SYSTEM OF MUSTARD INTENSIFICATION AS INFLUENCED BY SEEDLING AGES AND FERTILIZER DOSES

MD. MARUF HASAN

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

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BY

MD. MARUF HASAN

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Approved by:

Prof. Dr. Md. Shahidul Islam	**Prof. Dr. Parimal Kanti Biswas**
Supervisor	**Co-Supervisor**

Prof. Dr. Tuhin Suvra Roy
Chairman
Examination Committee

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar

Dhaka-1207

CERTIFICATE

*This is to certify that the thesis entitled, "**SYSTEM OF MUSTARD INTENSIFICATION AS INFLUENCED BY SEEDLING AGES AND FERTILIZER DOSES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MD. MARUF HASAN**, **Registration no. 14-05812** under 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 this investigation, has duly been acknowledged.

Date:

Place: Dhaka, Bangladesh

Prof. Dr. Md. Shahidul Islam

Department of Agronomy

Sher-e-Bangla Agricultural University

Dhaka-1207

Dedicated To

My Beloved Parents

And Respected

Teachers

Whose Prayers,

Efforts And

Wishes Are an

Inspiration

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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka to study the system of mustard intensification (SMI) as influenced by seedling ages and fertilizer doses during the period from October 2019 to February 2020 in *Rabi* season. The experiment consisted of two factors and followed randomized complete block design with three replications. Factor A: ages of mustard seedling (3) *viz;* S_1 = 10 days, S_2 = 15 days and S_3= 20 days and Factor B: different fertilizer doses (4) *viz;* F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer F_3 = 125% of recommended dose of fertilizer. Data on different parameters were collected for assessing results of the experiment and showed significant variation in respect of growth, yield and yield contributing characteristics of mustard due to the effect of seedling ages, different fertilizer dose and their Interaction. Among different ages of seedlings, transplanting 10 days old seedling recorded the maximum number of siliqua plant^{-1} (188.68), length of siliqua (8.94 cm), seeds siliqua^{-1} (29.67), 1000-seed weight (3.88 g), seed yield (2.08 t ha^{-1}), stover yield (3.23 t ha^{-1}), biological yield (5.30 t ha^{-1}) and harvest index (39.12 %). In the case of different fertilizer doses, application of 125% of recommended dose of fertilizer recorded the maximum number of siliqua plant^{-1} (203.56), length of siliqua (9.150 cm), number of seeds siliqua^{-1} (29.67), 1000-seed weight (3.96 g), seed yield (2.17 t ha^{-1}), stover yield (3.29 t ha^{-1}), biological yield (5.47 t ha^{-1}) and harvest index (39.69 %). In case of Interaction effect, the maximum number of siliqua plant^{-1} (219.33), length of siliqua (9.51 cm), number of seeds siliqua^{-1} (32.67), 1000 seeds weight (4.16 g) and seed yield (2.37 t ha^{-1}), biological yield (5.72 t ha^{-1}) and harvest index (41.46 %) were recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Thus for cultivation of mustard, transplanting 10 days old seedling along with 125% of recommended dose of fertilizer (F_3) application performed well towards higher seed production of mustard.

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ABBREVIATIONS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
Co	Cobalt
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agricultural Extension
DAS	Days after sowing
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
Max	Maximum
mg	Milligram
Min	Minimum
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
UPOV	Union for the Protection of Plant Varieties
Wt.	Weight

CHAPTER-I

INTRODUCTION

Mustard (*Brassica spp*. L.) is a worldwide cultivated thermo and photosensitive oilseed crop. Asia produces 41.50 % of mustard seed, which occupies the first position in terms of percentage share of production followed by the USA (FAO, 2018).

Edible oils play vital roles in human nutrition by providing calories and aiding in digestion of several fat soluble vitamins, for example Vitamin A (National Research Council, 1989). The per capita recommended dietary allowance of oil is 6 gm/day for a diet with 2700 Kcal (BNNC, 1984). Oilseeds were cultivated in less than 2.20 % of total arable land under rice-based cultivation system in Bangladesh, where three fourth of total cultivable land was engaged in rice production in 2015-16 (BBS, 2019). Mustard is the major oilseeds in Bangladesh, which exhibits an increase in production from 1994 to 2018 except few fluctuations in the case of total production and area under cultivation (FAO, 2018). Mustard occupied more than 69.94 % of the total cultivated area of oilseeds followed by sesame, groundnut, and soybean (BBS, 2019).With the increase in population, the demand for edible oil and oilseeds is in increasing trend (Alam, 2020). Bangladesh has to import a noticeable amount of edible oil and oilseeds to meet up the existing accelerating demand. The value of imported oilseed and edible oil has increased dramatically from USD 544 million in 2002-03 to USD 2371 million in 2018-19, which were 4.99 and 4.23 % of the total value of imports respectively (BB, 2020). Yield of mustard has increased from 0.75 tha^{-1} in 2001 to 1.15 tha^{-1} in 2019 (MoA, 2008; BBS, 2019). Bangladesh was not in an advantageous position in the case of mustard production (Miah and Rashid, 2015). Under these circumstances it becomes imperative to increase the productivity of mustard per unit area per unit time by exploiting the yield potential of existing cultivars with unconventional agronomic manipulations.

Among the different facts, method of planting and application of different doses of fertilizers play an important role in achieving higher seed yield.

The system of mustard intensification is a new approach for enhancement of oilseed production over the conventional planting system. Though the optimum time of sowing of the oilseed *Brassica* is the first fortnight of October in Northern Asia but sowing of these crops get delayed to November– the first week of December owing to the delayed harvest of *kharif* crops particularly rice, soybean and cotton, due to which productivity declines. In order to accommodate multiple cropping systems on scarcely available land, transplanting of seedlings rather than direct seeding of rapeseed-mustard should be practiced. Root intensification by transplanting the seedlings could offer such an option to boost the seedling growth and yield, which is already being practiced by raising a nursery in a seed-bed or trays or polythene bags in some irrigated rapeseed-mustard growing regions in the country like Umaria and Sehore districts of Madhya Pradesh, but needs to be optimized further (Chaudhary *et al*., 2016).

Aside from modifying seedling growth, transplanting also has other benefits. For example, a seed bed occupies a small field area during sowing, thereby saving field area and improving land utilization efficiency. Seed beds can even be arranged with specific substrates in a seedling factory. Thus, transplanting is much more flexible than direct seeding in terms of space utilization. Transplanting can, to some extent, alleviate the seasonal contradiction in a rice and canola rotation system. Rice canola (*Brassica napus* L.) rotation is essential for canola production in China. The delayed harvesting time of rice in recent years has seriously affected the seeding time of canola (Huang *et al.,* 2009). Consequently, rice harvesting should be completed before canola sowing. However, delayed planting of canola can reduce seed yield (Chen *et al.,* 2005). In contrast to direct seeding, seed sowing can be designed according to the optimal transplanting time on transplanting method. Therefore, transplanting is also more advantageous than direct sowing in terms of time management.

Although there are many benefits of transplanting in mustard production systems, the optimal age of mustard seedling for transplanting remains unknown. Furthermore, inappropriate seedling age is always misleading in terms of whether older or younger seedlings are employed for transplanting in practice. Thus, it necessitates seeking an optimal seedling age and evaluating its effect on seed yield. In rice, Patra and Haque (2011) reported that the most effective tiller per hill and the highest yield can be obtained by using 10 days old seedlings. Similar results were also observed by Sarwar *et al.* (2011). These results exhibited the importance of appropriate seedling age on obtaining the highest grain yield.

However, the productivity of oilseeds is now slowing down coupled with decline in soil fertility. Low and imbalanced use of fertilizers is one of the major reasons for low productivity. There is no alternative, than to use more plant nutrients for high productivity (Ahmad, 1992). A huge quantity of nutrients removed from most of the floodplains and large portion of the terrace soils with the intensification of agriculture in Bangladesh. As a result the level of soil fertility is depleting gradually reflecting the needs of more fertilizer application in the soil for sustaining crop productivity. The application of fertilizers either in excess or less than optimum rate affect both yield and quality of crop to remarkable extent, hence proper management of crop nutrition is of immense importance (Nawaz, 2002; Meena *et al*., 2003).

By considering the above facts the proposed research work was undertaken to achieve the following objectives:

Objectives:

i. To find out a suitable seedling age of mustard in SMI technique.

ii. To determine the optimum fertilizer doses for optimum growth and yield of mustard under SMI technique.

iii. To observe the Interaction effects of seedling age and fertilizer doses on the growth and yield of mustard under SMI technique.

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available regarding the system of mustard intensification as affected by seedling age and fertilizer doses to gather knowledge helpful in conducting the present piece of work.

2.1 Effect of seedling ages

Plant height

Pramanik and Bera (2013) reported that the increase in plant height from earlier transplanting seedlings might be due to more vigour, root growth and lesser transplant shock because of lesser leaf area during initial stages of crop growth, which stimulate increased cell division causing more stem elongation.

Sarker *et al.* (2013) conducted an study on the effect of age of seedlings on growth and yield of two modern rice varieties during Boro season and reported that plant height differed significantly among cultivars and increasing seedling age gradually decreasing plant height.

Murthy *et al.* (1993) reported that plant height did not vary with the use of different aged seedlings for transplantation.

Number of branches plant

Barla *et al.* (2018) carried out a field experiment during *kharif* 2011-12 and 2012-13 at Birsa Agricultural University to study the response of hybrid pigeon pea to planting geometry and age of seedling. The experiment was laid out in split plot design, comprising of two spacing i.e., 90 cm X 20 cm and 75 cm x 25 cm in main plot and method of establishment i.e., three seedling age 15, 30, 45 days old seedlings and one direct seeded pigeon pea in sub plot and were replicated five times. Experimental results showed that seedlings age significantly affect branches plant^{-1} and transplanting 15 days old seedling of pigeon pea recorded maximum branches plant^{-1} (37.14) while 45 days old seedlings recorded minimum branches plant^{-1} (22). It might be due to longer growing period of the crop for better development of parts to allocate greater accumulation of photosynthates in early planted crop which may result in the better development of growth.

Above ground dry matter weight

Ali *et al*. (2013) reported that the maximum dry matter production (211 g) was recorded from 15 days old seedlings and lowest (180 g) from 30 days old seedlings.

Mamun *et al.* (2013) reported that less dry matter production was noticed from 8 days old seedlings compared to 30 days old seedlings.

Sarker *et al.* (2013) reported that dry matter production differed significantly among different seedling age and it was higher in early transplanting seedling comparatively late one.

More *et al.* (2007) noticed that planting younger seedlings of 15 days age led to significant increase in dry matter production as compared to use of older seedlings of 20 and 28 days age and the extent of increase was 9.62 and 18.80%, respectively.

Mondal and Roy (1984) reported that seedling age affects dry matter accumulation. Crop raised with young seedling showed higher dry matter accumulation than older seedling.

1000-seed weight

Pramanik and Bera (2013) noticed that maximum 1000 grains weight 23.62 g was obtained from the transplanting of 10 days old seedling.

Sarwa *et al.* (2011) reported that younger seedlings of 10 days and 20 days old registered comparable higher 1000 grain weight of 21.43 g and 18.78 g, respectively and its significantly superior over 30 (15.54 g) and 40 days (14.8 g) old seedlings.

Seed yield

Singh *et al.* (2006) investigated and reported that more number of siliquae per plant, length of siliqua, seeds per siliqua, 1000-seed weight, which resulted in higher seed and stover yields of transplanted mustard than that of the direct-sown crop.

Basu *et al.* (2003) found that transplanting of 21 days old seedlings gave identical grain yield with direct sown crop and matured 8-10 days earlier.

Wlalo and Kunicki (2003) suggested that use of young transplants resulted in higher yield and better quality.

Momoh and Zhou (2001) reported that crop establishment was fastest in oilseed rape when transplanting was performed 35 days after sowing, suggesting that this transplanting period was optimal, and the highest seed yields of 1748.1 kg ha^{-1} and 1730.7 kg ha^{-1} were obtained when transplanting was performed after 30 and 35 days.

Stover yield

Bagheri *et al.* (2011) noticed that the highest (635.8 g m^{-2}) straw yield was obtained from 20 days old seedlings over 30 and 40 days.

Rajesh and Thanunathan (2003) reported that the seedling age had significant influenced on straw yield. Planting of 40 days old seedlings found to be optimum to get significantly higher (5.63 t ha^{-1}) straw yield compared to 30 (5.09 t ha^{-1}) and 50 (4.76 t ha^{-1}) days old seedlings.

Biological yield

Chakrabortty (2013) conducted a field experiment at the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2011 to May 2012 to study the growth and yield of Boro rice as affected by seedling age and planting geometry under System of Rice Intensification (SRI) and reported that seedling age varied biological yield of boro rice and the maximum biological yield (9.84 t ha^{-1}) was recorded in 16 days old seedling and the minimum biological yield (8.73 t ha^{-1}) was found in 30 days old seedling.

Harvest index

Sarkar *et al*. (2011) reported that the highest harvest index was obtained from 25 days old seedlings, while the lowest was found with 35 days old seedlings.

Pramanik and Bera (2013) reported that maximum harvest index of 45.19 and 47.00 were noticed from 10 days and 15 days old seedlings.

2.2 Effect of fertilizer doses

Plant height

Handayati and Sihombing (2019) was carried out an experiment to determine the effect of NPK fertilization on the growth and grain yield of this plant, a study was done in the Experimental Garden of the Assessment Institute for Agricultural Technology East Java (550 m above sea level), from November 2013 to March 2014. The experiment used a randomized block design and repeated four times. As treatments were the N-P-K fertilizer levels (kg ha^{-1}), *i.e.*, a. 120-50-50, b. 120-75-50, c. 120-50-75-, d. 120-75-75, e. 150-50-50, f. 150-75-50, g. 150-50-75, h. 150-75-75. The result showed that the plant growth affected by NPK fertilizer level. The highest plant posture found on g (150-50-75) treatment reaches 132.50 cm.

Bakht *et al.* (2015) reported that plant height significantly increased with an increase in NPK levels.

Trivedi *et al.* (2013) studied the effect of four fertilizer levels (50%, 75%, 100% and 125% RDF) on plant height and number of branches/plant in Indian mustard at Morena. Application of 125% RDF recorded significant increase in the plant height and number of branches/plant over 50 and 75% RDF, though it was remained at par with 100% RDF.

Singh *et al.* (2010a) studied the effect of four fertility levels (75% RDF, 100% RDF *i.e.* 80 kg N, 40 kg P2O5, 40 kg K2O/ha and 30 kg S/ha, 125% RDF and 150% RDF) on plant height, dry matter production/plant, and number of primary branches/plant on late sown (second week of November) Indian mustard at Varanasi. Application of 150% RDF significantly increased the plant height, dry matter production/plant and number of primary branches/plant over 75% RDF but it was at par with 100% and 125% RDF.

Khatkar *et al.* (2009) performed a field experiment during 2004-2005 at Agricultural Research Farm, Allahabad. The experiment consisted of three factors namely nitrogen (80 and 100 kg ha^{-1}) and sulphur (10, 20 and 30 kg ha^{-1}), phosphorus (40 and 60 kg ha^{-1}) with blanket application of potash at 40 kg ha^{-1}. Highest plant height, SPAD values and maximum plant dry weight was recorded with higher doses of these factors.

