was recorded from $S_3$ that means July 6 planting which was statistically similar (20.4 g) to $S_1$. The lowest weight (20.17g) was observed from $S_2$ that mean July 6.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of 100 seed weight (Fig 234). The highest 100 seed weight was found from $V_1$ (22.27g) PSC-121 which was statistically similar to $V_4$ (21.08 g) Changnuo-6 due to its tolerance, disease resistant and yield potentiality and whereas the lowest 100 seed weight was found from $V_2$ (17.73g) Yungnuo-7 due to susceptible characters.

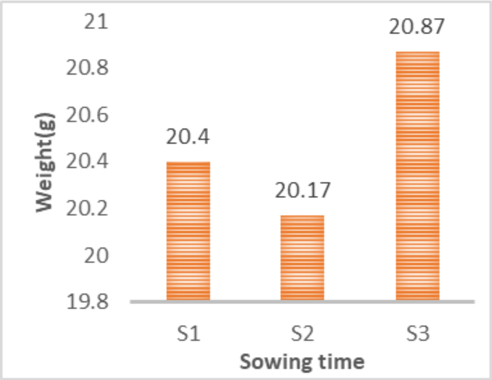


Fig. 234: 100-seed dry weight per plant of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =1.86)

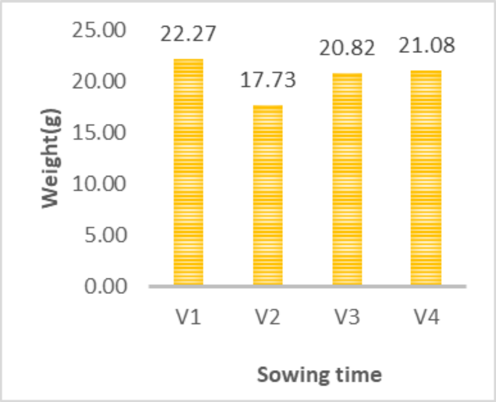


Fig. 235: 100-seed weight per plant of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =2.15)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on 100 seed weight (Fig. 235). The highest weight (22.83g) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (22.17g) by $V_1S_3$ from PSC-121 with July 6 planting and statistically similar results (21.79g) was also found from $V_1S_1$ that mean June 21 planting with PSC-121 variety. While the lowest weight (16.92g) was obtained from the treatment combination $V_2S_2$ that mean

June 21 planting with Yungnuo-7 variety followed (17.76) by $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety. Higher 100 seed weight under June 21 planting was attributed to 100 seed weight characters.

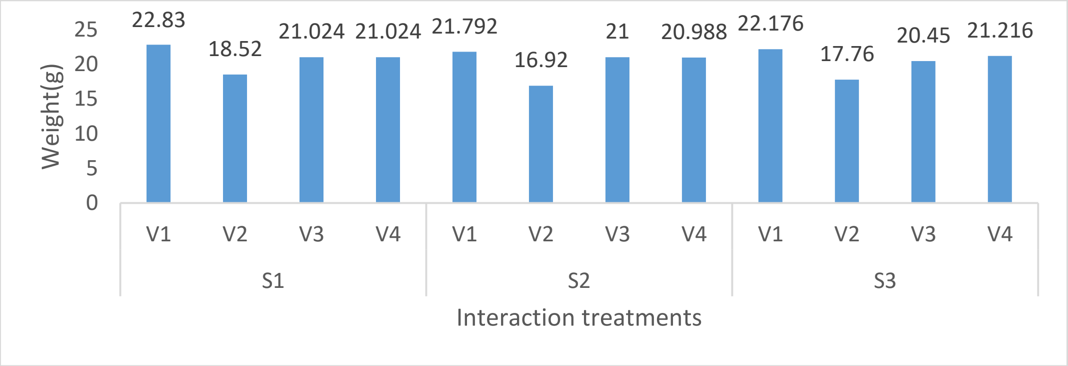


Fig.236: 100-seed weight of white maize as influenced by varying sowing dates and varieties in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =3.73).

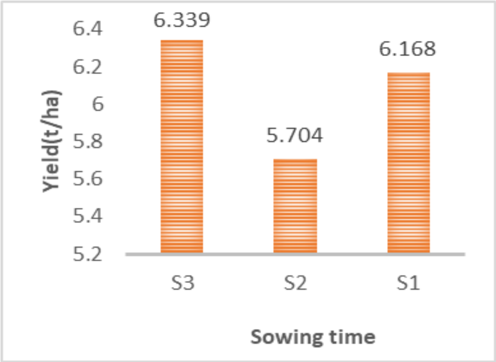
### 4.2.25 Seed yield per hectare

For optimization of yield, planting at an appropriate time is very critical (McCutcheon *et al.*, 2001). Ali *et al. (*2018) reported that one of the most important factors contributing to yield gap is a planting of maize on appropriate planting dates. Dekhane *et al.(*2017) contended that early planting in the spring is optimum and more efficient than delayed planting as through early planting germination occurs when days are longer and sun shines impact is more by way of an acute angel; whereas delaying planting date results in decrease in maize grain yields.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on seed yield per hectare. The results are presented below in Fig. 236-238.

### Effect of planting date

Yield have been presented in (Fig. 236). Planting date significantly affected weight of white maize. Crop sown on May 29 recorded the highest weight which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on weight. The highest weight (6.33 t ha $^{-1}$) was recorded from $S_1$ that means May 29 planting which was statistically similar (6.16 t ha $^{-1}$) to $S_2$. The lowest weight (5.70 t ha $^{-1}$) was observed from $S_2$ that mean June 21.



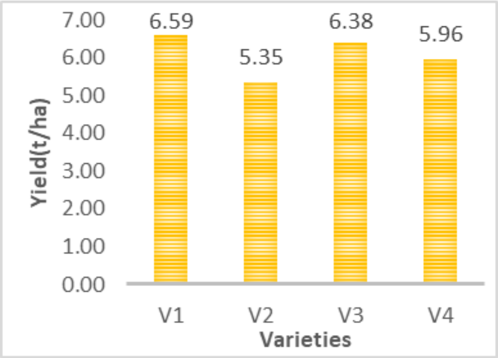


Fig 237: Seed yield per hectare of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =0.52)

Fig 238: Seed yield per hectare of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.60)

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of yield (Fig. 237). The highest weight was found from $V_1$ (6.59 t ha$^{-1}$) PSC-121 which was statistically similar to $V_2$ (6.38 t ha$^{-1}$) PSC-121 due to its tolerance, disease resistant and yield potentiality and whereas the lowest weight was found from $V_2$ (5.35 t ha$^{-1}$) Yungnuo-7 due to susceptible characters.

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on yield weight (Fig. 238). The highest weight (7.35 t ha$^{-1}$) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (6.73 t ha$^{-1}$) by $V_3S_1$ from Yungnuo-30 with May 29 planting and statistically similar results (6.5 t ha$^{-1}$) was also found from $V_1S_3$ that mean July 6 planting with PSC-121 variety. While the lowest weight (5.06 t ha$^{-1}$) was obtained from the treatment combination $V_2S_2$ that mean June 21 planting with Yungnuo-7 variety followed (5.31 t ha$^{-1}$) by $V_2S_3$ that mean July 6 planting with Yungnuo-7 variety. Higher weight under May 29 planting was attributed to ear weight characters.

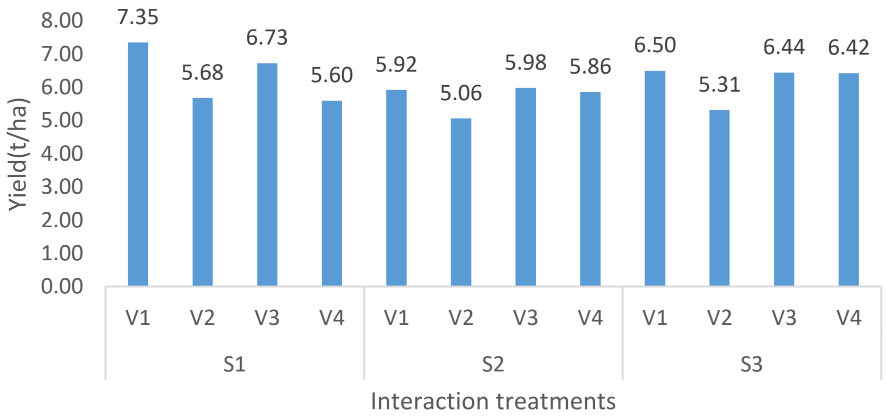


Fig. 239: Seed yield per hectare of white maize as influenced by varying sowing dates and varieties in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =1.04).

### 4.2.26 Biological yield per hectare

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on biological yield. The results are presented below in Fig. 239-241.

### Effect of planting date

Dry matter have been presented in (Fig. 239). Planting date significantly affected weight of white maize. Crop sown on June 21 recorded the highest weight which was statistically at per with July 6 planting. Different planting dates showed statistically significant differences on weight. The highest weight (14.10 tha$^{-1}$) was recorded from $S_1$ that means May 29 planting which was statistically similar (13.59) to $S_3$. The lowest weight (12.22g) was observed from $S_2$ that mean June 21.

### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of grain yield (Fig. 240). The highest weight was found from $V_1$ (14.50 tha$^{-1}$) PSC-121 which was statistically similar to $V_3$ (13.95 tha$^{-1}$) Yungnuo-30 due to its tolerance, disease resistant and yield potentiality and whereas the lowest weight was found from $V_2$ (11.32 tha$^{-1}$) Yungnuo-7 due to susceptible characters.