Chaudhary *et al.* (2003) investigated the effect of N, P, K and Zn on the growth and yield attributes of Indian mustard at Kanpur, Uttar Pradesh. He found that the application of N at 30 kg + P at 20 kg+ K at 20 + Zn at 5 kg, and N at 60 kg + P at 30 kg + S at 20 kg ha^{-1} showed the highest growth rate.

Branches $plant^{-1}$

Sandhu *et al.* (2015) at Ludhiana reported that maximum number of branches/plant were recorded with the application of 150 kg N/ha over 100 kg N/ha and 125 kg N/ha in Indian mustard in normal sown condition

Meena *et al.* (2013) at Kota observed increased in number of branches/plant at harvest in normal sown hybrid Indian mustard with increasing fertility levels. However, significant increase in primary branches/plant was recorded upto 100% RDF over 75% RDF and it was statistically at par with the 125% and 150% RDF.

Yadav *et al.* (2010) at Morena studied the effect of fertility level (50%, 75%, 100% and 125% RDF) on plant height, dry weight/plant and number of branches/plant in Indian mustard under normal sown condition. However, significant increase in plant height, dry weight/plant and number of branches/plant was recorded upto 125% RDF over 50%, 75% and 100% RDF.

Shukla *et al.* (2002) who found that the increasing nutrient supply through application of mixed fertilizer (NPKS) increased the number of branches in the mustard plant.The nutrient helps in initiating buds in plants. These buds ultimately become active branches from where leaves emerge as photosynthetic organs and the flowering nodes are developed. Thus it plays a vital role in increasing the crop yield.

Above ground dry matter weight

Keerthi *et al.* (2017) conducted a field experiment at Choudhary Charan Singh Haryana Agricultural University, Hisar to find out the effect of date of sowing and nitrogen levels on growth, yield, nitrogen uptake and nutrient use efficiencies in Indian mustard. The results revealed that increased dose of nitrogen application also increased the plant height and dry matter accumulation significantly.

Kumar *et al.* (2017) conducted a field experiment during *rabi* season 2014-15 at the N.E. Borlaug Crop Research Centre of the G.B Pant University of Agriculture and Technology, Pantnagar to study the effect of different fertility levels on growth, yield attributes, yield and quality of Indian mustard (*Brassica juncea* L.) cultivar RGN-73. Treatment consisted of three levels of nitrogen (60, 80 and 100 kg/ha), two levels of phosphorus (20 and 40 kg/ha) and two levels of potassium (0 and 30 kg/ha) were evaluated thrice in a randomized block design. Result revealed that all the growth attributes increased with increased fertility levels due to greater availability of nutrients in soil might have enhanced meristematic activity (multiplication and elongation of cells) leading to increased plant height, dry matter accumulation and CGR . Among different treatment application of 100 kg N + 40 kg P_2O_5 + 30 kg K_2O/ ha produced significantly higher CGR (0.046 g/m^2/day) comparatively to others treatments.

Athokpam (2010) conducted a field trial 2003-04 and 2004-05 to study the effect of NPK levels on the growth of broad leaf mustard on clay soil taking 13 treatment Interaction consisting of three doses of nitrogen (50, 100 and 150 kg), two levels of phosphorus (50 and 100 kg), two levels of potassium (50 and 100 kg ha^{-1}) and a control for each treatment, replicated thrice. The result revealed that the, leaf area index, net assimilation rate, plant growth efficiency, dry matter percentage increased significantly in highest fertility levels (100 kg N ha^{-1}, 100 kg, P_2O_5 ha^{-1}, and 100 kg K_2O ha^{-1}) in comparison to control.

Gardener *et al.* (1988) reported that crop growth rate is affected by a range of factors including temperature, levels of solar radiation, water and nutrient supply, crop, cultivar and its age. These factors influenced the size and efficiency of leaf canopy and hence the ability of crop to convert solar energy into economic growth.

Siliqua plant^{-1}

Singh *et al*. (2009) at New Delhi found that 100% RDF fertility level significantly increased yield attributes *viz*., numbers of siliquae per plant, numbers of pods per plant and seed weight per plant of mustard and lentil over control.

Bohra *et al.* (2006) conducted a field experiment to determine the effect of different levels of NPK (25, 50, 75 and 100% of the recommended dose), applied two weeks prior to sowing on Indian mustard cv. Pusa Bold in Varanasi, Uttar Pradesh, India, during 1999-2000 and 2000-01. Significant improvement in crop yield and yield attributes (siliquae plant^{-1}, test weight, siliqua length and seed yield plant^{-1}) was observed with increasing NPK levels from 25 to 100% of recommended dose.

Length of siliqua

Tripathi *et al.* (2010) reported that the higher values of yield attributes is the result of higher nutrient availability resulted in better growth and more translocation of photosynthates from source to sink.

Singh and Brar (1999) studied the effect of different levels of N and P and K on Indian mustard cv. Varuna and found that increasing levels of N up to 120 kg ha^{-1}, K and P up to 45 kg ha^{-1} increased the length of siliqua, number of siliqua, seed $siliqua^{-1}$, seed yield and test weight significantly.

Seed $siliqua^{-1}$

Keivanrad and Zandi (2012) investigated agronomical and qualitative features of Indian mustard in a semi-arid region of Takestan, Iran. They noticed the crop fertilized at 200 kg N/ha produced maximum siliquae/plant and more number of seeds/siliqua than those of control, 50, 100 and 150 kg N/ha.

Singh *et al.* (2010a) found that yield attributes (number of siliquae/plant, siliqua length, number of seeds/siliqua and 1000 seed weight) as well as seed and stover yield were increased with increasing fertility level upto 150% RDF, but statistically at par with 125% RDF.

Shukla *et al.* (2002) found that increased fertility levels increased seeds per siliqua.

1000-seed weight

Keerthi *et al.* (2017) at Hisar found that increased dose of nitrogen application also increased the numbers of siliquae/plant, number of seeds/siliqua and 1000-seed weight of Indian mustard significantly.

Sharma (2013) at Morena observed that increase in 1000-seed weight was increased with increasing fertility levels in normal sown Indian mustard. However, significant increase in 1000-seed weight was recorded upto 150% RDF over 75%, 100% and 125 % RDF.

Yadav *et al.* (2010) at Morena observed that application of 125% RDF recorded significant increase in the number of siliquae/plant, seed weight, 1000-seed weight, seed yield and stover yield of Indian mustard over 50 and 75% RDF but at par with 100% RDF.

Singh *et al.* (1985) found that 1000-seed weight was increased with the application of additional nutrients.

Seed yield

Paliwal *et al.* (2014) conducted a field experiment to evaluate the response of mustard (*Brassica juncea* L. Czernj. and Cosson) to potassium in combination with other nutrients on yield. The results revealed that higher seed yield per hectare was obtained at 150% NPK due to higher values of yield attributing characters viz., number of siliquae per plant, length of siliqua, 1000- seed weight and seed weight per plant.

Singh *et al.* (2011) from Kanpur, observed that increased seed yield with increased fertility levels. The highest seed yield (13.89 q/ha) was obtained with the application of N: P: K at the rate of 120:60:60 kg/ha followed by 100:50:50 and 80:40:40 kg/ha with an increase of 266, 223 and 73%, respectively, over control (N_0 P_0K_0).

Athokpam (2010) concluded that NPK content and vegetable yield increased significantly with the application of the treatment combination of 100 kg N ha^{-1}, 100 kg P_2O_5 ha^{-1}, and 100 kg K_2O ha^{-1} in comparison to control in mustard crop.

Ghimire and Bana (2011) conducted an experiment during *rabi* of 2008-09 and 2009-10 at Pantnagar, to study the effect of different doses of recommended fertilizers on yield and yield attributes. They concluded the fact that with an increase in recommended dose of fertilizer (RDF), seed and stover yields were increased significantly up to 100% (1.04 t/ha and 3.41 t/ha) and 125% of RDF (2.03 t/ha and 6.0 t/ha) in 2008-09 and 2009-10, respectively.

Stover yield

Ahmed *et al.* (2019) conducted a field experiment to assess the requirement of major nutrients (N, P, K, and S), and to recommend fertilizers for short-duration mustard variety BARI Sarisha-14. There were 8 treatments T1=100% soil test based (STB) nutrients (N, P, K, S, Zn & B @ 90, 25, 60, 15, 2 & 1 kg ha^{-1}, respectively) as per T_1 = Fertilizer Recommendation Guide (FRG, 2012), T_2=T_1+ 25% N of FRG, T_3=T_1+ 25% NP of FRG, T_4=T_1+ 25% NK of FRG, T_5=T_1+ 25% PK of FRG, T_6=T_1+ 25% NPK of FRG, T_7=75% of T_1 and T_8= native nutrient (control). The experiment was laid out in Randomized Complete Block Design with 3 replications. The results revealed that Stover yield of mustard was significantly influenced by the application of different doses of chemical fertilizers. The highest stover yield (2.96 t ha^{-1}) was recorded in treatment T_6 receiving 25% extra NPK over the 100% STB fertilizer rate and the lowest stover yield (1.40 t ha^{-1}) was recorded in T_8 treatment. This result was mainly because an optimum fertilizer facilitated maximum utilization of nutrients which enhanced total dry matter production and development of other yield contributing components.

Singh *et al.* (2010a) from Varanasi, reported that highest seed and stover yield were recorded at 150% RDF which was at par with 125 and 100% RDF.

Biological yield

Kumar *et al*. (2017) reported that the significant increase in seed and stover yields of mustard were largely a function of improved growth and the consequent increase in different yield components due to adequate supply of major plant nutrient under successive increase in nutrient doses, which finally resulted in higher seed yield and stover yield which ultimately resulted increased biological yield of mustard crop.

Kardgar *et al.* (2010) from Iran, reported that higher plant density, number of silique/plant, the number of seeds/silique, 1000-seed weight, seed yield, oil yield, biological yield and harvest index with increased nutrients levels.

Harvest index

Puste *et al*. (2012) found that increase application of N 80 kg/ha, P_2O_5 45 kg/ha and K_2O 40 kg/ha gave taller plants of mustard with more primary and secondary branches/plant and yield attributes of mustard viz. siliquae/plant, siliqua length, 1000-seed weight and higher percentage of harvest index than other.

Parihar *et al.* (2010) observed that application of NPK 120:40:40 kg/ha gave taller plants of mustard with more primary and secondary branches/plant and yield attributes of mustard viz. siliquae/plant, siliqua length, 1000-seed weight and higher percentage of harvest index than other treatment.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka to study the system of mustard intensification as affected by seedling ages and fertilizer doses. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Experimental period

The experiment was conducted during the period from October 2019 to February 2020 in *Rabi* season.

3.2 Description of the experimental site

3.2.1 Geographical location

The experiment was conducted both in the Central Laboratory & Agronomy Field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

3.2.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2.3 Soil

The soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix- II.

3.2.4 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-III.

3.2.5 System of mustard intensification

The system, known as System of Mustard Intensification (SMI) allows resource poor farmers to use less water and seeds and yet achieve significantly higher yields. This technology essentially advocates a radically different package of practices and has earlier been successfully tried in crops like rice and wheat. The principal of the SMI method is based on low seed rate, seed priming, transplanting young seedlings, wide a uniform spacing of single plants and application of enough organic manure.

3.3 Test crop

Mustard variety namely BARI Sarisha 13 was used as test crop for this experiment.. The important characteristics of the variety is mentioned below:

BARI Sarisha 13

BARI Sarisha 13 was developed by Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. It was developed by crossing between *B. campestris* and Swedish *B. oleraceae /B. albogleabra* and released, in the year of 2004. Plant height 85-90 cm, 5-6 primary branches are present in each plant, leaf deep green, smooth and not hairy, leaf without petiolel and round half of stem, blooming flower in inflorescence as downward position on bud, flower blooming period long, corolla color of flower is yellow, number of siliqua /plant 65-75, 2 chamber are present in pod, seed/siliqua 28-30, seed color pink, 1000-seed weight 3.7-3.9 g are the main characteristics of the crop. It's planting in *Rabi* season from mid October to mid November. Harvesting requires 105-110 days from seed sowing and yields 2.20-2.80 t/ha. Oil content in seeds 42-43% and tolerant to moderately waterlog condition.

3.4 Seed collection

Seeds of BARI Sarisha 13, was collected from Oil Seed Research Centre, Bangladesh Agricultural Research Institute, Gazipur.

3.5 Experimental treatment

There were two factors in the experiment namely ages of mustard seedling during transplanting and different fertilizer doses as mentioned below:

Recommended dose of fertilizer	
Fertilizers	Quantity/requirement (kg/ha)
Urea	250
TSP	170
MoP	85
Gypsum	150
Zinc sulphate	5
Boric Acid	10
Cow dung	8000

(Source: (BARI, 2019)

Factor A: Ages of mustard seedling (3) *viz;*

S_1 = 10 days

S_2 = 15 days

S_3= 20 days

Factor B: Different fertilizer doses (4) *viz;*

F_0 =0% (Control)

F_1 =75% of recommended doses of fertilizer

F_2 =100% of recommended doses of fertilizer

F_3 =125% of recommended dose of fertilizer

3.6 Detail of experimental preparation

3.6.1 Raising and transplanting of mustard seedlings

Seeds was sown in small area of well prepared seedbed inside of the main field. Seedbed was well ploughed and enough fertilizers for germination of seedlings. First seed sowing in the seed bed was 29 October 2019, second seed sowing was 3 November 2019 and third second seed sowing was 8 November 2019. The seedlings were grown under natural light, temperature, and moisture. The seedlings were thinned to one after the true leaf appeared in each well. The soil was monitored by a soil moisture detector to avoid drought stress. Soil with moisture less than 70% was considered to have light drought stress and was supplied with water (Sapeta *et al.* 2013). Weeds and pests were controlled by using normal practices.

3.6.2 Land preparation

The experimental land was opened with a power tiller on Date 15th November, 2019. Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on date 17th November, 2019 and was ready for transplanting seedling.

3.6.3 Experimental design

The experiment was laid out in randomized complete block design with 2 factor and three replications. There are 12 treatment Interaction and 36 unit plots. The unit plot size was 3.75 m^2 (2.5 m × 1.5 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively. The layout of the experimental field was shown in Appendix- IV.

3.6.4 Fertilizer application

Fertilizers were applied as par treatment requirement.

3.7 Intercultural operations

i) Weeding

Weeding were done at 15 and 40 DAT.

ii) Irrigation

Optimum irrigation was given to every plot for ensure soil moisture by using water cane. Continuously four days irrigation was given for establishing the young seedlings. Irrigation then after given in the following days. First irrigation was given at 15 DAT and the second irrigation at 40-45 DAT. A little irrigation was given at 55-60 DAT.

iii) Application of pesticides

In the experimental field mustard crops were attacked by aphids (*Lipaphis erysimi*. K). Malathion 57 EC at the rate of 2 ml/litre of water was applied for controlling aphids attack in the field. Spraying of pesticide was done in the afternoon while the pollinating bees were away from the experimental field.

3.8 General observations of the experimental field

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants, which were vigorous and luxuriant.

3.9 Harvesting and processing

From the experimental field, mustard crop was harvested at maturity when 80% of the siliquae turned into straw yellowish in color. Harvesting was done in the morning to avoid shattering. Crops were harvested from the pre demarcated area of 1 m^2 at the centre of each plot at ground level with the help of a sickle for grain and stover yield. Prior to harvesting, five plants were sampled randomly from each plot, were bundled separately, tagged them and brought to a clean cemented threshing floor from which different yield parameters were recorded. The crop was sun dried properly by spreading them over floor and seeds were separated from the siliquae by beating the bundles with the help of bamboo sticks. The seeds thus collected were dried in the sun for reducing the moisture in the seed to about 9% level. The stovers were also dried in the sun. Seed and stover yield were recorded. The biological yield was calculated as the sum of the seed yield and stover yield.