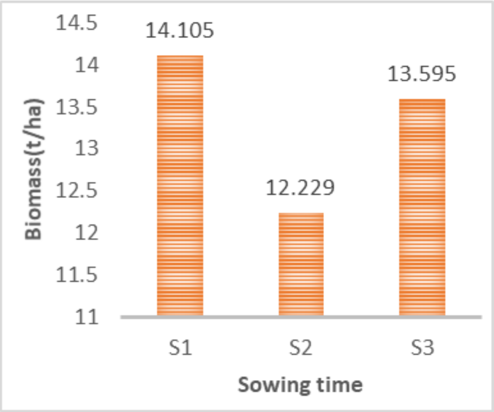


Fig. 240: Biological yield per hectare of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =1.4)

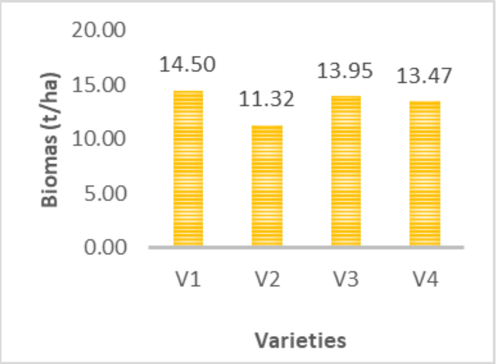


Fig. 241: Biological yield per hectare of different white maize genotypes grown across varying planting dates in Kharif 2017 season ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =1.61)

## Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on dry matter weight (Fig. 241). The highest weight (15.71 tha$^{-1}$) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (15.04 tha$^{-1}$) by $V_1S_3$ from PSC-121 with July 6 planting and statistically similar results (14.49 tha$^{-1}$) was also found from $V_3S_1$ that mean May 29 planting with Yungnuo-30 variety. While the lowest weight (10.19 t ha$^{-1}$) was obtained from the treatment combination $V_2S_2$ that mean June 21 planting with Yungnuo-7.

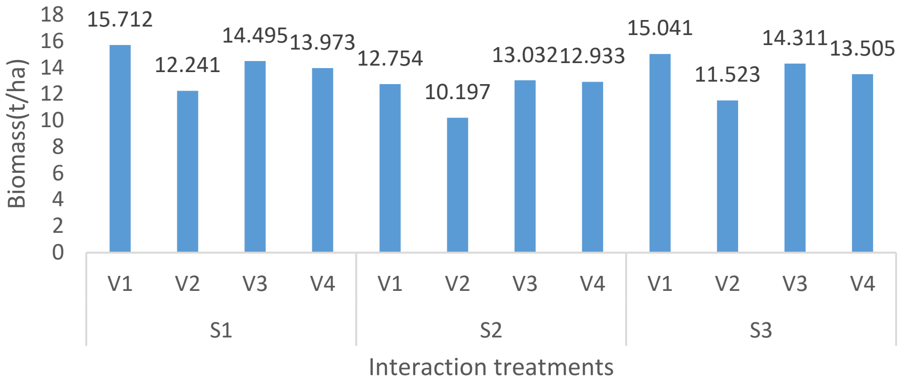


Fig.242: Biological yield per hectare of white maize as influenced by varying sowing dates and varieties in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =2.80)

### 4.2.27 Harvest Index:

Corn stover is made up of the stalk, leaves, husks and tassels left in the field after harvesting the grain with a combine. Stover can be harvested and used as a livestock feed, converted into ethanol or burned for heat or electricity. The amount of stover produced each crop year depends on weather, soils and management practices like fertilizer and pest control applications. As a general rule, the amount of stover produced is about the same as the amount of grain produced. This is commonly expressed in a ratio called harvest index.

In this trial the variety, planting dates and their interactions had significant effect (at least at 5% level of significance) on stover weight per plant. The results are presented below in Fig. 242-244.

#### Effect of planting date

HI have been presented in (Fig. 242). Planting date significantly affected weight of white maize. Crop sown on May 29 recorded the highest HI which was statistically at per with June 21 planting. Different planting dates showed statistically significant differences on HI. The highest HI (46.35%) was recorded from $S_1$ that means May 29 planting which was statistically similar (45.48%) to $S_2$. The lowest HI (45.01%) was observed from $S_3$ that mean July 6.

#### Effect of variety

Statistically significant variation was observed for different white maize genotypes in terms of HI (Fig. 243). The highest HI was found from $V_3$ (45.74%) Yungnuo-30 which was statistically similar to $V_2$ (45.68%) Yungnuo-7 due to its tolerance, disease resistant and yield potentiality and whereas the lowest HI was found from $V_1$ (45.62%) PSC-121 due to susceptible characters.

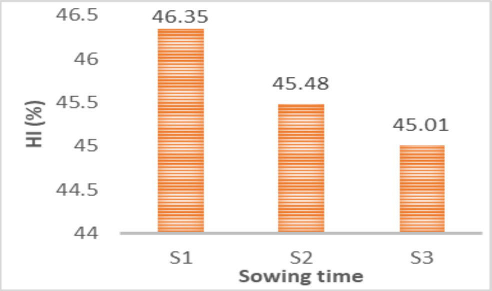


Fig 243: Harvest index of white maize as influenced by varying planting dates in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017; LSD5% =.21)

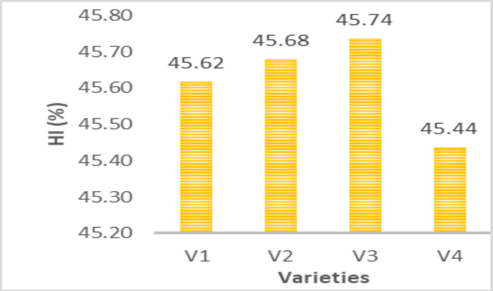


Fig 244: Harvest index of different white maize genotypes grown across varying planting dates in Kharif 2017 season; LSD5% =0.25)

### Interaction effect of planting dates and variety

Interaction effect of white maize genotypes and planting dates sowed significant differences on HI (Fig. 244). The highest weight (46.44%) was observed from $V_1S_1$ that mean May 29 planting with PSC-121 variety followed (46.44%) by $V_3S_1$ from Yungnuo-30 with May 29 planting and statistically similar results (46.41%) was also found from $V_2S_1$ that mean May 29 planting with Yungnuo-7 variety. While the lowest weight (45.00%) was obtained from the treatment combination $V_1S_3$ that mean July 6 planting with PSC-121.

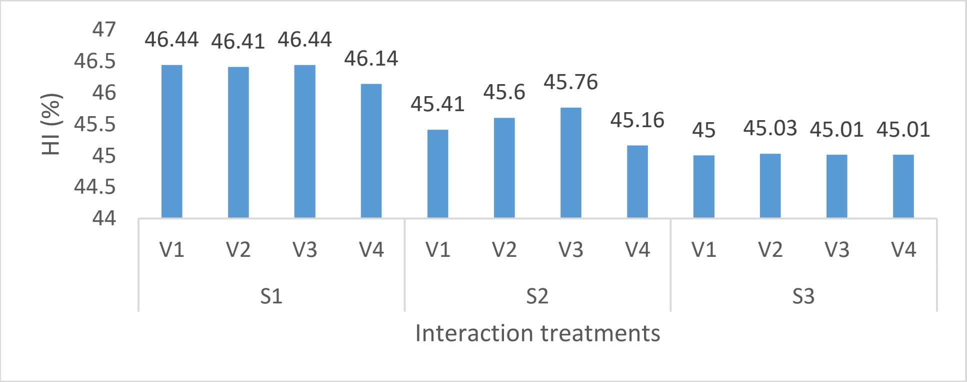


Fig 245: Harvest index of white maize as influenced by varying sowing dates and varieties in Kharif 2017 season ($S_1$= 29th May 2017, $S_2$= June 21st 2017, $S_3$= 6th July 2017) ($V_1$=PSC-121, $V_2$=Yangnuo-7, $V_3$= Yungnuo-30, $V_4$= Changnuo-6; LSD5% =0.43).

### 4.2.28 Growing day degree (GDD)

### Effect of planting date

The GDD values increased as the phenotypic stages progressed with the passing of time. The latest planting date required the highest GDD while the earliest planting had the lowest GDD.

### Effect of genotypes

Like planting date the GDD values increased with the advancement of time and progress of the phenotypic growth stages. The variety PSC-121 required the highest GDD compared to others and the variety Yangnjuo-7 had the lowest GDD.

### Interaction effect

The interaction effect of planting dates and variety had significant effect on the GDD required. $S_3V_4$ had the highest value of GDD (960 day degree).

**Table-9 Growing day degree required of different phenological stages in Kharif season as influenced by planting dates, variety and their interactions**

| | GDD for Emergence | GDD for Emergence - $V_6$ | GDD for $V_6$-$V_{10}$ | GDD for $V_{10}$-$V_{12}$ | GDD for $V_{12}$-50% tasseling | GDD for Tasseling to 50% silking | GDD for 50% silking to maturity |
|---|---|---|---|---|---|---|---|
| $S_1$ | 114 | 322 | 288 | 48 | 439 | 174 | 764 |
| $S_2$ | 120 | 255 | 283 | 38 | 435 | 181 | 865 |
| $S_3$ | 116 | 220 | 287 | 49 | 419 | 207 | 869 |
| LSD(0.05%) | 0.13 | 0.53 | 0.57 | 0.35 | 0.75 | 0.40 | 29.46 |
| $V_1$ | 118 | 314 | 280 | 79 | 395 | 233 | 851 |
| $V_2$ | 112 | 224 | 246 | 0 | 435 | 200 | 663 |
| $V_3$ | 118 | 257 | 338 | 52 | 435 | 154 | 953 |
| $V_4$ | 118 | 269 | 281 | 49 | 460 | 162 | 864 |
| LSD(0.05%) | 0.15 | 0.61 | 0.66 | 0.41 | 0.87 | 0.46 | 34.02 |
| $S_1V_1$ | 114 | 395 | 259 | 80 | 403 | 241 | 806 |
| $S_1V_2$ | 114 | 260 | 278 | 0 | 447 | 191 | 589 |
| $S_1V_3$ | 114 | 317 | 335 | 60 | 444 | 122 | 948 |
| $S_1V_4$ | 114 | 317 | 280 | 54 | 462 | 143 | 715 |
| $S_2V_1$ | 122 | 294 | 286 | 80 | 392 | 218 | 881 |
| $S_2V_2$ | 112 | 216 | 231 | 0 | 428 | 189 | 700 |
| $S_2V_3$ | 122 | 256 | 326 | 36 | 432 | 158 | 961 |
| $S_2V_4$ | 122 | 256 | 289 | 34 | 489 | 158 | 918 |
| $S_3V_1$ | 118 | 252 | 296 | 76 | 391 | 241 | 867 |
| $S_3V_2$ | 109 | 196 | 229 | 0 | 429 | 220 | 701 |
| $S_3V_3$ | 118 | 196 | 351 | 59 | 428 | 183 | 949 |
| $S_3V_4$ | 118 | 235 | 273 | 59 | 429 | 186 | 960 |
| LSD(0.05%) | 0.26 | 1.07 | 1.14 | 0.71 | 1.51 | 0.80 | 58.92 |
| CV5% | 2.65 | 0.23 | 0.23 | 0.89 | 0.20 | 0.24 | 4.00 |

Effect of temperature was pronounced in maize cultivars and at different dates of planting. Maize yield was significantly high in PSC-121 over Yangnuo-7 during both years of experimentation. Early planting also resulted in significantly higher yield compared to planting at later dates. Total growing degree days (GDD) was less in PSC-121 (2638.25.) than Yangnuo-7 (2763.00) at first date of planting and followed by subsequent days sown at 30 days interval. The effect of temperature in reducing the length of growing cycle especially the grain filling phase is the most important factor in explaining reduced yields at warmer temperatures (White and Reynolds, 2003).

As delay in planting date can lead to a linear decrease in grain yields (Anapalli *et al*., 2005). There was no relationship between heat and yield at Kharif. By accelerating crop development, elevated temperatures limit the amount of solar radiation received by the plant during each developmental stage. Aggregated over the entire growing period, less interception of solar energy is problematic.

The number of growing degree days (GDD) needed for maize hybrids to reach various developmental stages is fairly uniform across environments (Hoegemeyer, 2013). An application of the GDD approach was developed by Neild and Richman, (1981) where they combined thermal units with precipitation in an agroclimatic index to determine where different corn hybrids could be grown around the world.

### Relations of growing day degrees with different yield attributes and yield of white maize

Regression analysis was made between growing day degree (GDD) with the yield and yield attributes using both linear and polynomial regression models. It was observed that a positive relationship was existed in both regression analysis models (Table 4.9, Fig 245 to 256). But a stronger dependency was observed while polynomial regression was fitted with the GDD. Higher regression coefficient values were observed at polynomial regression model than those at the linear model. The regression coefficients in linear and polynomial levels respectively were 0.1803 and 0.2048 with plant height, 0.8048 and 0.8072 with stover weight, 0.1866 and 0.2071 with ear weight, 0.4900 and 0.5031 with dry weight per plant, 0.6118 and 0.6278 with yield per hectare; and 0.5828 and 0.5976 with the biological yield per hectare. It signified that these parameters were highly dependent on the accumulated growing day degrees and the curve was best fitted in polynomial or quadratic functions showing a stronger positive curvilinear relationship rather than a linear relationship.

**Table 10 Regression coefficient values under linear and polynomial regression analysis of GDD with the yield attributes and yield of white maize**

| **Regression coefficient** | **Plant height** | **Stover wt.** | **Ear wt.** | **Dry wt.plant$^{-1}$** | **Yieldha$^{-1}$** | **Biological yieldha$^{-1}$** |
|---|---|---|---|---|---|---|
| Linear | 0.1803 | 0.8048 | 0.1866 | 0.4900 | 0.6118 | 0.5828 |
| Polynomial | 0.2048 | 0.8072 | 0.2071 | 0.5031 | 0.6278 | 0.5976 |

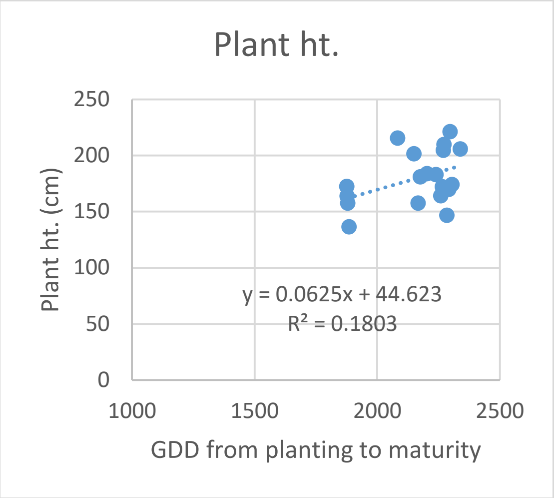


Fig.246: Simple linear regression analysis of accumulated GDD for planting to maturity with per plant height of white maize

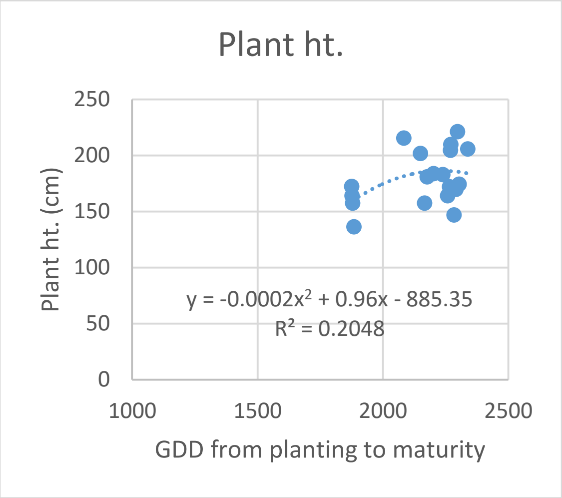


Fig.247: Polynomial regression analysis of accumulated GDD for planting to maturity with per plant height of white maize

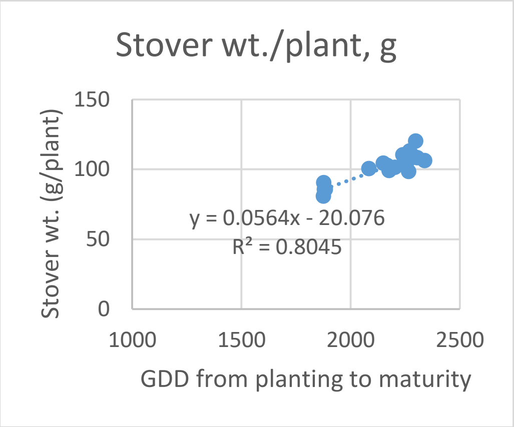


Fig.248: Simple linear regression analysis of accumulated GDD for planting to maturity with stover weight of white maize

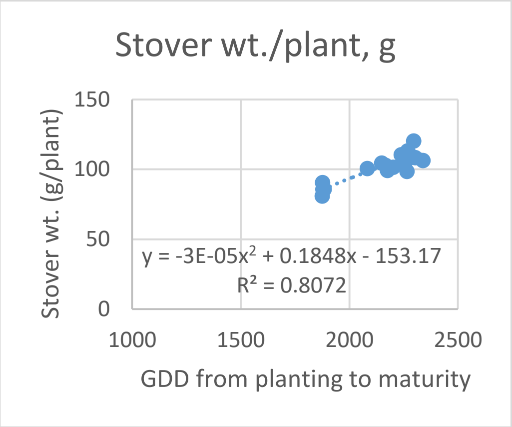


Fig.249: Polynomial regression analysis of accumulated GDD for planting to maturity with stover weight of white maize

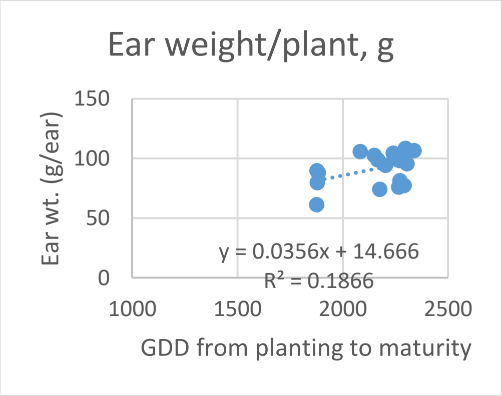


Fig.250: Simple linear regression analysis of accumulated GDD for planting to maturity with ear dry weight per plant of white maize

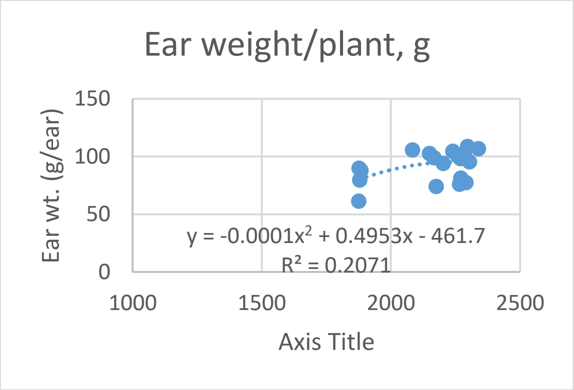


Fig.251: Polynomial regression analysis of accumulated GDD for planting to maturity with ear dry weight per plant of white maize

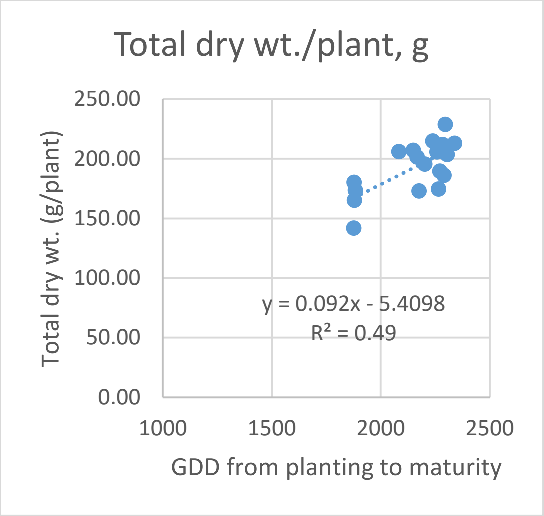


Fig. 252: Simple linear regression analysis of accumulated GDD for planting to maturity with per plant dry weight per plant of white maize

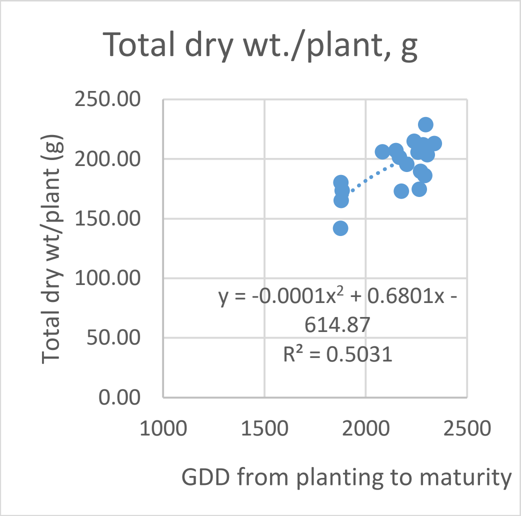


Fig. 253: Polynomial regression analysis of accumulated GDD for planting to maturity with per plant dry weight per plant of white maize