3.10 Data collection

The data were recorded on the following parameters;

a) Growth parameters

i. Plant height (cm)
ii. Number of branches plant^{-1}
iii. Above ground dry matter weight plant^{-1} (g)

b) Yield contributing characters

i. Siliqua plant^{-1} (no.)
ii. Length of siliqua (cm)
iii. Seeds siliqua^{-1} (no.)
iv. 1000-seed weight (g)

c) Yield characters

i. Seed yield (t ha^{-1})
ii. Stover yield (t ha^{-1})

iii. Biological yield (t ha^{-1}) and

iv. Harvest index (%)

3.11 Procedure of recording data

i) Plant height (cm)

The height of the 5 randomly selected plants was measured from the ground level to the tip of the plants at 10, 30, 50 DAT and at harvest. Mean plant height of mustard were calculated and expressed in cm.

iii) Number of branches plant^{-1}

The branches plant^{-1} were counted from five randomly sampled plants. It was done by counting total number of secondary branches of all sampled plants then the average data were recorded. Data on different parameters were recorded at 30, 50 DAT and harvest.

iii) Above ground dry matter weight plant^{-1}(g)

Five plants were collected randomly from each plot at 30, 50 DAS and harvest respectively. The sample plants were oven dried for 72 hours at 70°C and then dry matter content was determined. Mean dry matter plant^{-1} of mustard plant were calculated and expressed in gram (g) plant^{-1}.

iv) Number of siliqua plant^{-1}

Siliqua plant^{-1} was counted from the 5 randomly selected plant samples and then the averaged siliqua was calculated.

v) Length of siliqua (cm)

Length of 5 siliquae that collected randomly from the sampled plants were recorded and the mean length was calculated.

vi) Seeds siliqua^{-1} (no.)

Seeds siliqua^{-1} was counted from splitting five siliquae which were collected randomly from sample plants and then mean value was calculated.

vii) 1000-seed weight (g)

1000-seed were counted randomly from the seeds of each sample plant, then weighed it in an electrical balance in gram (g).

viii) Seed yield (t ha^{-1})

The mean seed weight was taken by threshing the plants of each sample area and then converted to t ha^{-1} in dry weight basis.

ix) Stover yield (t ha^{-1})

The stover yield of mustards were calculated after threshing and separation of the seeds from the plant of sample area and then expressed in t ha^{-1} on dry weight basis.

x) Biological yield (t ha^{-1})

The summation of seed yield and above ground stover yield is regarded as the biological yield. It was calculated as,

Biological yield =Grain yield + Stover yield.

xii) Harvest index (%)

Harvest index was calculated on dry weight basis with the help of following formula.

Harvest index (HI %) = $\frac{\text{Grain yield}}{\text{Biological yield}} \times 100$

Here, Biological yield = Grain yield + stover yield

3.12 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program named Statistix 10 Data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

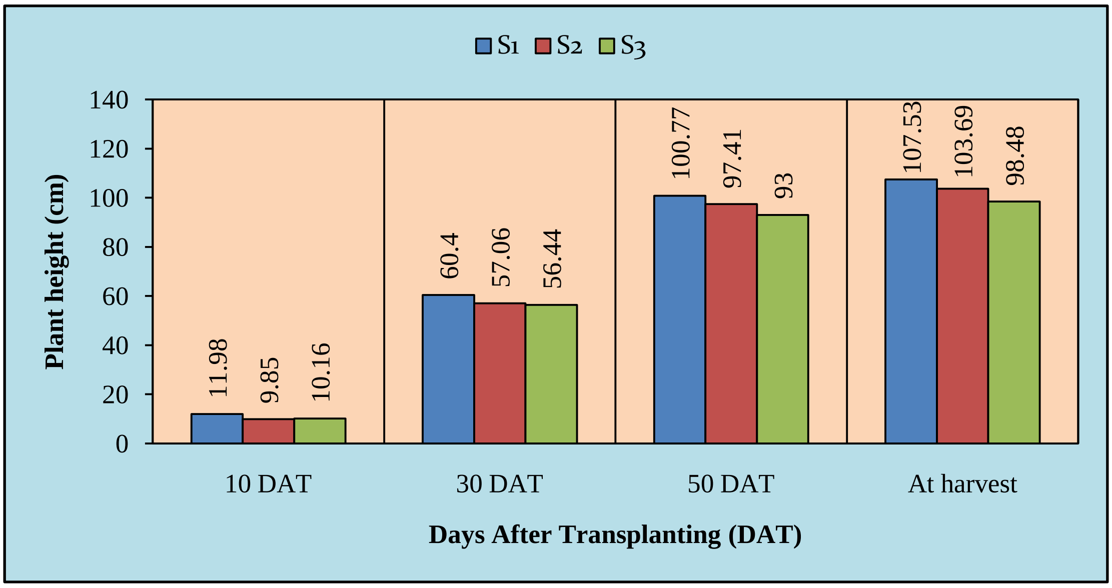
Results obtained from the present study have been presented and discussed in this chapter with a view to study the system of mustard intensification as affected by seedling ages and fertilizer doses. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Plant growth parameters

4.1.1 Plant height (cm)

Effect of seedling ages

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. Different seedling ages had significant effect on plant height of mustard at different days after transplanting (Figure. 1). Experimental results revealed that, the maximum plant height (11.98, 60.40, 100.77 and 107.53 cm) at 10, 30, 50 DAT and at harvest, respectively were recorded in 10 day old seedling (S_1). Whereas 15 days old seedling (S_2) recorded the minimum plant height (9.85) at 10 DAT, which was statistically similar to that of 20 day old seedling (S_3) (10.16 cm). At 30, 50 DAT and at harvest respectively, the minimum plant height (56.44, 93.00 and 98.48 cm respectively) were recorded in 20 days old seedling (S_3), which were statistically similar to that of 15 days old seedling (S_2) recorded plant height (57.06 cm) only at 30 DAT and significantly different from that of 15 DAT and at harvest. This might be due to the fact that optimum ages of seedlings (which in this case was 10 days old seedlings) helped the crop to complete its vegetative phase in favorable climatic conditions. The result obtained from the present study was similar to the findings of Pramanik and Bera (2013) and reported that the increase in plant height from the youngest seedlings might be due to more vigour, root growth and lesser transplant shock because of lesser leaf area during initial stages of crop growth, which stimulate increased cell division causing more stem elongation. Sarker *et al.* (2013) also reported that plant height differed significantly among cultivars and increasing seedling ages gradually decreased plant height.

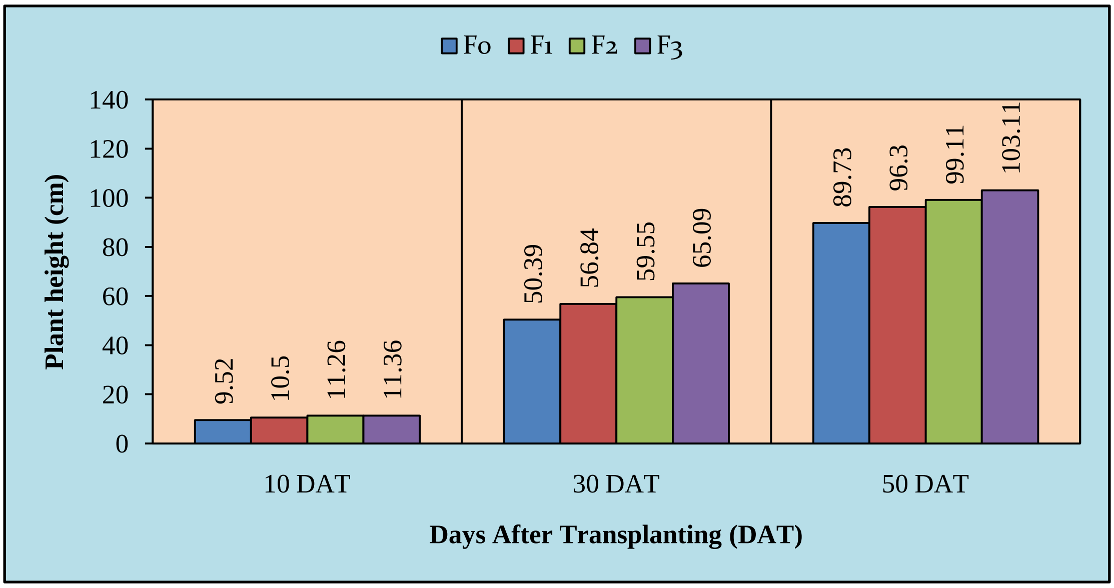


Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 1. Effect of seedling ages on plant height of mustard at different DAT [$LSD_{(0.05)}$= 0.36, 1.59, 2.61 and 3.39 at 10, 30, 50 DAT and at harvest, respectively]

Effect of fertilizer doses

Different fertilizer doses significantly influenced plant height of mustard at different days after transplanting (Figure. 2). Experimental results revealed that, the maximum plant height (11.36, 65.09, 103.11 and 108.51 cm) at 10, 30, 50 DAT and at harvest, respectively were recorded in 125% of recommended dose of fertilizer (F_3) treated plot, which was statistically similar to that of 100% of recommended doses of fertilizer (F_2) treated plot, recorded plant height (11.26 cm and 104.92) at 10 DAT and at harvest respectively. Whereas the minimum plant height (9.52, 50.39, 89.73 and 96.08 cm) at 10, 30, 50 DAT and at harvest, respectively were recorded in 0% of recommended dose of fertilizer (F_0) treated plot (Control). Plant height increased with increased fertility levels due to greater availability of nutrients in soil might have enhanced meristematic activity (multiplication and elongation of cells) leading to increased plant height. Handayati and Sihombing (2019) also found similar result which supported the present finding and reported that the plant growth influenced by NPK fertilizer level. Bakht *et al.* (2015) reported that plant height significantly increased with an increase in NPK levels. Trivedi *et al.* (2013) reported that application of 125% RDF recorded significant increase in the plant height and number of branches/plant over 50 and 75% RDF, though it was remained at 100% RDF.



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 2. Effect of fertilizer doses on plant height of mustard at different DAT [$LSD_{(0.05)}$= 0.42, 1.84, 3.02 and 3.91at 10, 30, 50 DAT and at harvest, respectively].

Interaction effect of seedling ages and fertilizer doses

Different ages of seedling along with different doses of fertilizer application significant effect on plant height of mustard (Table 1). Experimental results showed that, transplanting 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot recorded the maximum plant height (12.66, 68.43, 110.82 and 115.06 cm) at 10, 30, 50 DAT and at harvest, respectively, which was statistically similar to that of 10 days old seedling (S_1) along with 100 % of recommended doses of fertilizer (F_2) treated plot recorded plant height (12.58 cm) and with 10 days old seedling (S_1) along with 75 % of recommended dose of fertilizer (F_1) treated plot recorded plant height (12.58 cm) at 10 DAT; with 15 days old seedling (S_2) along with 125% of recommended dose of fertilizer (F_3) treated plot recorded plant height (65.83 cm) at 30 DAT and with 10 days old seedling (S_1) along with 100 % of recommended dose of fertilizer (F_2) treated plot recorded plant height (105.67 cm) at

50 DAT. Whereas transplanting 20 days old seedling along with 0 % of recommended dose of fertilizer (F_0) treated plot recorded the minimum plant height (9.04 cm) at 10 DAT, which was statistically similar with 15 days old seedling along with 75 % of recommended dose of fertilizer (F_1) treated plot recorded plant height (9.10 cm) and 15 days old seedling along with 0 % of recommended dose of fertilizer (F_0) treated plot recorded plant height (9.42 cm). At 30 DAT the minimum plant height (49.71 cm) was recorded in 15 days old seedling (S_2) along with 0 % of recommended dose of fertilizer (F_0) treated plot, which was statistically similar to that of 20 days old seedling (S_3) along with 0 % of recommended dose of fertilizer (F_0) treated plot recorded plant height (50.24 cm) and with 10 days old seedling (S_1) along with 0 % of recommended dose of fertilizer (F_0) treated plot recorded plant height (51.22 cm). At 50 DAT and at harvest respectively, 20 days old seedling (S_3) along with 0 % of recommended dose of fertilizer (F_0) treated plot recorded the minimum plant height (83.90 and 86.42 cm) at 50 DAT and at harvest, respectively.

Table 1. Interaction effect of seedling ages and fertilizer doses on plant height of mustard at different DAT

Seedling ages × Fertilizer doses	Plant height (cm)			
	10 DAT	30 DAT	50 DAT	At harvest
S_1F_0	10.11 c-e	51.22 ef	90.55 d	102.77 b-d
S_1F_1	12.58 a	59.68 b-d	96.03 bc	104.07 b-d
S_1F_2	12.58 a	62.27 b	105.67 a	108.23 b
S_1F_3	12.66 a	68.43 a	110.82 a	115.06 a
S_2F_0	9.42 ef	49.71 f	94.73 b-d	99.06 d
S_2F_1	9.10 f	53.73 e	97.74 bc	106.33 bc
S_2F_2	10.47 bd	58.98 cd	97.79 bc	102.93 b-d
S_2F_3	10.40 b-d	65.83 a	99.40 b	106.46 bc
S_3F_0	9.04 f	50.24 f	83.90 e	86.42 e
S_3F_1	9.83 de	57.10 d	95.12 b-d	99.88 cd
S_3F_2	10.73 bc	57.41 d	93.86 cd	103.61 b-d
S_3F_3	11.02 b	61.00 bc	99.12 b	104.02 b-d
$LSD_{(0.05)}$	0.72	3.19	5.23	6.77
CV(%)	4.00	3.24	3.18	3.87

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Notes *viz:*

S_1 = 10 days old seedling

S_2 = 15 days old seedling

S_3= 20 days old seedling

F_0 = 0% (Control)

F_1 = 75% of recommended doses of fertilizer

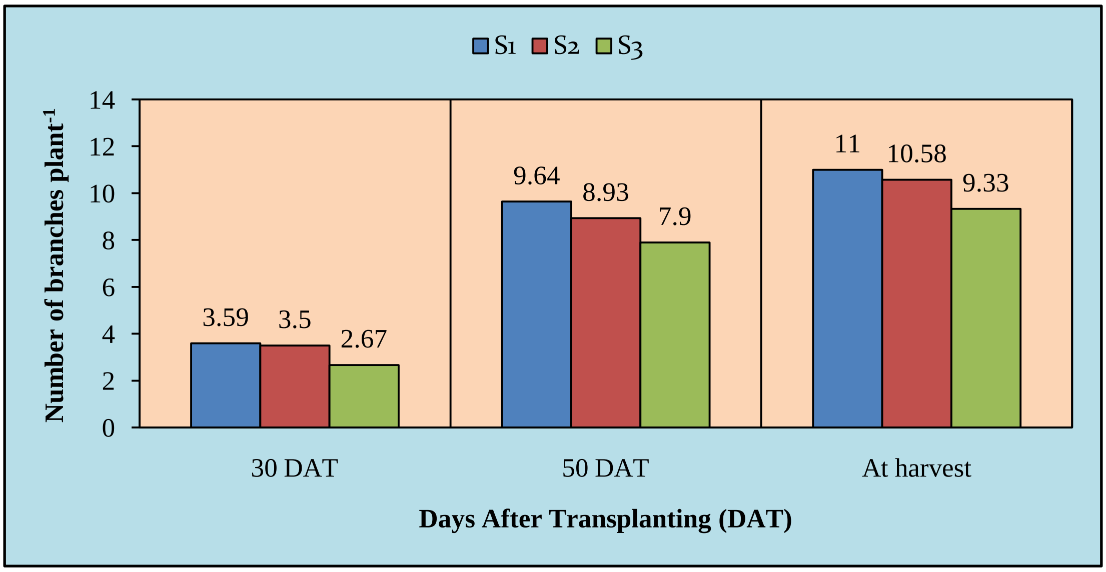
F_2 = 100% of recommended doses of fertilizer

F_3 = 125% of recommended dose of fertilizer

4.1.2 Number of branches plant^{-1}

Effect of seedling ages

Seedling ages had significant effect on number of branches plant^{-1} of mustard at different days after transplanting (Figure 3). Experimental results revealed that, the maximum number of branches plant^{-1} (3.59, 9.64 and 11.00) at 30, 50 DAT and at harvest respectively was recorded in 10 days old seedlings (S_1) which was statistically similar with 15 days old seedlings (S_2) recorded number of branches plant^{-1} (3.50) at 30 DAT. Whereas the minimum number of branches plant^{-1} (2.67, 7.90 and 9.33) was recorded in 20 days old seedlings (S_3). The differences of number of branches plant^{-1} might be due to longer growing period of the crop for better development of parts to allocate greater accumulation of photosynthates in the crop from youngest seedlings which may result in the better development of growth. Barla *et al.* (2018) also found similar result which supported the present finding and reported that seedlings ages significantly influenced branches plant^{-1} and transplanting 15 days old seedling of pigeon pea recorded maximum branches plant^{-1} (37.14) while 45 days old seedlings recorded minimum branches plant^{-1} (22).