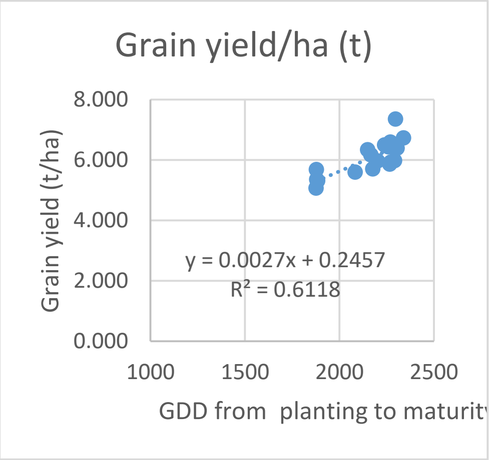


Fig.254: Simple linear regression analysis of accumulated GDD for planting to maturity with seed yield per hectare of white maize

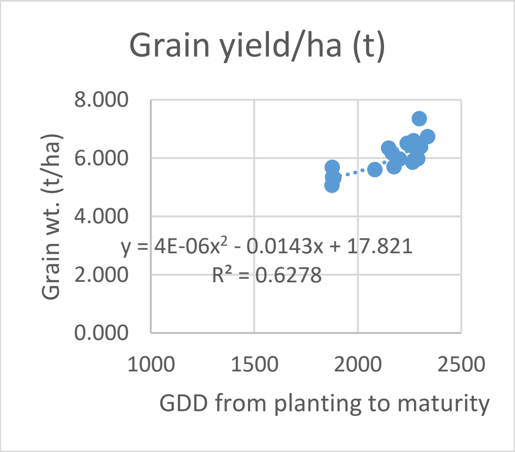


Fig. 255: Polynomial regression analysis of accumulated GDD for planting to maturity with seed yield per hectare of white maize

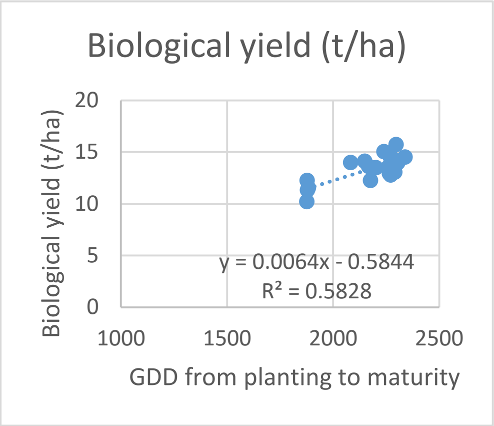


Fig.256: Simple linear regression analysis of accumulated GDD for planting to maturity with biological yield per hectare of white maize

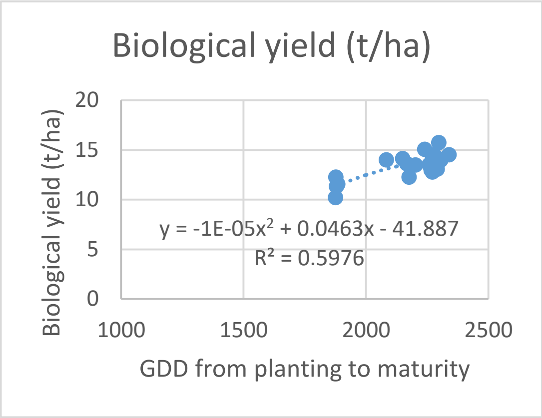


Fig. 257: Polynomial regression analysis of accumulated GDD for planting to maturity with biological yield per hectare of white maize

**Table 10 Correlation coefficient of dry matter at different growth stages of white maize**

| | **30 d dm $pl^{-1}$** | **45 d dm $pl^{-1}$** | **60 d dm $pl^{-1}$** | **75 d dm $pl^{-1}$** | **90 d dm $pl^{-1}$** | **Harvesting time dm $pl^{-1}$** |
|---|---|---|---|---|---|---|
| **30 d dm $pl^{-1}$** | 1.00 | | | | | |
| **45 d dm $pl^{-1}$** | 0.50 | 1.00 | | | | |
| **60 d dm $pl^{-1}$** | 0.90 | 0.44 | 1.00 | | | |
| **75 d dm $pl^{-1}$** | 0.28 | 0.34 | 0.52 | 1.00 | | |
| **90 d dm $pl^{-1}$** | -0.02 | -0.17 | 0.22 | 0.28 | 1.00 | |
| **Harvesting time dm $pl^{-1}$** | -0.24 | 0.21 | 0.01 | 0.36 | 0.29 | 1.00 |

d= days, dm=dry matter

In this study the phenological stages were seen to be influenced in this study by both planting date and variety. The developmental stage was five to seven days earlier in Kharif season compared to those in Rabi seasons. Days to emergence varied due to growing season. Rabi seasons' crops required some hours to emerge compared to that of in the Kharif season. The longest duration was taken by $S_3$ (6.08 d) in 2016-17 while $S_2$ in 2017-18. In both the season $S_1$ had the shortest time to emerge (5.25-5.33d). In case of genotypes, $V_1$ and $V_3$ took longer time to emerge (5.67-5.79d) in 2016-17 Rabi and 2016 Kharif season, however the interaction of planting dates and variety was somewhat inconsistent.

Normally maize seed's emergence under favourable conditions occurs within 4 to 5 days after planting. If cool or dry conditions exists, emergence may be delayed several weeks. At the VE stage, the nodal root system begins to grow. In this trial, days to emergence was significantly ($p<0.05$) affected by genotypes, planting time and also by their interactions. Banotra *et al.* (2017) reported that the crop sown on April 15, March 29 and April 30 recorded statistically similar but significantly more plant height, leaf area index, dry matter accumulation, cob length, and grain yield than the crop sown on 15 May and onwards. Sangoi (1993) found that hybrid maize planted during earlier planting date had elongated growth period of more than 2 weeks than planted in delayed date.

Ten to 12 color leaf stage of development is one of the most important stages in maize when the plants initiates the rapidest growth rate implicating that high and intensive care specially regarding water and fertilizer management is important at this stage. $S_1$ attained 10 color leaf stage at the earliest (39.73d in first Rabi while 56.67d in the second Rabi season while the respective duration for $S_3$ were 41.07 and 58.92 d respectively. In Kharif season, $S_3$ had the 10 leaves at the earliest. In all the season, $V_1$ and $V_3$ produced 10 leaves at the latest (41 d in the first Rabi (61.67 d in the second Rabi, 36 d in Kharif) while $V_2$ at the earliest (39.63 d at first Rabi, 52 d in second Rabi). The interaction treatment $S_1V_1$ always delayed to produce 10 leaves while $S_1V_2$ in the both the Rabi season had 10 leaves at the earliest (36 and 51 d respectively).

There were three to seven days intervals between tasseling and silking and so only the silking has been discussed. Khan *et al.* *(*2011) reported that days to tasseling were significantly affected by planting date. Days to tasseling decreased with delay in planting. Since, tassel initiation is correlated with maturity of genotype and so late maturing genotype will take more days to tasseling (Lejeune and Bernier, 1996) and vice versa. Maize variety Azam was found to be belonged to medium maturity group (Khan *et al.*, 2004) and accordingly it took significantly less days to tasseling like the

Yangnuo-7 of this study. Days to tasseling decreases with delay in planting from March to July.

Days to silking indicates the length of the plants life cycle as the reproductive stages of most of the genotypes does not vary remarkably. $S_1$ in both the Rabi season had the shortest silking days (68-69 d) while $S_3$ in the Kharif season had the earliest silking (60 d). Likewise $S_3$ in both the Rabi season had the longest silking days (around 73 d). $V_1$ in all the seasons had the longest silking days (77-79 d in Rabi seasons, 66 d in Kharif season) while $V_2$ produced silk at the earliest. The interaction treatment $S_3V_1$ had the longest silking days in both the Rabi season (80-81 d). The silking stage begins when the silk (hair like structure at the apex of the ear) is visible outside the husk. Pollen falls onto the silks to potentially fertilize the ovules. Each ovule can produce an individual kernel. Moisture stress at this time can cause the desiccation of silks and/or pollen grains, which could reduce seed set. Khan *et al.* (2011) reported that days to silking were significantly affected by planting dates. Sweet corn planted on 17 th March took more days to silking (72.2). Delay in planting decreased days to silking and minimum days up to 56.73 days which was noted with 26 th the July planted crop. This decrease in days to silking may be due to increase in mean temperature with delay in planting date. The results in relation to silking of this study is also in agreement with Mederski and Jones (1963) who reported a decrease in the number of days from planting to silking as the soil temperature increased. Shrestha *et al.* (2016) in another study observed that April 7th planting showed longest days to silking (58.08) and also seed fill duration (51.25) than other planting dates. The reason for lengthening of different phonological stages were due to relatively cooler temperature in the surrounding atmosphere.

In this study the days to silking was significantly ($p<0.05$ and $p<0.01$) affected by genotypes, planting time and their interactions. Determination of planting dates for maize genotypes is crucial for higher crop yields. Significant effects of planting date and landraces on days to silking in corn were also reported by Khan *et al.* (2009) and Shafi *et al.* (2006). Late planting of maize caused elongation of silking to physiological maturity period due to adverse effect of low temperature on pace of maturity period as well as proper grain black layer filling was also affected (Tollenaar and Bruulsema, 1998). Daynard, (1972) observed that time interval requirement of thermal condition during planting to mid – silking stage in maize crop was lengthened whereas, the requirement of thermal exposure interval by mid – silking to grain black layer formation stage was shortened as a result of late seed planting. Banotra *et al.* (2017) found a significant difference in silking due to varietals effect. The cultivar Misthi took maximum days (60.71 days) to silking which was then followed by cultivar Sugar-75 (60.32 days) and Gold star (60.21 days). This variation in the number of days taken to silking was due to genetic variation of the different sweet corn cultivars as was also observed by Khan *et al.* (2009).

Physiological maturity was observed to be at the longest with $S_3$ in both the Rabi seasons (130-132 d), while it was at the earliest with $S_1$ in Kharif season (60 d). Likewise $V_1$ in all the seasons had the latest maturity (136 d in first Rabi, 139 d in second Rabi, 115 d in Kharif) while $V_2$ at the earliest (113 in Rabi, 96 d in Kharif). Banotra *et al*. (2017) studied six planting dates (29 March, 15 April, 30 April, 15 May, 30 May and 19 June) on three sweet corn cultivars (Misthi, Sugar-75 and Gold star) and revealed that maximum of 94.67 days was taken by the crop to reach harvest maturity with March 29 sown crop which was statistically at par with that of the April 15 and April 30 sown crops showing 94.57 and 94.26 days, respectively. Sweet corn crop planted on June 19 planting required minimum days to reach these stages. Among the different genotypes, cultivar Misthi has been found to be adjudged as the best cultivar and the period from 29 March to 30 April as the optimum planting window with 15 April as appropriate planting date for judicious utilization of applied resources for optimization of yields under sub-tropical Jammu, India.

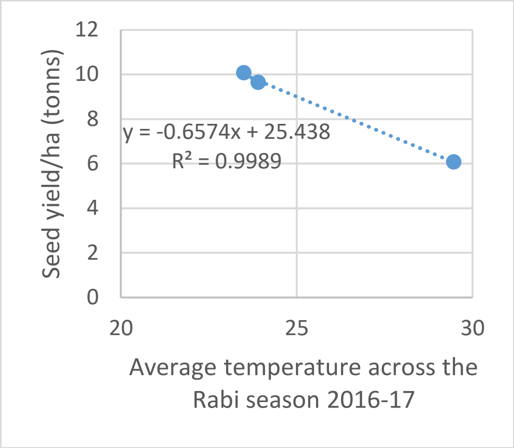
Plant height indirectly indicates the amount of total biomass of a crop plant. $S_1$ had always had the highest plant height in all the seasons (201 cm) while $S_3$ the lowest (157-158 cm). Likewise $V_1$ had the longest plants in both Rabi and Kharif seasons (203-205 cm) while $V_2$ the shortest (157-158 cm). The interaction of $S_1V_1$ had the highest plant height in Kharif and second Rabi seasons (221 and 218 cm respectively). $S_1$ and $V_1$ always was in the group of having significantly higher leaf area (above 0.80 $m^2plant^{-1}$) in the first Rabi season. In other cases the production of leaf area was a bit inconsistent. $V_2$ had always had the least leaf area (below 0.70 $m^2plant^{-1}$, below o.60 $m^2$ in Kharif season).

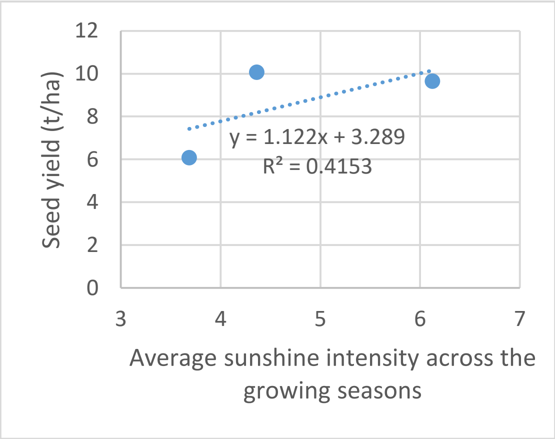
$S_3$ in both the Rabi season had the highest LAI (5.40-4.48) while in Kharif season planting date does not show much variation in LAI (4.47-4.48). All the genotypes except $V_2$ did not differ in LAI, $V_2$ always had the least LAI (4.89 in first Rabi, 5.05 in second Rabi, 3.99 in Kharif). Likewise no particular interaction treatment showed superiority producing LAI in all the season. CGR increased linearly from 30 DAS to maturity (3.45 and 5.16 respectively in first Rabi; 1.92 and 5.98 espectively in Kharif; 3.8 and 5.32 espectively in second Rabi). At 90 to maturity the highest CGR was obtained with S3 in the first Rabi season (22.23) while in the second Rabi it was with the $S_1$ (18.18). All the planting dates had miarginal differences (21-22) in the CGR value in the Kharif season. $V_1$ in first Rabi season had the highest CGR (22.76) among other genotypes. Likewise, $V_1S_1$ had the highest CGR (23.32) during 90 to maturity stage. Reverse to the CGR, RGR decreased from 30 DAS and onward reaching to 0.01 at 45-60 DAS time. $S_1$ in both the Rabi seasons had the highest RGR (0.05) while in Kharif season it was $S_3$ which had the highest (0.057). Again, in contrast to many other parameters, $V_2$ showed the highest RGR values in both the Rabi seasons (0.056-0.060) compared to other genotypes. But $V_1S_1$ in the first season showed the highest RGR (0.06) while the $V_3S_3$ the lowest (0.03). Like RGR, NAR decreased as the plant advance towards maturity at different growth stages. $S_1$ in the first Rabi and also in Kharif season had the highest NAR value between 45-60 DAS stage (0.0025 in first Rabi, 0.002 in Kharif). In the same seasons, $V_1$ along with some other genotypes except $V_2$ had the highest values in NAR (0.002). $S_1V_1$ in Rabi 2016-17 showed the highest values in NAR (0.003) at 45-60 DAS.

$S_1$ had the highest stover yield in all the seasons in first Rabi, Kharif and second Rabi (113, 104 and 115 gplant$^{-1}$ respectively) while $S_2$ had the least (112 and 99 in Rabi and Kharif respectively). $V_1$ had always in the higher order having greater values in stover dry weight (120, 113 and 123 gplant$^{-1}$ respectively). $S_1V_1$ had the highest stover in Kharif and Rabi season (113 and 124 g respectively). The reduction in vegetative growth on plants sown in March probably limited source of photosynthetic (Tollenaar, 1999) which resulted in lower values of yield components. In order to minimized negative effect of some abiotic and biotic stress on plant, planting date can play a major role in determining the seed yield, quality, seed germination and understanding whole phenology stages in many regions (Koca and Canavar, 2014). Like the stover, the highest ear weight was obtained with $S_1$ in all the seasons (144, 103 and 143 g respectively in first Rabi, kharf and second Rabi seasons) while the least with $S_3$ (142 in first Rabi, 117 g in Kharif). $V_2$ always had the lowest ear weights (117, 61 and 101 g respectively in first Rabi, Kharif and second Rabi seasons). $S_1V_1$ had always the highest ear weight (156, 108 and 154 gplant$^{-1}$ respectively in first Rabi, Kharif and second Rabi). Dry matterplant$^{-1}$ was at the highest with $S_1$, $V_1$ and $S_1V_2$ in all the seasons of 2016-17, 2017 and 2017-18 (257, 207 and 269; 274, 211 and 278; 276, 229 and 279 g) while $V_2$ had the least values (165 and 240 g in Kharif and Rabi respectively). Like dry matterplant$^{-1}$ the highest number of grain was found with the $S_1$, $V_1$ and $S_1V_2$ in all the seasons of 2016-17, 2017 and 2017-18 (282, 249 and 322; 322, 309 and 302; and 337, 333 and 323 g respectively) while $V_2$ had the least values (162, 217 and 183 g in first Rabi, Kharif and second Rabi respectively).

Likewise, the highest grain weight per plant was found with the $S_1$, $V_1$ and $S_1V_2$ in all the seasons of 2016-17, 2017 and 2017-18 (149, 95 and 135; 160, 92 and 144; and 162, 102 and 150 g respectively) while $V_2$ had the least values (117, 74 and 105 g in first Rabi, Kharif and second Rabi respectively). $S_1$ had the highest 100 seed weight in both the Rabi seasons (32.17 and 32.38 g respectively).$V_4$ in both the Rabi while $V_1$ in Kharif had the highest 100 seed weight (Rabi 32-33 and Kharif 22g), $S_1V_1$ in

Kharif and Rabi last had among others with the highest value in 100 seed weight (23 and 34 g respectively). The interaction with $V_2$ had always the lower 100 seed weight values (17-28g). Like some other yield contributing parameters, the highest seed yield per hectare was found with the $S_1$, $V_1$ and $S_1V_2$ in all the seasons of 2016-17, 2017 and 2017-18 (9.982, 6.339 and 10.145; 10.590, 6.590 and 11.480; and 10.77, 7.35 and 11.650 tha$^{-1}$ respectively) while V2 had the least values (7.360, 5.35 and 7.879 tha$^{-1}$ in first Rabi, Kharif and second Rabi respectively).





On an average the Rabi season's seed yield was 9.852 tha$^{-1}$, while the Kharif season showed seed yield of 6.070 tha$^{-1}$. So, in the kahrif season 38% seed yield was reduced probably due to the insufficient sunlight. It was observed that the average temperature had a negative relationship (negative slope in the linear regression formulae on the graph set beside), but this negative relation was found to be highly significant ($R^2$= 0.9989). However, in this study the seed yield was higher in Rabi than in Kharif. This happened as in the Kharif the solar radiation was very poor due to the overcasting of the cloud in day time which eventually caused a great limitations to more dry matter accumulation in seed. The function of sunshine on the seed yield has been demonstrated in the other graph where it is observed that the sunshine and seed yield is positively related having a positive slope (1.12) and a regression coefficient ($R^2$=0.4153).

For optimization of yield, planting at an appropriate time is very critical (McCutcheon *et al.*, 2001). Ali *et al.* (2018) reported that one of the most important factors contributing to yield gap is a planting of maize on appropriate planting dates. Dekhane *et al.* (2017) contended that early planting in the spring is optimum and more efficient than delayed planting as through early planting germination occurs when days are longer and sun shines impact is more by way of an acute angel; whereas delaying planting date results in decrease in maize grain yields.