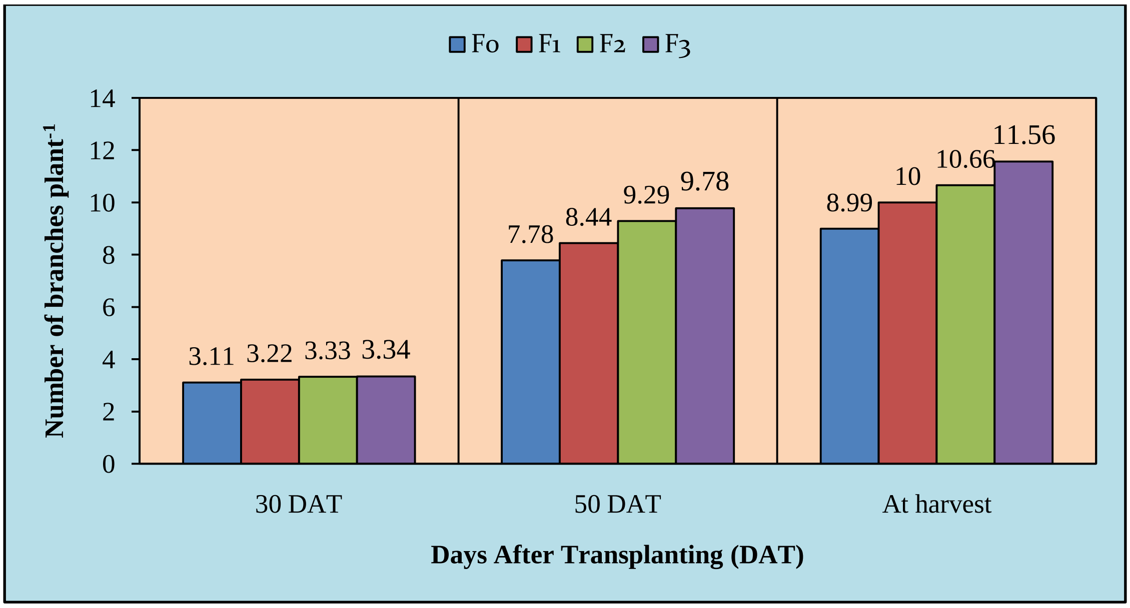


Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 3. Effect of seedling ages on number of branches plant^{-1} of mustard at different DAT [$LSD_{(0.05)}$= 0.09, 0.31 and 0.41 at 30, 50 DAT and at harvest, respectively].

Effect of fertilizer dose

Different fertilizer dose significantly influenced number of branches plant^{-1} of mustard at different days after transplanting (Figure 4). Experimental results showed that, the maximum number of branches plant^{-1} (3.34, 9.78 and 11.56) at 30, 50 DAT and at harvest, respectively were recorded in 125% of recommended dose of fertilizer treated plot (F_3), which was statistically similar to that of 100% of recommended doses of fertilizer treated plot (F_2) recorded number of branches plant^{-1} (3.34) at 30 DAT. Whereas the minimum number of branches plant^{-1} (3.11, 7.78 and 8.99) at 30, 50 DAT and at harvest, respectively were recorded in 0 % of recommended dose of fertilizer treated plot (F_0). The increasing nutrient supply through application of fertilizer (NPKS) increased the number of branches in the mustard plant. The nutrient helps in initiating buds in plants. These buds ultimately become active branches from where leaves emerge as photosynthetic organs and the flowering nodes are developed. Thus it plays a vital role in increasing the crop yield. Sandhu *et al.* (2015) also found similar result, which supported the present findings and reported that maximum number of branches plant^{-1} were recorded with increasing fertilizer application. Meena *et al.* (2013) found significant increase in primary branches plant^{-1} due to increasing fertilizer dose and it was recorded upto 100% RDF over 75% RDF and it was statistically at par with the 125% and 150% RDF.



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 4. Effect of fertilizer doses on number of branches plant^{-1} of mustard at different DAT [$LSD_{(0.05)}$= 0.10, 0.35 and 0.48 at 30, 50 DAT and at harvest, respectively].

Interaction effect of seedling ages and fertilizer doses

Different ages of seedling along with different dose of fertilizer application significantly influenced the number of branches plant^{-1} of mustard at different days after transplanting (Table 2). Experimental results showed that, the maximum number of branches plant^{-1} (3.67, 10.77 and 13.00) at 30, 50 DAT and at harvest respectively was recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot, which was statistically similar with 10 days old seedling (S_1) along with 100 % of recommended dose of fertilizer (F_2) treated plot recorded number of branches plant^{-1} (3.67); with 10 days old seedling (S_1) along with 75 % of recommended dose of fertilizer (F_1) treated plot recorded number of branches plant^{-1} (3.67); with 15 days old seedling (S_2) along with 125 % of recommended dose of fertilizer (F_3) treated plot recorded number of branches plant^{-1} (3.67); with 15 days old seedling (S_2) along with 100 % of recommended dose of fertilizer (F_2) treated plot recorded number of branches plant^{-1} (3.66) at 30 DAT. Whereas the minimum number of branches plant^{-1} (2.67, 7.25 and 8.33) at 30, 50 DAT and at harvest respectively was recorded in 20 days old seedling (S_3) along with 0 % of recommended doses of fertilizer treated plot (F_0), which was statistically similar with 20 days old seedling (S_3) along with 75 % of recommended doses of fertilizer (F_1) treated plot recoded number of branches plant^{-1} (2.67), to that of 20 days old seedling (S_3) along with 100 % of (F_2) recommended doses of fertilizer treated plot recoded number of branches plant^{-1} (2.67) and with 20 days old seedling (S_3) along with 125 % of (F_3) recommended doses of fertilizer treated plot recoded number of branches plant^{-1} (2.67) at 30 DAT; with 20 days old seedling (S_3) along with 75 % of recommended doses of fertilizer (F_1) treated plot recoded number of branches plant^{-1} (7.29 and 8.67) at 50 DAT and at harvest, respectively.

Table 2. Interaction effect of seedling ages and fertilizer doses on number of branches plant^{-1} of mustard at different DAT

Seedling ages × Fertilizer doses	Branches plant^{-1} (no.)		
	30 DAT	50 DAT	At harvest
S_1F_0	3.33 b	8.71 c	9.33 cd
S_1F_1	3.67 a	9.52 b	10.67 b
S_1F_2	3.67 a	9.55 b	11.00 b
S_1F_3	3.67 a	10.77 a	13.00 a
S_2F_0	3.33 b	7.37 d	9.33 cd
S_2F_1	3.33 b	8.51 c	10.67 b
S_2F_2	3.66 a	9.93 b	11.33 b
S_2F_3	3.67 a	9.89 b	11.00 b
S_3F_0	2.67 c	7.25 d	8.33 e
S_3F_1	2.67 c	7.29 d	8.67 de
S_3F_2	2.67 c	8.40 c	9.66 c
S_3F_3	2.67 c	8.67 c	10.67 b
$LSD_{(0.05)}$	0.18	0.61	0.83
CV(%)	3.18	4.10	4.74

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Notes *viz:*

S_1 = 10 days old seedling

S_2 = 15 days old seedling

S_3= 20 days old seedling

F_0 = 0% (Control)

F_1 = 75% of recommended doses of fertilizer

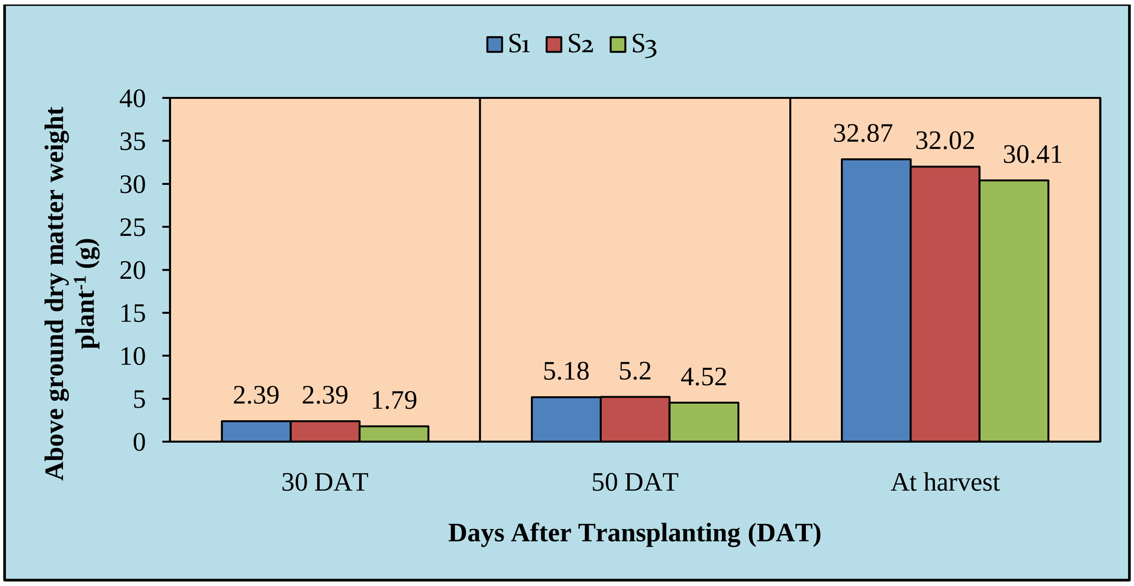
F_2 = 100% of recommended doses of fertilizer

F_3 = 125% of recommended dose of fertilizer

4.1.3 Above ground dry matter weight plant^{-1} (g)

Effect of seedling ages

The above ground dry matter weight plant^{-1} consists of all its constituents excluding water. Significant variation was observed in above ground dry matter weight plant^{-1} of mustard at different days after transplanting due to seedling ages (Figure 5). Experimental results showed that, the maximum above ground dry matter weight (2.39, 5.18 and 32.87 g plant^{-1}) at 30, 50 and at harvest, respectively was recorded in 10 days seedling (S_1), which was statistically similar to that of 15 days old seedling (S_2) (2.39 and 5.20 g plant^{-1}) at 30 and 50 DAT. Whereas the minimum above ground dry matter weight plant^{-1} (1.79, 4.52 and 30.41 g) at 30, 50 and at harvest respectively was recorded in 20 days seedling (S_3). Delay in transplanting results in concomitant reduction in dry matter production of seedling and longer stay of seedling in the nursery affects seedling growth pattern in response to high seedling competition. Also the transplanting shock received during transplanting at advanced stage resulted in poor growth of old seedling, which might have hindered the dry weight accumulation. Ali *et al*. (2013) also found similar result which supported the present finding and reported that the maximum dry matter production (211 g) was recorded from 15 days old seedlings and lowest (180 g) from 30 days old seedlings. Mamun *et al.* (2013) reported that less dry matter production was noticed from 8 days old seedlings compared to that of 30 days old seedlings.

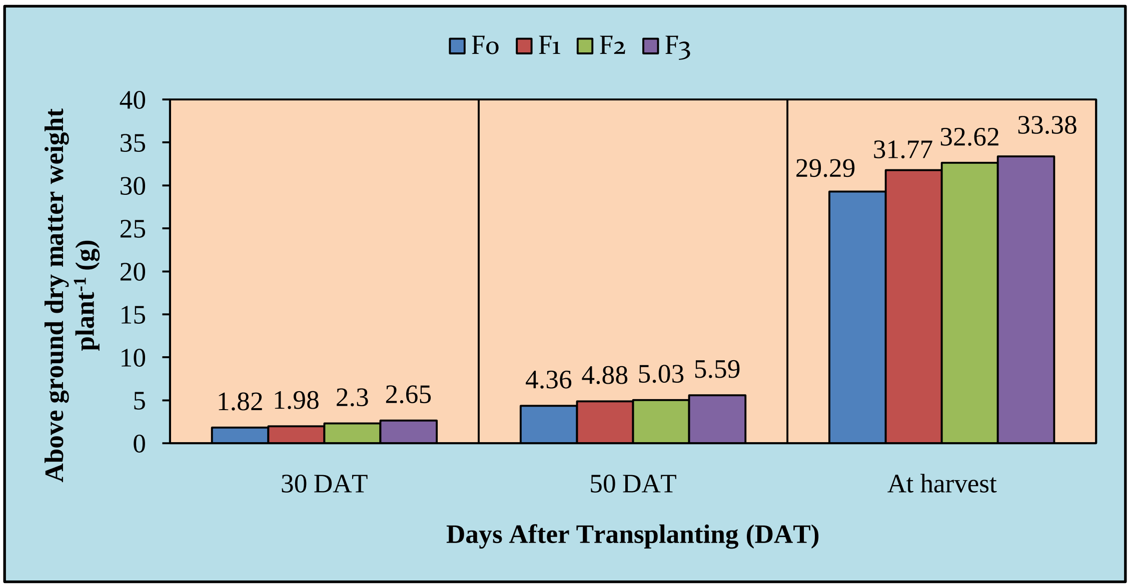


Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 5. Effect of seedling ages on above ground dry matter weight plant^{-1} of mustard at different DAT [$LSD_{(0.05)}$= 0.09, 0.10 and 0.76 at 30, 50 DAT and at harvest, respectively].