In general, changes in plant's surroundings such as fluctuation in temperature and humidity result in allocation of photosynthate to sinks (seed) (Gormus and Yucel, 2002). Unfavorable planting date causes plants subject to adverse growing conditions during germination and early seedling growth. Also, planting too late, generally results in reduced yields and increases vulneRability to insects, weeds and unsuitable weather. Whereas weather condition particularly cloudy days and intensive rains might have forced the plants to enter into reproductive phase early thus resulting in shorter growth period and the plant do not get enough time for complete maturity during delayed planting (Azadbakht *et al.*, 2012; Ramachandrudu *et al.*, 2013).

The effect of temperature in reducing the length of growing cycle especially the grain filling phase is the most important factor in explaining reduced yields at warmer temperatures (White and Reynolds, 2003). The extreme temperatures have an adverse effect on the yield of major crops in different parts of the world. K. K. Murari *et al*. (2018) finds an inverse linear relationship between yield and extreme degree days. The impact of extreme temperature on yields (EDD) was greater than the impact of rainfall and GDD and suggests that the inverse relationship between EDD and crop yield holds for the different quantile levels. It focuses on climate and climate variability, and clearly shows that exposure to extreme heat is the most important effect of climate change on agriculture that can be currently observed in Karnataka.

In general in crops especially in grain crops there is a close positive relations with the grain yield and other yield attributes like number of reproductive units, number of grains per reproductive unit, individual grain weight and also with the biological weight either per plant or in an unit area of land.

The highest biological yield per hectare was found with the $S_1$, $V_1$ and $S_1V_2$ in all the seasons of 2016-17, 2017 and 2017-18 (21.330, 14.104 and 21.455; 22.720, 14.500 and 22.119 tha$^{-1}$; and 22.62, 15.712 and 23.000 tha$^{-1}$ respectively) while V2 had the least values (7.360, 5.35 and 7.879 tha$^{-1}$ in first Rabi, Kharif and second Rabi respectively). The significantly the highest harvest indices were with $S_1$ having values in the range of 46-50 across seasons and the corresponding values with $V_1$ were 47-52 and $S_1V_1$ (in most cases) 47-54. Interaction treatments with $V_2$ had in most of the cases lower harvest index values.

GDD in Rabi seasons for the seedling emergence, $V_6$, $V_{10}$, $V_{12}$, tasseling, silking and maturity ranged respectively from 67-71, 248-327, 168-218, 130-133, 162-271, 78-84 and 880-945 day degrees, while the corresponding values in Kharif season were 116, 267, 286, 145, 431, 187, 833 day degrees. Unlike in some other parameters, the GDD with S1 was not at the highest although this planting date had higher values in most of the plant parameters. The highest GDD was obtained with $S_3$ in Rabi seasons (1982 degree days) while with $S_2$ in Kharif season (2177 day degrees). In Kharif season, the GDD was the highest (2305 day degrees) showing a bit higher values than in Rabi with $V_1$ (around 2000 day degrees). That is the Kharif crops had higher day degrees as compared to that of the Rabi crops. This could be explained in the way that despite shorter life duration the Kharif crop had much higher ambient temperature compared to Rabi season.

Regression analyses of some yield attributes with the GDD showed that the data were best fitted to the polynomial regression as compared to the linear regression showing a higher regression coefficient (in most cases over 0.70). Based on the polynomial regression curvilinear model as was observed in this study, it may be opined that although the GDD of each of the yield attributes in general have a definite values. In this study it was observed that it varied depending on the changes of the planting dates and genotypes. It was also observed from the polynomial regression analyses that with the increase in GDD, the values of all the yield attributes also increased to a certain limit and there after it tended to decrease. The cumulative GDDs at maturity for the highest values for the weights in first Rabi, Kharif and second Rabi seasons respectively were 1868, 2240 and 1980°C-d in stover; 1986, 2240 and 1935°C-d in ear; 1916, 2339 and 2036°C-d in per plant dry weight; 1986, 2339 and 2165°C-d in per hectare yield; and 1986, 2339 and 1887°C-d in per hectare biomass yield.

Precise calculations of growing degree days (GDD) are an important component in crop simulation models and managerial decisions. Traditional methods for calculating GDD assume linear developmental responses to temperature and cannot precisely account for the delay in growth or development at temperatures above the optimal temperature ($T_{opt}$). A new nonlinear method for calculating GDD was developed. (Teal *et al*., 2020).

One study showed that the days required for attainment of different phenophases viz., seedling, peak vegetative, tasseling, silking, first harvest and last harvest and yield of baby corn both in Rabi and Kharif season were influenced by GDD (thermal time) (Thavaprakaash *et al*., 2007). Works of Dahmardeh *et al*. (2002) also showed that the planting dates and variety of maize were affected by the GDD. They showed that among the tested genotypes (SC 108, SC 301, SC 604, SC 704 and TVG), the best hybrid SC 704 accumulated growing degree days (GDD) and was the highest for seed yield and all yield components. Again among the planting dates (6th July, 21st July and 20th August), the plant sown on 5th August, accumulated suitable GDD and produced the highest seed yield, biological yield and harvest index.

In another study with planting date and genotypes, Hamid *et al*. (2019) observed a marked variations in days to attaining phenological stages, temperature accumulation, duration of growth stages and grain yield across locations and planting dates. October planted maize in Bandarban completed its life cycle in 116 days while February planted maize in Kaharol suffered from high temperatures. December planted maize in Birganj experienced cool weather in vegetative phase and nearly optimal temperatures during reproductive phase. High temperatures hastened maturity reducing the duration of reproductive growth. Early planted maize produced the highest grain yield. Higher grain yield was positively related with the duration of reproductive growth phase. Late planting reduced maize grain yield mainly through lowering the number of kernels per ear and reducing kernel weight.

# SUMMARY AND CONCLUSION

# CHAPTER V

# SUMMARY AND CONCLUSION

## Summary

Four experiments were conducted at the experimental farm of the Sher-e-Bangla Agricultural University, Dhaka during the Rabi 2016-17, Kharif 2017 and rabi 2017-18 to study the effects of three planting dates in both Rabi and Kharif and four genotypes on the phenology, growth and yield of white maize. The planting dates were Nov 25, Dec 10 and Dec 25 in Rabi and May 29, June 21 and July 6 in Kharif. The test genotypes were PSC-121, Yangnuo-7, Yangnuo-30 and Changnuo-6.Data were collected on different phenological growth stages, physiological attributes, dry matter and yieldwere collected and subjected to appropriate statistical analyses. Significant genotypexplanting date differences were observed in terms days to emergence. Changnuo-6 took the longest time for emergence--6.67 and 6.33 days when sown on December 10 and 25, respectively. Yangnuo-30 took the shortest time for emergence among the genotypes taking 5.0 days when sown on November 25.Also, November 25 sown PSC-121 took a short period, 5.33 days, for emergence. In general, delayed emergence in mid to late December was due to the lower temperature than that in November.

In the Rabi season, planting earlier enabled the maize plant to attain the 10-collar leaf stage early, e.g., the November 25 sown crop took the shortest time, 39.73 d to attain this stage. In the kharif season, the July 6 sown crop reached this stage at the earliest. The genotype PSC-121 took the longest time (51d) to reach the 10-collar leaf stage when sown on November while this period was the shortest (36 d) for the combination Yangnuo-7 x November 25.

In case of days to silking, the earliest planting date in Rabi, i.e., November 25, enabled the maize crop to reach this stage in the shortest time (68-69 d) while planting later, i.e., December 25 delayed silking by 4-5 days. In Kharif, the July 6 planting brought about silking in 60 d. Irrespective of season, PSC-121 was the slowest among the genotypes in terms of days to silking stage (77-79 d in Rabi and 66 d in Kharif), and delayed planting further prolonged this (80-81 d) in both Rabi and Kharif seasons. Yangnuo-7 was the fastest among the genotypes to reach the silking stage. Delayed planting generally delayed physiological maturity of white maize in both Rabi and Kharif seasons. As for example, with the latest planting (December 25) in Rabi, the time taken to mature was 130-132 d while with the earliest planting date, i.e. November 25 it was 126 d. Likewise, in the Kharif season, the earliest sown (May 29) crop took the shortest time (60 d) to mature. Among the genotypes, PSC-121took the longest period of time (136-139 d in Rabi and 115 d in Kharif) to mature while Yangnuo-7 took the shortest (113 d in Rabi and 96 d in Kharif).

Planting late (December 25) in the Rabi season resulted in the highest leaf area index (LAI), 5.40-4.48, but in the Kharif season planting date was not observed to significantly influence LAI (4.47-4.48). The genotypes PSC-121, Yangnuo-30 and Changnuo-6 did not differ significantly from one another in terms of LAI, but Yangnuo-7 had a significantly lower LAI irrespective of season (4.89-5.05 in Rabi and 3.99 in Kharif). In this respect, the genotype x planting date interaction was not significant.

The crop growth rate (CGR) of maize increased linearly from 30 days after planting (DAS) to maturity (3.62 and 5. 24, respectively, in Rabi and 1.92 and 5.98, respectively in Kharif). Planting date influenced CGR in the rabi season (18.18 with the November 25 planting and 22.22 with the Decmber 25 planting) but had only a marginal effect, with a flat value of 21-22, in the Kharif season. PSC-121 had the highest CGR, 22.76, among the genotypes in the Rabi season with the November 25 planting.

To the contrary, the relative growth rate (RGR) declined between 30 DAS and onward dipping to 0.01 in the 45-60 DAS period. Planting early (November 25) gave the highest RGR (0.05) in Rabi while late planting (July 6) gave the highest RGR (0.057) in Kahrif. The genotype Yangnuo-7 had the highest RGR values (0.056-0.060)in theRabi season.  Like RGR, the net assimilation rate (NAR) decreased as the plant advanced towards maturity through different growth stages. Early planting, in both Rabi and Kharif gave the highest NAR values(0.0025 in Rabi, 0.002 in Kharif) at the 45-60 DAS stage. The genotype PSC-12, Yangnuo-30 and Changnuo-6 had the highest NAR values (0.002). The PSC-121 x November 25 planting combination had the highest NAR value of0.003 at the 45-60 DASstage.

Dry matter/plant was the highest for earliest sown PSC-121 in both Rabi and Kharif and Yangnuo-7 gave the lowest.  This was true for the yield attribute, number of grains.  The other yield attribute, 100 seed weight was also influence by planting date and genotype. The highest 100 seed weight of 32.17- 32.38g in Rabiwas obtained with early planting (November 25). The genotype PSC-121 when early sown (November 25) was the best performer in terms of 100 seed weight, 34 and 23g in Rabi and Kharif, respectively. Yangnuo-7 had the lowest 100 seed wright, 28 and 17g, respectively.  The variations in the yield components were generally reflected in seed yield of the four maize genotypes. Early sown (November 25) PSC-121, with 9.98-11.48 t/ha in Rabi and 7.35 t/ha in Kharif, out yielded any of the other three genotypes  while Yangnuo-7 fared poorly with 7.36-7.88 and 5.35 t/ha in Rabi and

Kharif, respectively. Likewise, the highest biological yield of 23.00 t/ha was obtained with earliest sown PSC-121 in Rabi, the same combination gave 14.10 t/ha in Kharif.

The temperature dependence parameter, growing day degree (GDD) of white maize genotypes in the Rabi for seedling emergence, V6, V10, V12, tasseling, silking and maturity ranged, respectively, 67-71, 248-327, 168-218, 130-133, 162-271, 78-84 and 880-945 day degrees, while the corresponding values in kharif season were 116, 267, 286, 145, 431, 187, 833 day degrees. GDD, like other phenological parameters, was influenced by planting date and genotype. For December 25 planting in Rabi, GDD was 1982, while it was 2177 for the June 21 planting in Kharif. In Kharif season, GDD was the highest (2305 day degrees) for PSC-121, which was a bit higher than 2000 day degrees in Rabi.

## Conclusion

This three-year study on the effects of genotype and planting date on the phenology, growth and yield of four white maize yielded useful scientific information which can be used to initiate and expand the production of white maize in Bangladesh for human consumption.

The maize genotypes tested, PSC-121, Yangnuo-7, Yangnuo-30 and Changnuo-6, grew through the usual phonological stages and events to maturity and delivered reasonable economical yield in both the Rabi and Kharif seasons. This indicated that it would be practically possible to grow them in farmers' fields under the prevailing agro-ecological conditions of Bangladesh.

A delay in planting delayed the time required for seedling emergence and to reach the 10-leaf collar, tasseling, silking stages and maturity, and reduced yield of the white maize genotypes PSC-121, Yangnuo-7, Yangnuo-30 and Changnuo-6 in both Rabi and Kharif seasons.

In the rabi season, the genotype PSC-121 took the maximum time, 141.33 d, to mature due to delayed planting, whereas the time needed for maturity was minimum, 111d (Yangnuo-7) when planting was done at the optimum time, i.e., November 25.

The genotype PSC-121 gave the best results in terms of the yield contributing characters, 100 seed weight, grain number/plant and grain weight/plant. Consequently, the highest seed yield was obtained with genotype.

Planting date was of critical importance in maize yield. For example, the highest yield of 11.46 t/ha (PSC-121) in the Rabi season was achieved when planting was done on November 25, and in general, the earlier the planting the higher was the yield irrespective of variety.

The total growing degree days (GDD) was less in PSC-121 than that in Yangnuo-7 with the first date of planting. There was a negative correlation between temperature and yield.

On an average, the seed yield in the Rabi season was 9.852 t/ha, while in the Kharif season it was 6.070 t/ha. Thus, there was a 38% lower yield in the warm Kharif season than that in the cool Rabi season.

Overall, planting PSC-121 early on in the Rabi season would be the appropriate practice in the cultivation of white maize in Bangladesh.

These results need to be fine-tuned through further experimentation in different maize growing areas of the country.

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## CHAPTER VI

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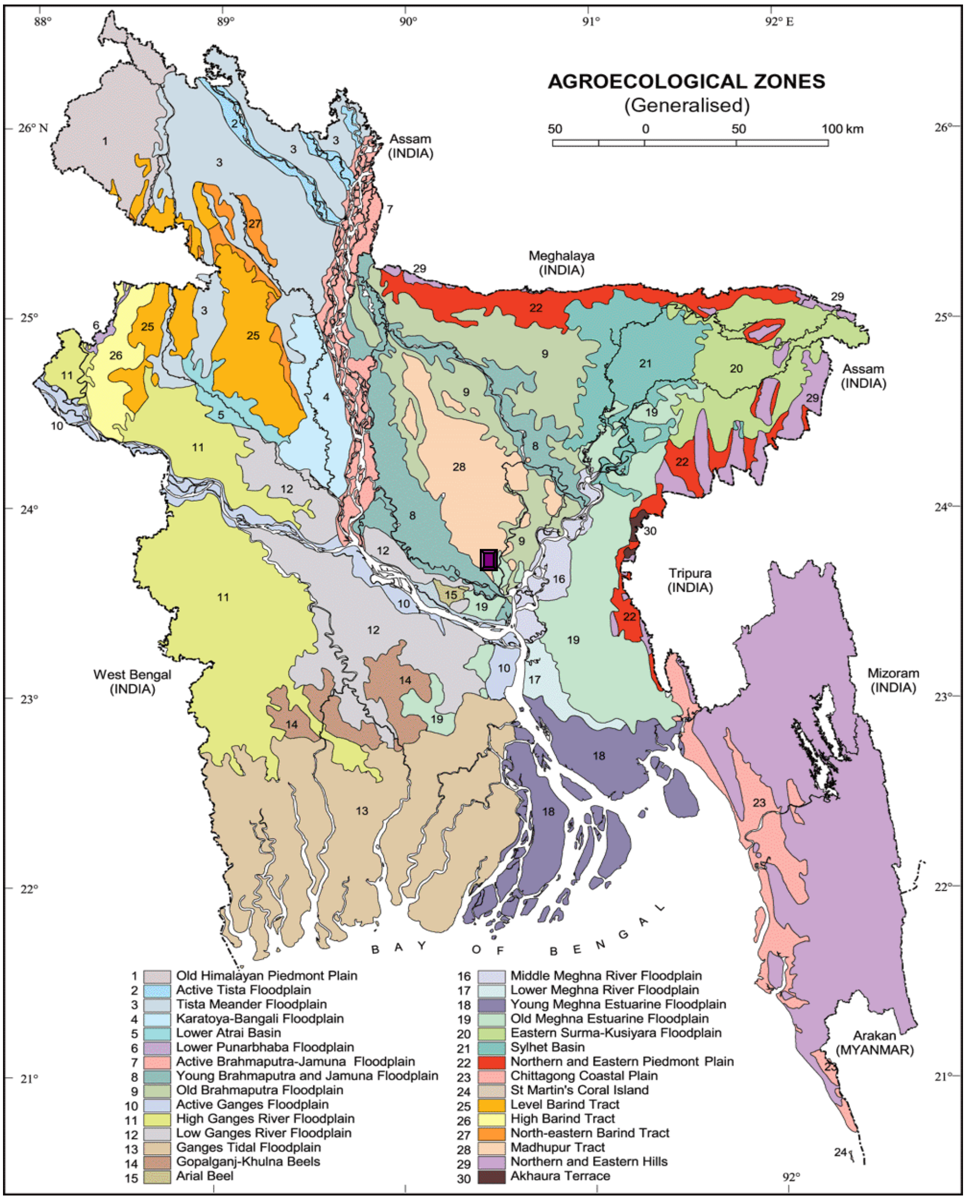
# APPENDICES

# APPENDICES

## Appendix I: Map showing the experimental sites under study



## Appendix II: Characteristics of soil of experimental is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1207

### A. Morphological characteristics of the experimental field

| Morphological features | Characteristics |
|---|---|
| Location | Research Field laboratory, SAU, Dhaka |
| AEZ | Madhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | Medium hHigh land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |

## Appendix III: Line graph showing the experimental sites average maximum and minimum temperature from November-16 to April-18 under study area.

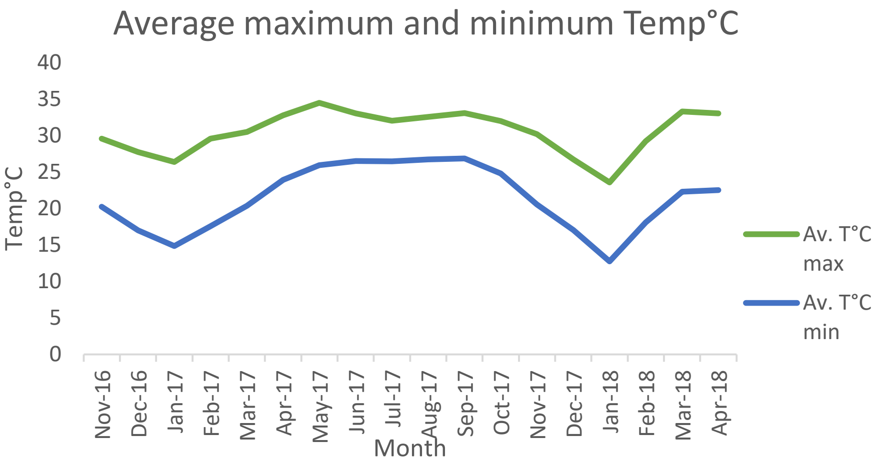


Fig: Line graph showing the experimental sites average maximum and minimum temperature from November-16 to April-18 under study area

**Appendix IV**: 1.The experimental sites average maximum and minimum temperature from November-16 to April-18 under study area

| Month | Av. T°C max. | Av. T°C min. |
|---|---|---|
| Nov-16 | 29.6 | 20.22 |
| Dec-16 | 27.75 | 17 |
| Jan-17 | 26.36 | 14.86 |
| Feb-17 | 29.56 | 17.58 |
| Mar-17 | 30.48 | 20.38 |
| Apr-17 | 32.78 | 23.94 |
| May-17 | 34.5 | 25.92 |
| Jun-17 | 33.04 | 26.51 |
| Jul-17 | 32.05 | 26.48 |
| Aug-17 | 32.58 | 26.74 |
| Sep-17 | 33.07 | 26.88 |
| Oct-17 | 31.99 | 24.8 |
| Nov-17 | 30.18 | 20.56 |
| Dec-17 | 26.71 | 17.05 |
| Jan-18 | 23.56 | 12.75 |
| Feb-18 | 29.21 | 18.11 |
| Mar-18 | 33.31 | 22.3 |
| Apr-18 | 33.03 | 22.53 |
| May-18 | 32.67 | 22.56 |

## Appendix V: Line graph showing the experimental sites average Relative Humidity (RH) from November-16 to April-18 under study area.