Effect of fertilizer dose

Fertilizers play an important role for the growth and development of the plant. In this experiment, results showed that, different dose of fertilizer significantly influenced above ground dry matter weight plant^{-1} of mustard at different days after transplanting (Figure 6). Results showed that, the maximum above ground dry matter weight plant^{-1} (2.65, 5.59 and 33.38 g) at 30, 50 DAT and at harvest, respectively were recorded in 125% of recommended dose of fertilizer treated plot (F_3), which were statistically similar to that of, 100% of recommended dose of fertilizer treated plot (F_2) recorded above ground dry matter weight plant^{-1} (32.62 g) at harvest respectively. Whereas the minimum above ground dry matter weight plant^{-1} (1.82, 4.36 and 29.29 g) at 30, 50 DAT and at harvest respectively was recorded in 0 % of recommended dose of fertilizer treated plot (F_0). The higher values of above ground dry matter weight plant^{-1} is the result of higher nutrient availability resulted in better growth and more translocation of photosynthates from source to sink. The result obtained from the present study was similar to the findings of Athokpam (2010) who reported that the, dry matter percentage increased significantly in highest fertility levels (100 kg N ha^{-1}, 100 kg, P_2O_5 ha^{-1}, and 100 kg K_2O ha^{-1}) in comparison to control.



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 6. Effect of fertilizer doses on above ground dry matter weight plant^{-1} of mustard at different DAT [$LSD_{(0.05)}$= 0.10, 0.11 and 0.88 at 30, 50 DAT and at harvest, respectively].

Interaction effect of seedling ages and fertilizer doses

Interaction effect of seedling ages and fertilizer doses had significant effect on above ground dry matter weight plant^{-1} of mustard at different days after transplanting. (Table 3). Experimental results revealed that, the maximum above ground dry matter weight plant^{-1} (2.78, 5.79 and 34.71 g) at 30, 50 DAT and at harvest, respectively were recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot, which were statistically similar, to that of 15 days old seedling (S_2) along with 125% of recommended dose of fertilizer (F_3) treated plot recorded above ground dry matter weight plant^{-1} (2.77 g), with 15 days old seedling (S_2) along with 100% of recommended dose of fertilizer (F_2) treated plot (2.64 g) at 30 DAT; with 15 days old seedling (S_2) along with 125% of recommended dose of fertilizer (F_3) treated (5.76 and 33.58 g) at 50 DAT and at harvest, respectively. Whereas the minimum above ground dry matter weight plant^{-1} (1.54, 3.91 and 28.56 g) at 30, 50 DAT and at harvest, respectively were recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot, which were statistically similar, with 20 days old seedling (S_3) along with 75 % of recommended dose of fertilizer (F_1) treated plot (1.54 g) to that of 20 days old seedling (S_3) along with 100 % of recommended dose of fertilizer (F_2) treated (1.67 g) at 30 DAT; with 15 days old seedling (S_2) along with 0% of recommended dose of fertilizer (F_0) treated plot (29.62 g) and with 10 days old seedling (S_1) along with 0% of recommended dose of fertilizer (F_0) treated plot (29.69 g) at harvest, respectively.

Table 3. Interaction effect of seedling ages and fertilizer doses on above ground dry matter weight plant^{-1} of mustard at different DAT

Seedling ages × Fertilizer doses	Above ground dry matter weight (g plant^{-1})		
	30 DAT	50 DAT	At harvest
S_1F_0	1.98 e	4.63 d	29.69 ef
S_1F_1	2.20 d	4.95 c	33.25 a-c
S_1F_2	2.60 b	5.34 b	33.83 ab
S_1F_3	2.78 a	5.79 a	34.71 a
S_2F_0	1.93 e	4.54 d	29.62 ef
S_2F_1	2.21 d	5.19 b	31.88 cd
S_2F_2	2.64 ab	5.30 b	33.00 bc
S_2F_3	2.77 ab	5.76 a	33.58 ab
S_3F_0	1.54 f	3.91 e	28.56 f
S_3F_1	1.54 f	4.49 d	30.19 e
S_3F_2	1.67 f	4.46 d	31.03 de
S_3F_3	2.40 c	5.21 b	31.86 cd
$LSD_{(0.05)}$	0.18	0.20	1.52
CV(%)	4.86	2.32	2.83

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Notes *viz:*

S_1 = 10 days old seedling

S_2 = 15 days old seedling

S_3= 20 days old seedling

F_0 = 0% (Control)

F_1 = 75% of recommended doses of fertilizer

F_2 = 100% of recommended doses of fertilizer

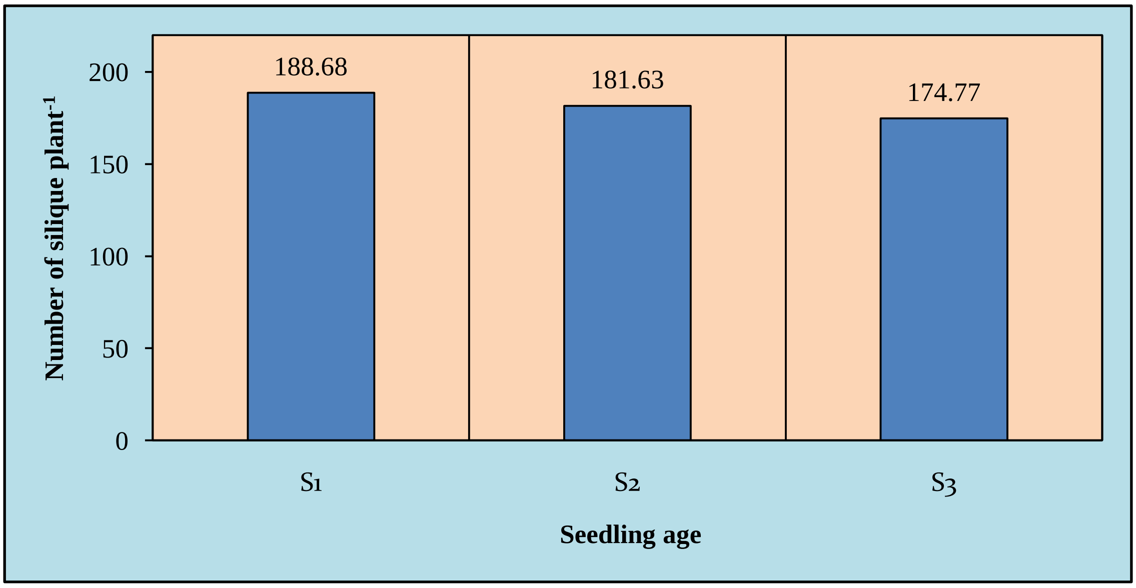
F_3 = 125% of recommended dose of fertilizer

4.2 Yield contributing characters

4.2.1 Number of silique plant^{-1}

Effect of seedling ages

Different seedling ages significantly influenced the number of silique plant^{-1}of mustard (Figure. 7). Experimental results showed that, the maximum number of silique plant^{-1} (188.68) was recorded in 10 days old seedling (S_1) whereas the minimum number of silique plant^{-1} (174.77) was recorded in 20 days old seedling (S_3). The lower number of siliqua plant^{-1} in treatments having agesd seedlings might be reason that if the seedling ages was higher, the severe damage of seedlings during transplantation, which not only affects vegetative growth, but also impairs reproductive growth.



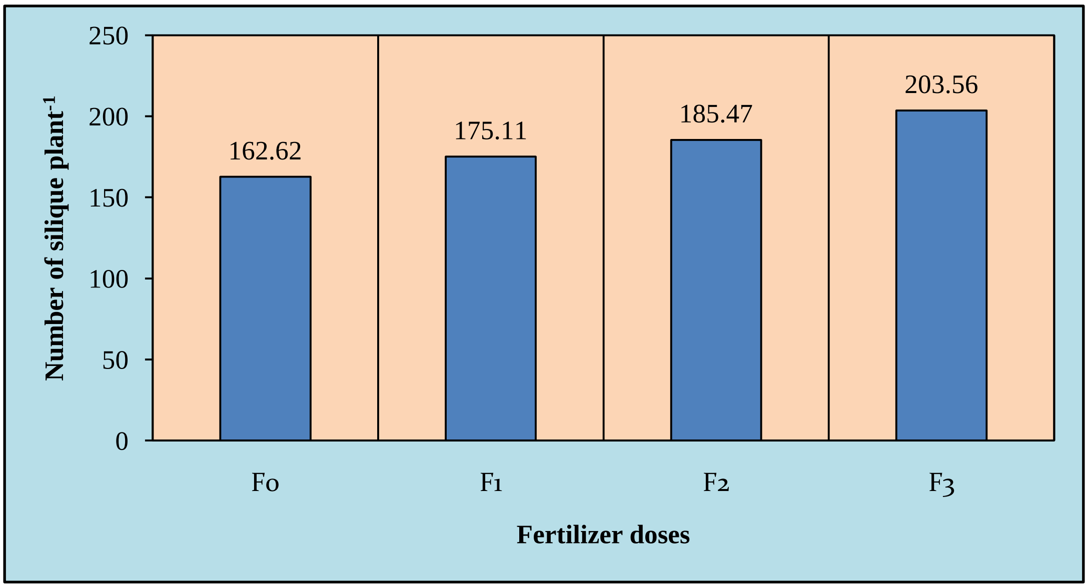
Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure. 7. Effect of seedling ages on number of siliqua plant^{-1} of mustard [$LSD_{(0.05)}$= 4.86].

Effect of fertilizer dose

Different fertilizer doses had significant effect on number of silique plant^{-1} of mustard. (Figure. 8). Experimental results showed that, the maximum number of silique plant^{-1} (203.56) was recorded in 125% of Recommended dose of fertilizer (F_3) treated plot whereas the minimum number of silique plant^{-1} (162.62) was recorded in

0% of recommended dose of fertilizer (F_0) treated plot. The higher values of yield attributes is the result of higher nutrient availability resulted in better growth and more translocation of photosynthates from source to sink. Singh *et al*. (2009) and Bohra *et al.* (2006) also found similar result which supported the present finding and reported that increasing fertilizer dose significant increasingin crop yield and yield attributes (siliquae plant^{-1}, test weight, siliqua length and seed yield plant^{-1}) over control treatment.



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 8. Effect of fertilizer doses on number of siliqua plant^{-1} of mustard [$LSD_{(0.05)}$= 5.62].

Interaction effect of seedling ages and fertilizer doses

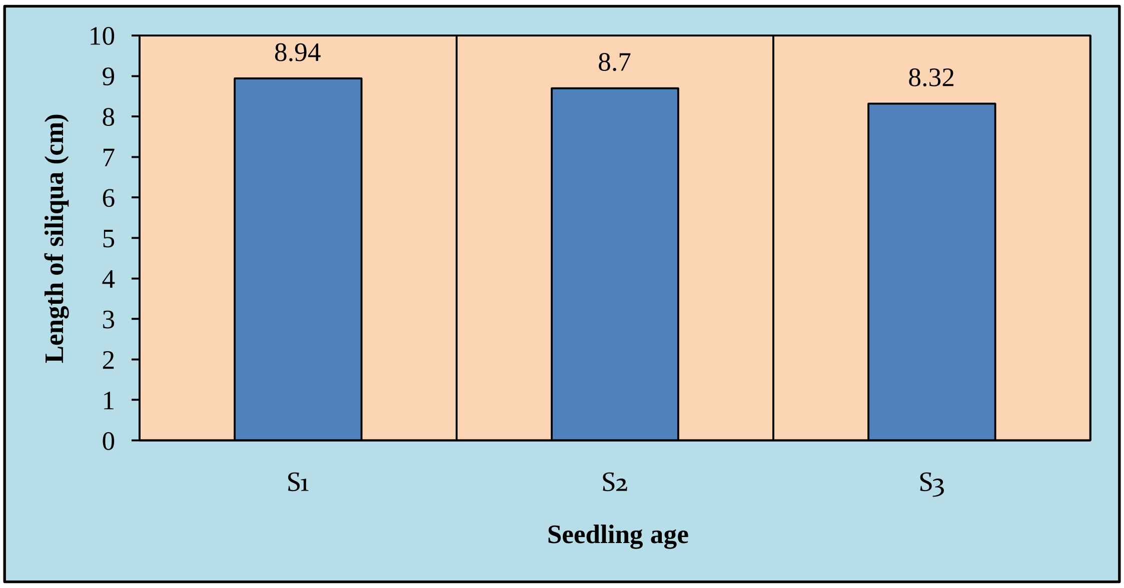
Different agess of seedling along with different dose of fertilizer application significantly influenced the number of silique plant^{-1} (Table 4). Experimental results revealed that, the maximum number of silique plant^{-1} (219.33) was recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum number of silique plant^{-1} (159.07) was recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot, which was statistically similar with 15 days old seedling (S_2) along with 0% of recommended dose of fertilizer (F_0) treated plot, recorded number of silique plant^{-1}

(160.47) and with 10 days old seedling (S_1) along with 0% of recommended dose of fertilizer (F_0) treated plot recorded number of silique plant^{-1} (168.33).

4.2.2 Length of siliqua (cm)

Effect of seedling ages

Different seedling ages had significant effect on length of siliqua (cm) of mustard (Figure 9). Experimental results showed that, the maximum length of siliqua (8.94 cm) was recorded in 10 days old seedling (S_1) whereas the minimum length of siliqua (8.32 cm) was recorded in 20 days old seedling (S_3). Transplants of young ages seedlings of 10 days might have availed weather conditions and environment properly through improved upper ground plant and below ground root development. Better root development of 10 days old transplants might has utilized plant nutrients and soil moisture in sufficient amount throughout life period, thus improved plant growth, yield attributes comparable to 20 days old seedling transplanting.

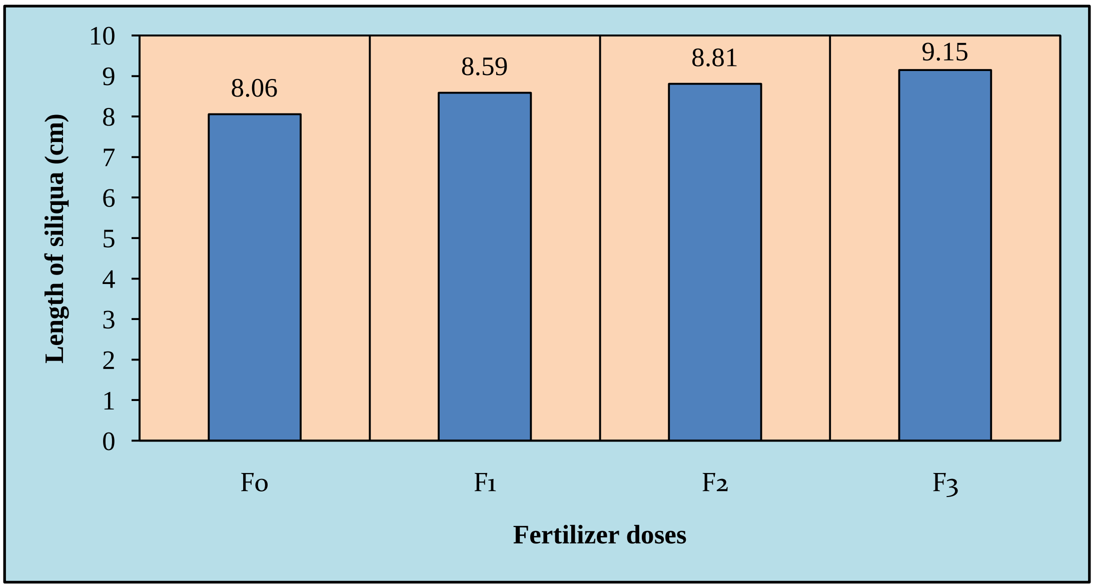


Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 9. Effect of seedling ages on length of siliqua of mustard [$LSD_{(0.05)}$= 0.12].

Effect of fertilizer dose

Different fertilizer dose significantly influenced the length of siliqua (cm) of mustard (Figure 10). Experimental results showed that, the maximum length of siliqua (9.150 cm) was recorded in 125% of recommended dose of fertilizer (F_3) treated plot whereas the minimum length of siliqua (8.06 cm) was recorded in 0% of recommended dose of fertilizer (F_0) treated plot. Increasing levels of fertilizer improved the yield attributing characters of mustard. The result obtained from the present study was similar with the findings of Tripathi *et al.* (2010) who reported that the higher values of yield attributes is the result of higher nutrient availability resulted in better growth and more translocation of photosynthates from source to sink. Singh *et al.* (1999) also found that increasing levels of N up to 120 kg ha^{-1}, K and P up to 45 kg ha^{-1} significantly increased the length of siliqua.



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 10. Effect of fertilizer doses on length of siliqua of mustard

[$LSD_{(0.05)}$= 0.14]

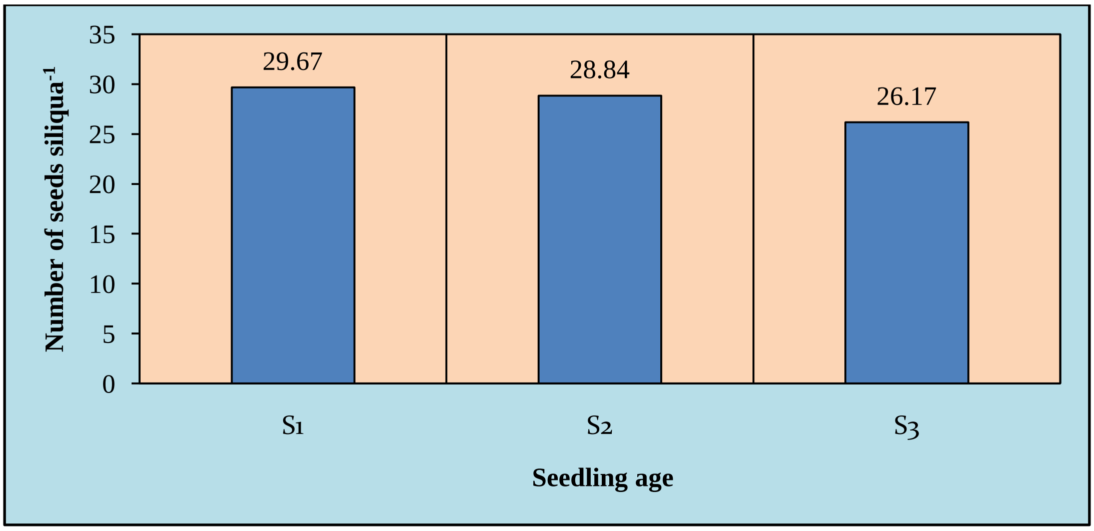
Interaction effect of seedling ages and fertilizer doses

Different ages of seedling along with different dose of fertilizer application significantly influenced the length of siliqua (cm) of mustard (Table 4). Experimental results revealed that, the maximum length of siliqua (9.51 cm) was recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum length of siliqua (7.70 cm) was recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot.

4.2.3 Number of seeds siliqua^{-1}

Effect of seedling ages

Different seedling ages had significant influenced the number of seeds siliqua^{-1} of mustard (Figure 11). Experimental results showed that, the maximum number of seeds siliqua^{-1} (29.67) was recorded in 10 days old seedling (S_1) which was statistically similar with 15 days old seedling recorded number of seeds siliqua^{-1} (28.84) whereas the minimum number of seeds siliqua^{-1} (26.17) was recorded in 20 days old seedling (S_3). The variation of number of seeds siliqua^{-1} at different seedling ages might be due to the reason that, transplanting seedling at early ages into the field easily handle the transplanting shock and comparative little or no root damage was occurred during this time, whereas late transplanting result in poor growth, heavy transplanting shock, root damage, less solar radiation absorption and nutrient uptake occurred which ultimately impact on growth yield and yield contributing characters of mustard.

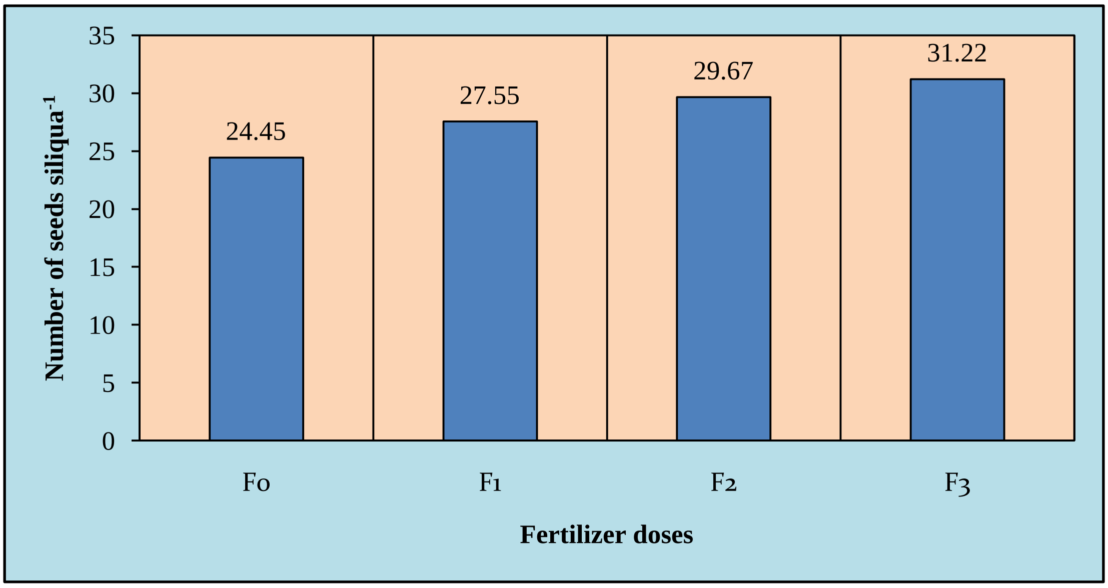


Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 11. Effect of seedling ages on number of seeds siliqua^{-1} of mustard [LSD$_{(0.05)}$= 0.88].

Effect of fertilizer dose

Different fertilizer dose significantly effect on number of seeds siliqua^{-1} of mustard (Figure 12). Experiment result showed that, the maximum number of seeds siliqua^{-1} (31.22) was recorded in 125% of recommended dose of fertilizer (F_3) treated plot whereas the minimum number of seeds siliqua^{-1} (24.45) was recorded in 0% of recommended dose of fertilizer (F_0) treated plot. Increasing fertilizer dose increasing number of seeds siliqua^{-1} might be due to source sink interaction, meaning maximum proportion of various nutrient source is used to produce maximum seeds siliqua^{-1} and grain filling. The result obtained from the present study was similar with the findings of Keivanrad and Zandi (2012) and they reported that crop fertilized at 200 kg N/ha produced maximum siliquae/plant and more number of seeds/siliqua than those of control, 50, 100 and 150 kg N/ha. Shukla *et al.* (2002) also reported that increased fertility levels increased seeds per siliqua.



F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 12. Effect of fertilizer dose number of seeds siliqua^{-1} of mustard [LSD$_{(0.05)}$= 1.01].

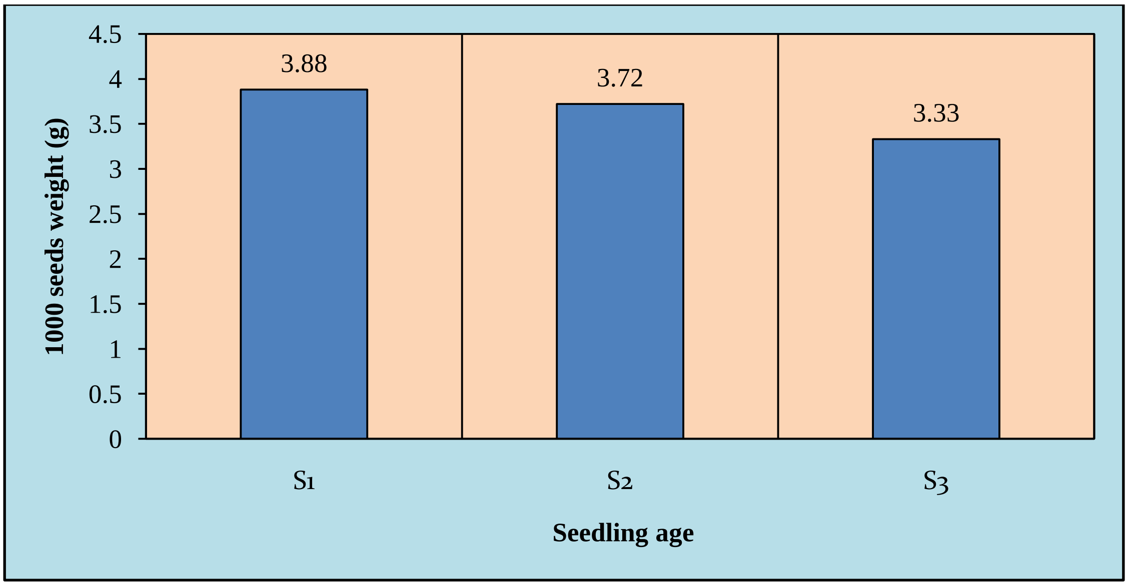
Interaction effect of seedling ages and fertilizer doses

Different ages of seedling along with different dose of fertilizer application significantly influenced the number of seeds siliqua^{-1} of mustard. (Table 4). Experimental results revealed that, the maximum number of seeds siliqua^{-1} (32.67) was recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum number of seeds siliqua^{-1} (20.67) was recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot.

4.2.4 Weight of 1000-seed (g)

Effect of seedling ages

Seedling ages significantly influenced the 1000-seed weight (g) of mustard (Figure 13). Experimental results showed that, the maximum 1000-seed weight (3.88 g) was recorded in 10 days old seedling (S_1) whereas the minimum 1000-seed weight (3.33 g) was recorded in 20 days old seedling (S_3). Plants kept for longer time in nursery bed either get too leggy or become too woody due to check of growth and such old ages seedlings do not make a quick start when transplanted in the main field as a result its causes negative impact on yield contributing characters compares to early transplanting of the seedling. The result obtained from the present study was similar with the findings of Pramanik and Bera (2013) and they reported that maximum 1000-seed weight 23.62 g was obtained from the transplanting of 10 days old seedling. Sarwa *et al.* (2011) also reported that younger seedlings of 10 days and 20 days old registered comparable higher 1000 grains weight of 21.43 g and 18.78 g respectively and its significantly superior over 30 (15.54 g) and 40 days (14.8 g) old seedlings.

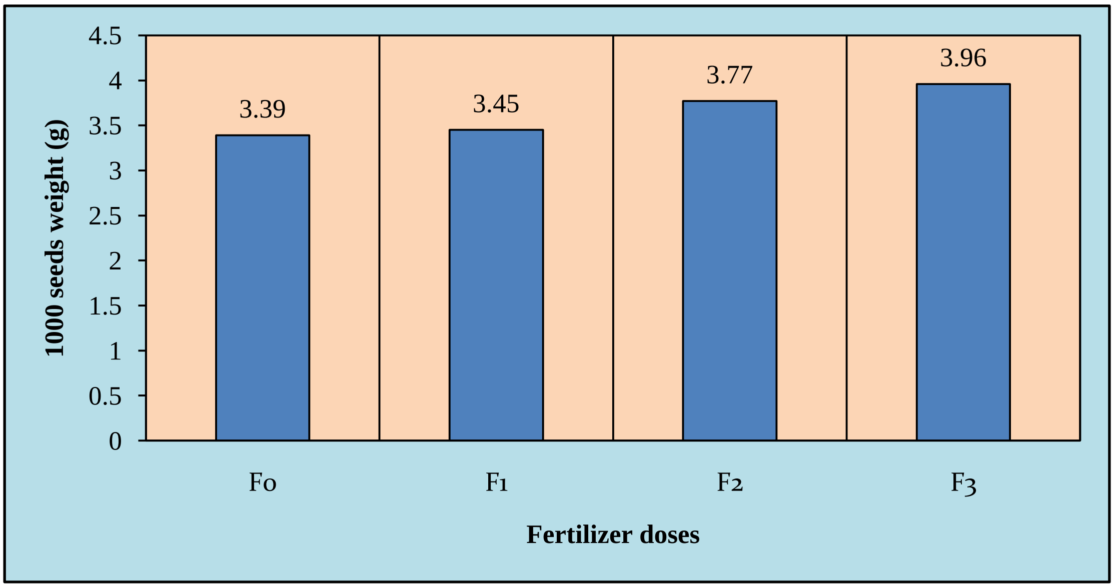


Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 13. Effect of seedling ages on 1000 seeds weight of mustard [$LSD_{(0.05)}$= 0.10].

Effect of fertilizer dose

Different fertilizer dose had significant effect on 1000-seed weight (g) of mustard (Figure 14). Experimental results showed that, the maximum 1000-seed weight (3.96 g) was recorded in 125% of recommended dose of fertilizer (F_3) treated plot whereas the minimum 1000-seed weight (3.39 g) was recorded in 0% of recommended dose of fertilizer (F_0) treated plot which was statistically similar with 75% of recommended dose of fertilizer (F_1) treated plot recorded 1000-seed weight (3.45 g). Plants with higher fertilizer doses recorded the highest 1000-seed weight (g). However, the plants that didn't receive any fertilization gave the lowest values of 1000-seed weight (g). It could be concluded that increasing fertilization resulted in an increase in the amount of metabolites synthesized by mustard plant and this, in turn, might account much for the superiority of 1000-seed weight (g). The results obtained from the present study was similar with the findings of Sharma (2013) and reported that 1000-seed weight increased with increasing fertility levels in normal sown Indian mustard. Yadav *et al.* (2010) also reported that application of 125% RDF recorded significant increase in the number of 1000 seed weight, of Indian mustard over 50 and 75% RDF but at par with 100% RDF. Singh *et al.* (1985) also found that 1000-seed weight was increased with the application of additional nutrients.



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 14. Effect of fertilizer dose on 1000 seeds weight of mustard

[$LSD_{(0.05)}$= 0.12].

Interaction effect of seedling ages and fertilizer doses

Interaction effect of seedling ages and fertilizer doses showed significant effect on number of 1000-seed weight (g) of mustard. (Table 4). Experimental results revealed that, the maximum 1000-seed weight (4.16 g) was recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum number of seeds siliqua^{-1} (2.90 g) was recorded in 20 days old seedling (S_1) along with 0% of recommended dose of fertilizer (F_0) treated plot, which was statistically similar with 20 days old seedling (S_3) along with 75% of recommended dose of fertilizer (F_1) treated plot recorded 1000-seed weight ((2.90 g).