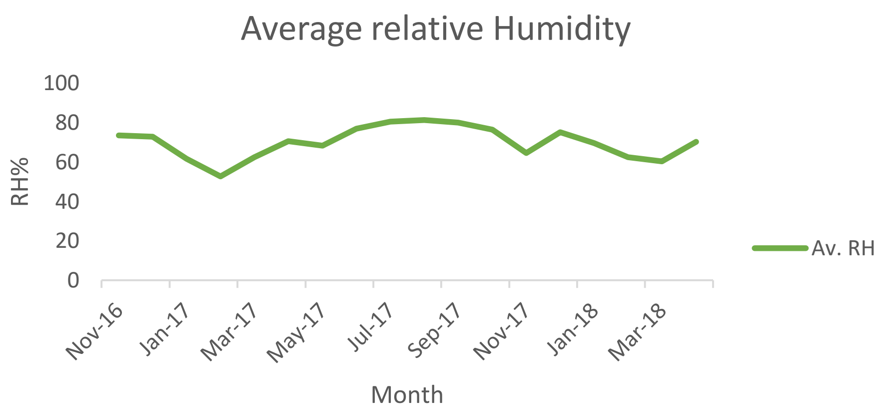


Fig: Line graph showing the experimental sites average Relative Humidity (RH) from November-16 to April-18 under study area.

## Appendix V: Line graph showing the experimental sites average sunshine hours from November-16 to April-18 under study area.

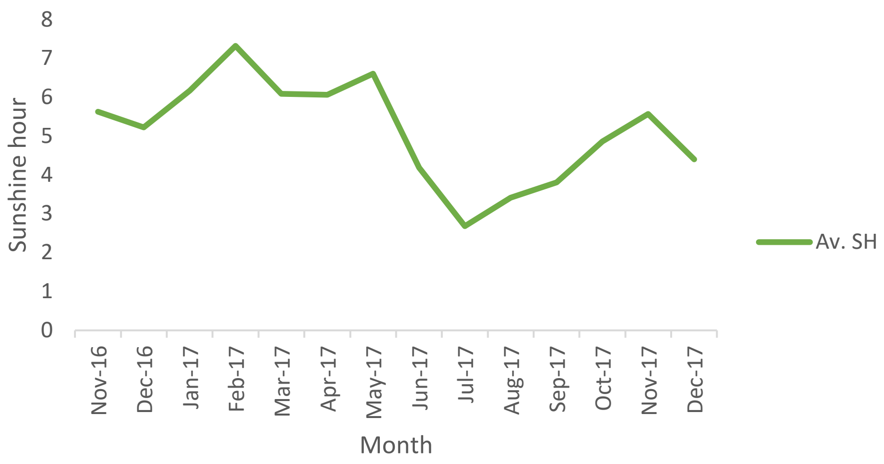


Fig: Line graph showing the experimental sites average sunshine hours from November-16 to April-18 under study area**.**

**Appendix VI.**The experimental sites average sunshine hours from November-16 to Deccember-2017 under study area.

| month | Av. SH |
|---|---|
| Nov-16 | 5.63 |
| Dec-16 | 5.22 |
| Jan-17 | 6.17 |
| Feb-17 | 7.32 |
| Mar-17 | 6.09 |
| Apr-17 | 6.06 |
| May-17 | 6.61 |
| Jun-17 | 4.19 |
| Jul-17 | 2.68 |
| Aug-17 | 3.41 |
| Sep-17 | 3.81 |
| Oct-17 | 4.86 |
| Nov-17 | 5.57 |
| Dec-17 | 4.4 |

# Appendix VII: Line graph showing the experimental sites average Total Rainfall (T Rain) from November-16 to April-18 under study area.

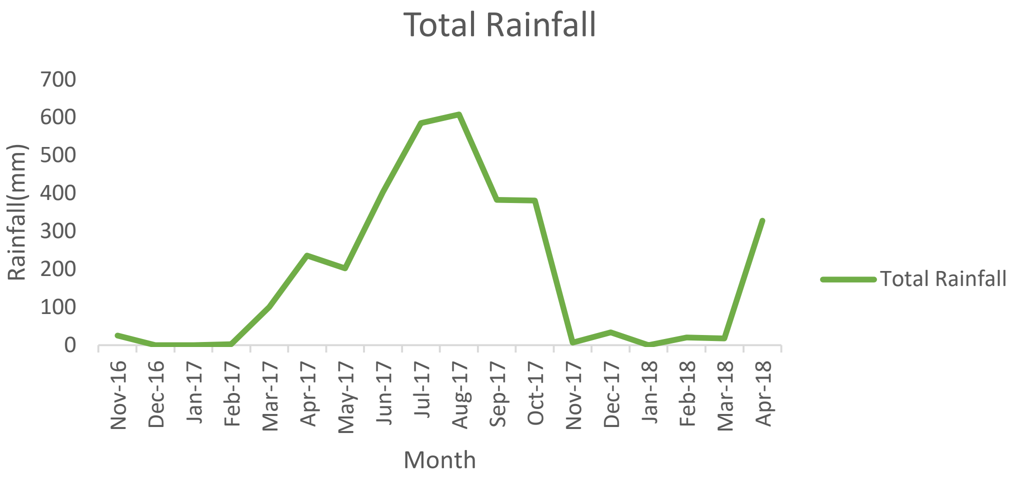


Fig: Line graph showing the experimental sites average Total Rainfall (T Rain) from November-16 to April-18 under study area

### Appendix VIII: Mean square values of ANOVA for phonological and growth parameter of white maize as affected by genotype and planting date at SAU during Rabi 2016-2017

| Source of variation | Days to $V_6$ | Days to $V_{10}$ | Days to V12 | Days to tasseling |
|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 |
| Error MS | 0.68 | 0.12 | 0.10 | 1.8 |

### Appendix IX: Mean square values of ANOVA for yield and yield contributing parameter of white maize as affected by genotype and planting date at SAU during Rabi 2016-2017

| Source of variation | Days to Total dry weight | Days to 100 grain weight | Days to yield | Days to Biological yield |
|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 |
| Error MS | 0.78 | 2.72 | 0.010 | 0.17 |

### Appendix X: Mean square values of ANOVA for Leaf area index of white maize as affected by genotype and planting date at SAU during Rabi 2016-2017

| Source of variation | Days to 30DAS | Days to 45DAS | Days to 60DAS | Days to 75DAS | Days to 90DAS | Days to Harvesting |
|---|---|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 | 12 | 12 |
| Error MS | 1.09E-03 | 0.0015 | 0.111 | 0.05 | 0.03 | 0.02 |

### Appendix XI: Mean square values of ANOVA for phonological and growth parameter of white maize as affected by genotype and planting date at SAU during Kharif 2017-2018

| Source of variation | Days to V6 | Days to V10 | Days to V12 | Days to tasseling |
|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 |
| Error MS | 6.27 | 16.78 | 39.96 | 32.38 |

### Appendix XII: Mean square values of ANOVA for yield and yield contributing parameter of white maize as affected by genotype and planting date at SAU during Kharif 2017-2018

| Source of variation | Days to Total dry weight | Days to 100 grain weight | Days to yield | Days to Biological yield |
|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 |
| Error MS | 126.34 | 7.97 | 0.61 | 4.46 |

**Appendix XIII: Mean square values of ANOVA for Leaf area index of white maize as affected by genotype and planting date at SAU during Kharif 2017-2018**

| Source of variation | Days to 30DAS | Days to 45DAS | Days to 60DAS | Days to 75DAS | Days to 90DAS | Days to Harvesting |
|---|---|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 | 12 | 12 |
| Error MS | 0.004 | 0.003 | 0.23 | 0.10 | 0.19 | 0.22 |

**Appendix XIV: Mean square values of ANOVA for phonological and growth parameter of white maize as affected by genotype and planting date at SAU during Rabi 2017-2018**

| Source of variation | Days to V6 | Days to V10 | Days to V12 | Days to tasseling |
|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 |
| Error MS | 0.012 | 0.016 | 0.006 | 0.006 |

**Appendix XV: Mean square values of ANOVA for yield and yield contributing parameter of white maize as affected by genotype and planting date at SAU during Rabi 2017-2018**

| Source of variation | Days to Total dry weight | Days to 100 grain weight | Days to yield | Days to Biological yield |
|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 |
| Error MS | 1.22 | 1.08 | 0.010 | 3.09 |

**Appendix XVI: Mean square values of ANOVA for Leaf area index of white maize as affected by genotype and planting date at SAU during Rabi 2017-2018**

| Source of variation | Days to 30DAS | Days to 45DAS | Days to 60DAS | Days to 75DAS | Days to 90DAS | Days to Harvesting |
|---|---|---|---|---|---|---|
| Error Degree of freedom | 12 | 12 | 12 | 12 | 12 | 12 |
| Error MS | 2.70 | 1.10E-03 | 0.115 | 0.015 | 0.01 | 0.0077 |

## List of Plate showing the experimental picture of different varieties.

Plate 1**:** Photographs showing PSC-121 maize variety on field condition.

Plate 2**:** Photographs showing Changnuo-6 maize variety on field condition.

Plate 3**:** Photographs showing Yungnuo-30 maize variety on field condition.

Plate 4**:** Photographs showing Yungnuo-7 maize variety on field condition.

Plate 5**:** Photographs showing White maize variety on field condition.

Plate 6**:** Photographs showing calculating time required for thr phenotypic development of white maize variety under different planting dates.

Plate 7**:** Photographs showing PSC-121 maize variety tasseling stage on field condition.

Plate 8**:** Photographs showing Yungnuo-7 maize variety tasseling stage on field condition.

Plate 9**:** Photographs showing Yungnuo-30 maize variety tassling stage on field condition.

Plate 10**:** Photographs showing Changnuo-6 maize variety at tasseling stage on field condition.