Table 4. Interaction effect of seedling ages and fertilizer doses on number of silique plant^{-1}, length of siliqua, number of seeds siliqua^{-1} and 1000 seeds weight of mustard

Seedling ages × Fertilizer doses	Number of silique plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	1000 seeds weight (g)
S_1F_0	168.33 f-h	8.37 d	27.00 de	3.70 cd
S_1F_1	178.67 c-e	8.91 b	28.33 cd	3.77 b-d
S_1F_2	188.40 c	8.95 b	30.67 b	3.87 bc
S_1F_3	219.33 a	9.51 a	32.67 a	4.16 a
S_2F_0	160.47 gh	8.11 e	25.67 e	3.57 d
S_2F_1	169.67 e-g	8.65 c	29.00 bc	3.67 cd
S_2F_2	187.33 c	9.03 b	30.00 bc	3.73 b-d
S_2F_3	209.03 b	8.99 b	30.67 b	3.91 b
S_3F_0	159.07 h	7.70 f	20.67 f	2.90 e
S_3F_1	177.00 d-f	8.20 de	25.33 e	2.90 e
S_3F_2	180.67 cd	8.44 cd	28.33 cd	3.70 cd
S_3F_3	182.33 cd	8.95 b	30.33 b	3.80 bc
$LSD_{(0.05)}$	9.73	0.25	1.76	0.20
CV(%)	3.16	1.70	3.67	3.26

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Notes *viz:*

S_1 = 10 days old seedling

S_2 = 15 days old seedling

S_3= 20 days old seedling

F_0 = 0% (Control)

F_1 = 75% of recommended doses of fertilizer

F_2 = 100% of recommended doses of fertilizer

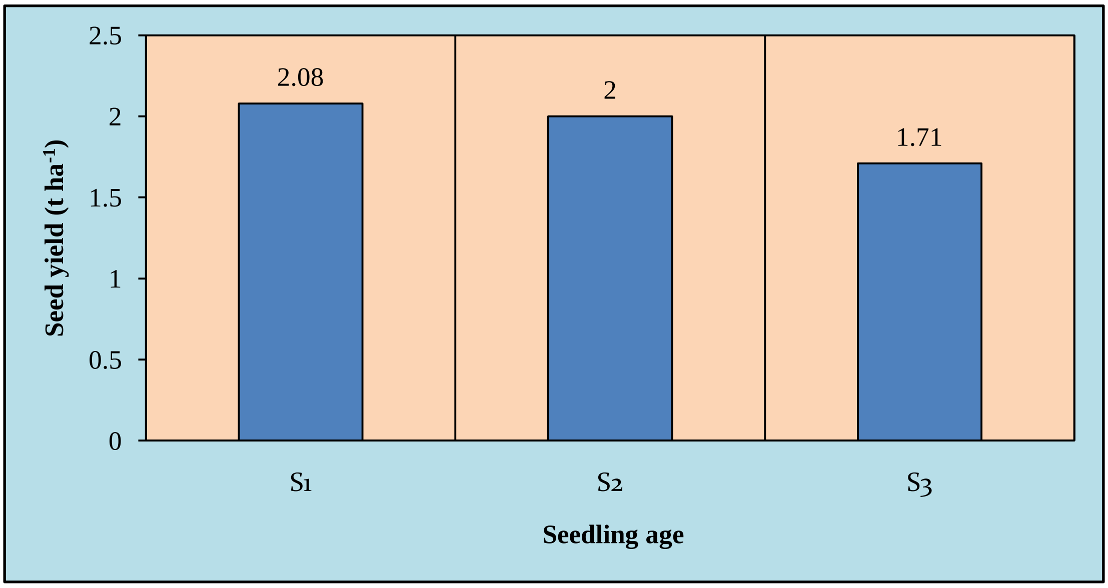
F_3 = 125% of recommended dose of fertilizer

4.3 Yield characters

4.3.1 Seed yield (t ha^{-1})

Effect of seedling ages

Seedling ages significantly influenced the seed yield (t ha^{-1}) of mustard (Figure 15). Experimental results showed that, the seed yield (2.08 t ha^{-1}) was recorded in 10 days old seedling (S_1) whereas the minimum seed yield (1.71 t ha^{-1}) was recorded in 20 days old seedling (S_3). These yields might be attributed to number of siliqua plant^{-1}, length of siliqua (cm), number of seeds siliqua^{-1} and 1000 seeds weight (g). Transplants of early ages seedlings might have availed weather conditions and environment properly through improved upper ground plant and below ground root development. Better root development of early ages seedlings might has utilized plant nutrients and soil moisture in sufficient amount throughout life period in the field, thus improved plant growth, yield attributes and finally produced higher yield per unit area. Wlalo and Kunicki (2003) also found similar result which supported the present finding and reported that use of young transplants seedling resulted in higher yield and better quality.



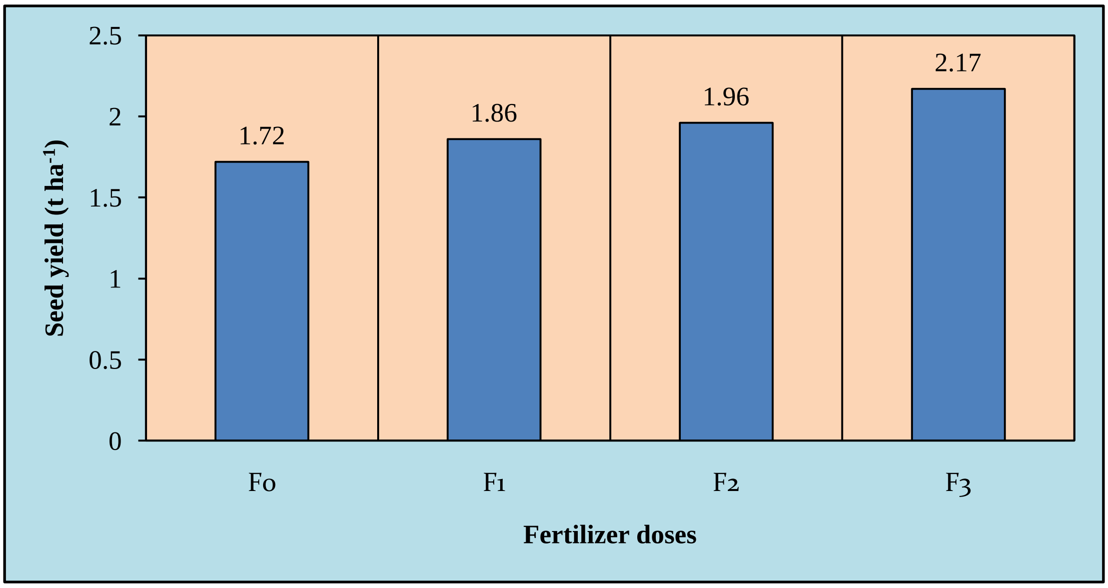
Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 15. Effect of seedling ages on seed yield of mustard

[$LSD_{(0.05)}$= 0.05].

Effect of fertilizer dose

Fertilizer application at different dose had significant influenced the seed yield (t ha^{-1}) of mustard (Figure 16). Experimental results showed that, the maximum seed yield (2.17 t ha^{-1}) was recorded in 125% of recommended dose of fertilizer (F_3) treated plot whereas the minimum seed yield (1.72 t ha^{-1}) was recorded in 0% of recommended dose of fertilizer (F_0) treated plot. The higher values of yield is the result of higher nutrient availability resulted in better growth and more translocation of photosynthates from source to sink. Paliwal *et al.* (2014) reported that higher seed yield per hectare was obtained at 150% NPK due to higher values of yield attributing characters viz. number of siliquae per plant, length of siliqua, 1000- seed weight and seed weight per plant. Singh *et al.* (2011) also reported that highest seed yield (13.89 q/ha) was obtained with the application of N: P: K at the rate of 120:60:60 kg/ha followed by 100:50:50 and 80:40:40 kg/ha with an increase of 266, 223 and 73% respectively, over control (N_0 P_0K_0).



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 16. Effect of fertilizer doses on seed yield of mustard

[$LSD_{(0.05)}$= 0.06]

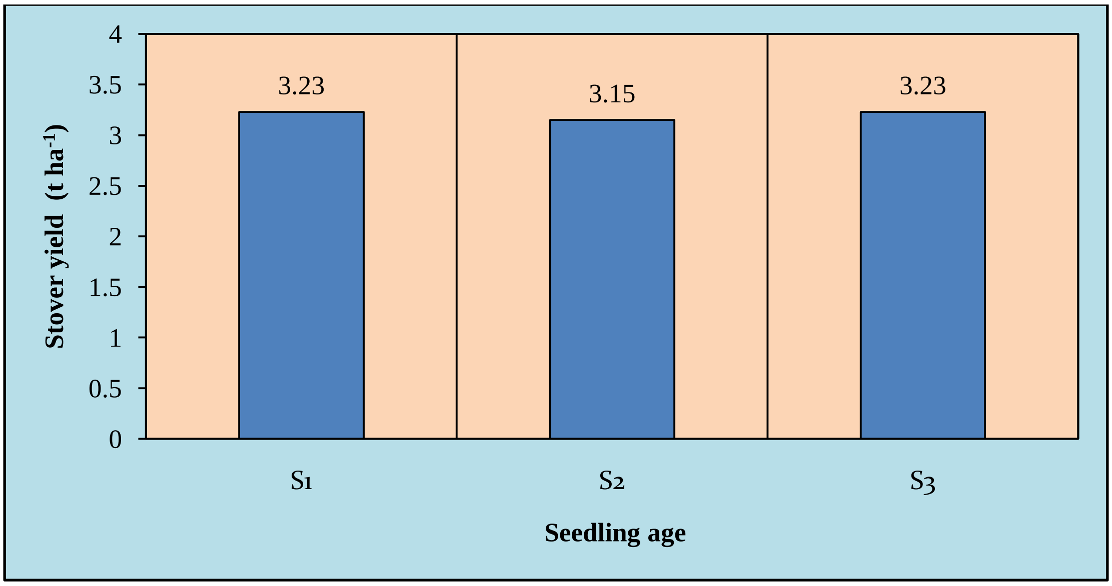
Interaction effect of seedling ages and fertilizer doses

Seedling ages along with fertilizer doses significant influenced the seed yield (t ha^{-1}) of mustard (Table 5). Experiment result revealed that, the maximum seed yield (2.37 t ha^{-1}) was recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum seed yield (1.43 t ha^{-1}) was recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot.

4.3.2 Stover yield (t ha^{-1})

Effect of seedling ages

Stover yield (t ha^{-1}) was significantly varied due to the influenced the different seedling ages of mustard (Figure 17). Experimental results showed that, the maximum stover yield (3.23 t ha^{-1}) was recorded in 10 days old seedling (S_1) which was statistically similar with 20 days old seedling (S_3) recorded stover yield (3.23 t ha^{-1}). Whereas the minimum stover yield (3.15 t ha^{-1}) was recorded in 15 days old seedling (S_2). The result obtained from the present study was similar ro the findings of Bagheri *et al.* (2011) and reported that the highest (635.8 g m^{-2}) straw yield was obtained from 20 days old seedlings over 30 and 40 days. Rajesh and Thanunathan (2003) also reported that the seedling ages had significant difference on straw yield. Planting of 40 days old seedlings found to be optimum to get significantly higher (5.63 t ha^{-1}) straw yield compared to 30 (5.09 t ha^{-1}) and 50 (4.76 t ha^{-1}) days old seedlings.



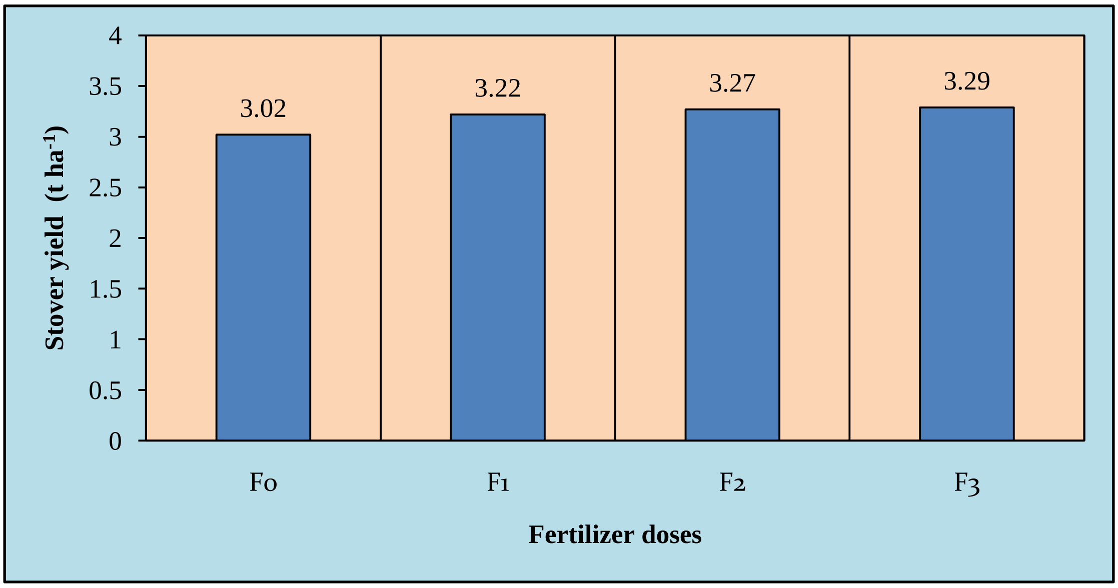
Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 17. Effect of seedling ages on stover yield of mustard

[$LSD_{(0.05)}$= 0.06].

Effect of fertilizer dose

Fertilizer application at different dose had significant influenced the stover yield (t ha^{-1}) of mustard (Figure 18). Experimental results showed that, the maximum stover yield (3.29 t ha^{-1}) was recorded in 125% of recommended dose of fertilizer (F_3) treated plot which was statistically similar with 100% of recommended dose of fertilizer (F_2) treated plot recorded stover yield (3.27 t ha^{-1}) and with 75% of recommended dose of fertilizer (F_1) treated plot recorded stover yield (3.22 t ha^{-1}).Whereas the minimum stover yield (3.02 t ha^{-1}) was recorded in 0% of recommended dose of fertilizer (F_0) treated plot. Ahmed *et al.* (2019) reported that optimum fertilizer facilitated maximum utilization of nutrients which enhanced total dry matter production and development of other yield contributing components which ultimately impact on stover yied. Singh *et al.* (2010) also reported that highest stover yield was recorded at 150% RDF which was at par with 125 and 100% RDF.



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 18. Effect of fertilizer doses on stover yield of mustard

[LSD$_{(0.05)}$= 0.07]

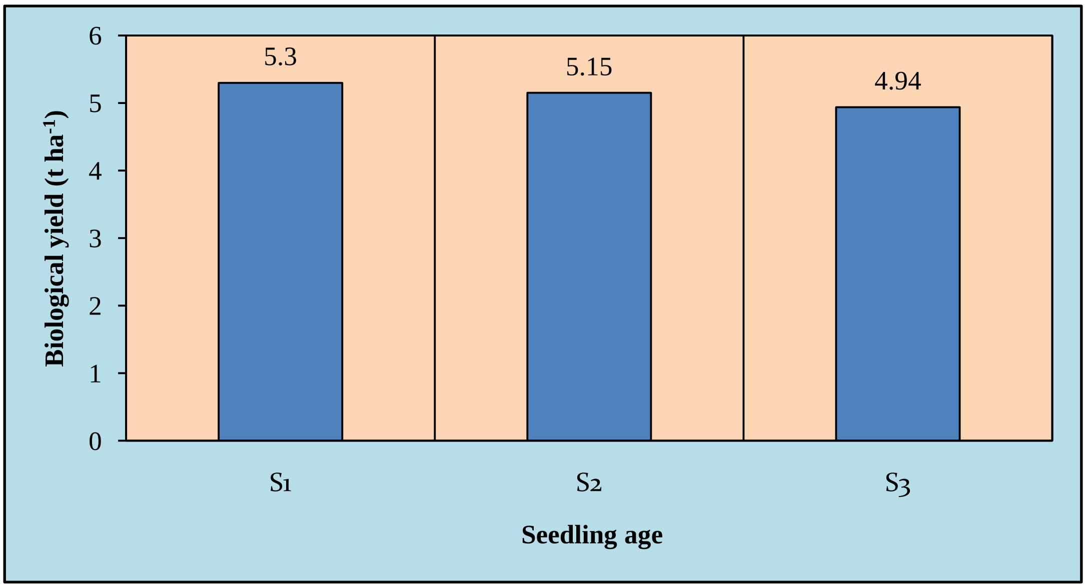
Interaction effect of seedling ages and fertilizer doses

Seedling ages along with fertilizer doses significant influenced the stover yield (t ha^{-1}) of mustard. (Table 5). Experimental results revealed that, the maximum stover yield (3.37 t ha^{-1}) was recorded in 10 days old seedling (S_1) along with 75% of recommended dose of fertilizer (F_1) treated plot, which was statistically similar with 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot recorded stover yield (3.35 t ha^{-1}), with 10 days old seedling (S_1) along with 100% of recommended dose of fertilizer (F_2) treated plot recorded stover yield (3.33 t ha^{-1}), with 20 days old seedling (S_3) along with 125% of recommended dose of fertilizer (F_3) treated plot recorded stover yield (3.30 t ha^{-1}), with 15 days old seedling (S_2) along with 125% of recommended dose of fertilizer (F_3) treated plot recorded stover yield (3.30 t ha^{-1}), with 15 days old seedling (S_2) along with 100% of recommended dose of fertilizer (F_2) treated plot recorded stover yield (3.27 t ha^{-1}). Whereas the minimum stover yield (2.86 t ha^{-1}) was recorded in 10 days old seedling (S_1) along with 0% of recommended dose of fertilizer (F_0) treated plot, which was statistically similar with 15 days old seedling (S_2) along with 0% of recommended dose of fertilizer (F_0) treated plot recorded stover yield (2.89 t ha^{-1}).

4.3.3 Biological yield (t ha^{-1})

Effect of seedling ages

Biological yield (t ha^{-1}) was significantly varied due to the effect of different seedling ages of mustard (Figure 19). Experimental results showed that the maximum biological yield (5.30 t ha^{-1}) was recorded in 10 days old seedling (S_1). Whereas the minimum biological yield (4.94 t ha^{-1}) was recorded in 20 days old seedling (S_3). Chakrabortty (2013) also found similar result which supported the present finding and reported that seedling ages significantly varied biological yield of boro rice and the maximum biological yield (9.84 t ha^{-1}) was recorded in 16 days old seedling and the minimum biological yield (8.73 t ha^{-1}) was found in 30 days old seedling.



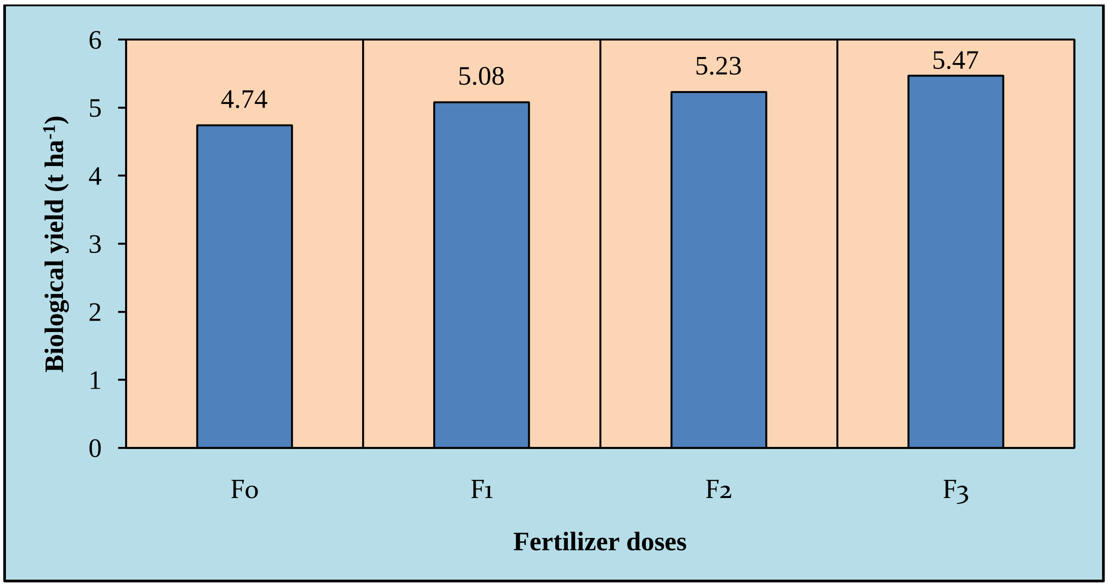
Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 19. Effect of seedling ages on biological yield of mustard

[LSD$_{(0.05)}$= 0.09].

Effect of fertilizer dose

Fertilizer application at different dose significantly influenced the biological yield (t ha^{-1}) of mustard (Figure 20). Experimental results showed that, the maximum biological yield (5.47 t ha^{-1}) was recorded in 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum biological yield (4.74 t ha^{-1}) was recorded in 0% of recommended dose of fertilizer (F_0) treated plot. Kumar *et al*. (2017) reported that the significant increase in seed and stover yields of mustard were largely a function of improved growth and the consequent increase in different yield components due to adequate supply of major plant nutrient under successive increase in nutrient doses which finally resulted in higher seed yield and stover yield which ultimately resulted increased biological yield of mustard crop. Kardgar *et al.* (2010) also reported that higher plant density, number of silique/plant, the number of seeds/silique, 1000-seed weight, seed yield, oil yield, biological yield and harvest index with increased nutrient levels.



Here, F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 20. Effect of fertilizer doses on biological yield of mustard [$LSD_{(0.05)}$= 0.09].

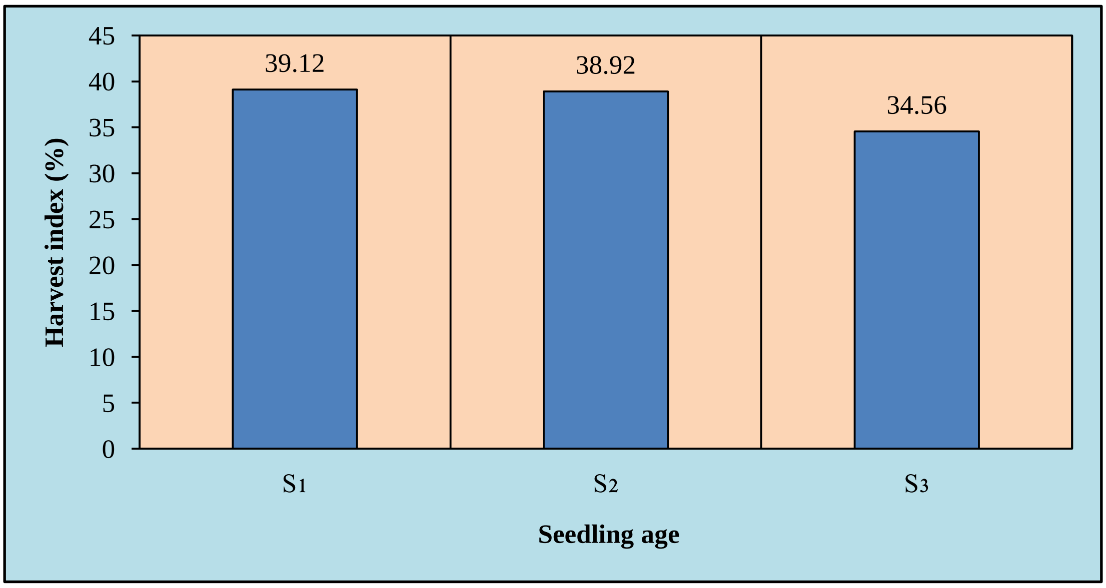
Interaction effect of seedling ages and fertilizer doses

Interaction effect of seedling ages and fertilizer doses showed significant effect on biological yield (t ha^{-1}) of mustard (Table 5). Experimental results revealed that, the maximum biological yield (5.72 t ha^{-1}) was recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum biological yield (4.73 t ha^{-1}) was recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot which was statistically similar with 15 days old seedling (S_2) along with 0% of recommended dose of fertilizer (F_0) treated plot recorded biological yield (4.74 t ha^{-1}), with 10 days old seedling (S_1) along with 0% of recommended dose of fertilizer (F_0) treated plot recorded biological yield (4.75 t ha^{-1}), and with 20 days old seedling (S_3) along with 75% of recommended dose of fertilizer (F_0) treated plot recorded biological yield (4.83 t ha^{-1}).

4.3.4 Harvest index (%)

Effect of seedling ages

Seedling ages significantly influenced the harvest index (%) of mustard (Figure 21). Experimental results showed that, the maximum harvest index (39.12 %) was recorded in 10 days old seedling (S_1) which was statistically similar with 15 days old seedling (S_2) recorded harvest index (38.92 %). Whereas the minimum harvest index (34.56 %) was recorded in 20 days old seedling (S_3). The result obtained from the present study was similar with the findings of Sarkar *et al*. (2011) and reported that the highest harvest index was obtained from 25 days old seedlings, while the lowest was found with 35 days old seedlings. Pramanik and Bera (2013) also reported that maximum harvest index of 45.19 and 47.00 was noticed from 10 days and 15 days old seedlings.



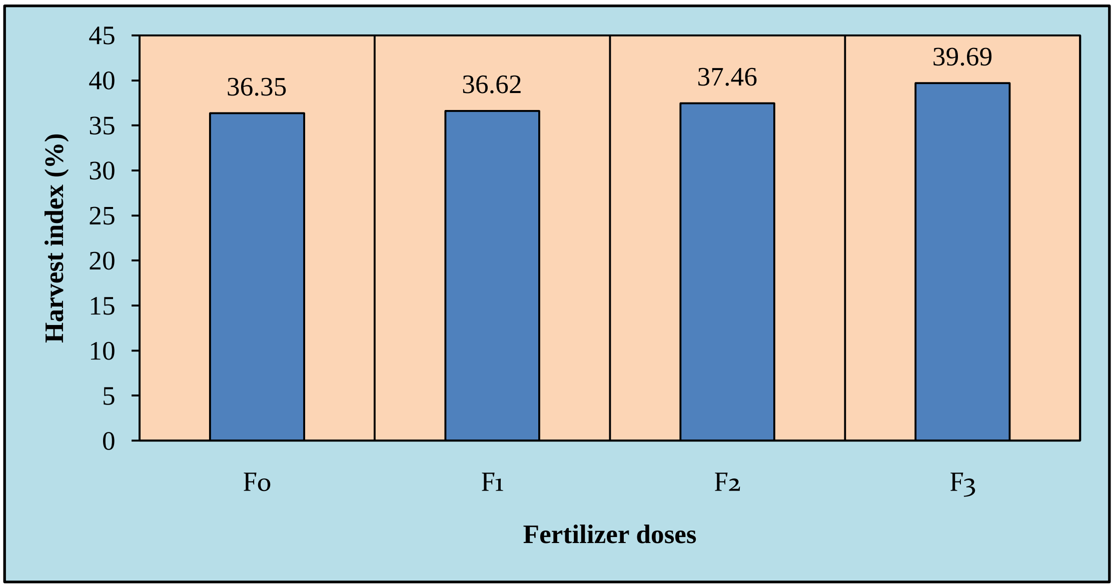
Here, S_1 = 10 days old seedling, S_2 = 15 days old seedling, and S_3= 20 days old seedling

Figure 21. Effect of seedling ages on harvest index of mustard

[$LSD_{(0.05)}$= 0.64].

Effect of fertilizer dose

Fertilizer application at different dose significantly influenced the harvest index (%) of mustard (Figure 22). Experimental results showed that, the maximum harvest index (39.69 %) was recorded in 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum harvest index (36.35 %) was recorded in 0% of recommended dose of fertilizer (F_0) treated plot which was statistically similar with 75% of recommended dose of fertilizer (F_1) treated plot recorded harvest index (36.62 %). The significant increase in seed and stover yields of mustard were largely a function of improved growth and the consequent increase in different yield components due to adequate supply of major plant nutrient under successive increase in nutrient doses which finally resulted in higher seed yield, stover yield ultimately resulted increased biological yield and harvest of mustard crop. Puste *et al*. (2012) reported that increase application of N 80 kg/ha, P_2O_5 45 kg/ha and K_2O 40 kg/ha gave higher percentages of harvest index than other treatment.



F_0 = 0% (Control), F_1 = 75% of recommended doses of fertilizer, F_2 = 100% of recommended doses of fertilizer and F_3 = 125% of recommended dose of fertilizer

Figure 22. Effect of fertilizer doses on harvest index of mustard [LSD$_{(0.05)}$= 0.74].

Interaction effect of seedling ages and fertilizer doses

Different seedling ages along with fertilizer doses significantly influenced the harvest index (%) of mustard (Table 5). Experimental results revealed that, the maximum harvest index (41.46 %) was recorded form 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum harvest index (30.23 %) was recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot.

Table 5. Interaction effect of seedling ages and fertilizer doses on seed yield, stover yield, biological yield and harvest index of mustard

Seedling ages × Fertilizer doses	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
S_1F_0	1.89 ef	2.86 f	4.75 h	39.79 b
S_1F_1	1.95 d-f	3.37 a	5.32 b-d	36.65 de
S_1F_2	2.09 bc	3.33 a-c	5.42 bc	38.56 bc
S_1F_3	2.37 a	3.35 ab	5.72 a	41.46 a
S_2F_0	1.85 fg	2.89 f	4.74 h	39.03 bc
S_2F_1	1.98 de	3.12 e	5.10 ef	38.85 bc
S_2F_2	2.01 cd	3.27 a-d	5.28 c-e	38.08 c
S_2F_3	2.18 b	3.30 a-d	5.48 b	39.71 b
S_3F_0	1.43 i	3.30 a-d	4.73 h	30.23 g
S_3F_1	1.66 h	3.17 de	4.83 gh	34.37 f
S_3F_2	1.78 g	3.20 c-e	4.98 fg	35.73 e
S_3F_3	1.97 de	3.23 b-e	5.20 de	37.89 cd
$LSD_{(0.05)}$	0.10	0.13	0.19	1.28
CV(%)	3.19	2.35	2.13	2.02

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Notes *viz:*

S_1 = 10 days old seedling

S_2 = 15 days old seedling

S_3= 20 days old seedling

F_0 = 0% (Control)

F_1 = 75% of recommended doses of fertilizer

F_2 = 100% of recommended doses of fertilizer

F_3 = 125% of recommended dose of fertilizer

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm SAU, Dhaka to study the system of mustard intensification as affected by seedling ages and fertilizer doses during the period from October 2019 to February 2020 in *Rabi* season. The experiment was consisted of two factors and followed randomized complete block design with three replications. Factor A: ages of mustard seedling (3) *viz;* S_1 = 10 days, S_2 = 15 days and S_3= 20 days and Factor B: different fertilizer doses (4) *viz;* F_0 = 0% (Control), F_1 =75% of recommended doses of fertilizer, F_2 =100% of recommended doses of fertilizer F_3 =125% of recommended dose of fertilizer. Data on different parameters were collected for assessing results for the experiment and showed significant variation in respect of growth, yield and yield contributing characteristics of mustard due to the effect of seedling ages, different fertilizer dose and their Interaction.

In case of seedling ages of mustard, the maximum plant height (11.98, 60.40, 100.77 and 107.53 cm) at 10, 30, 50 DAT and at harvest respectively, number of branches plant^{-1} (3.59, 9.64 and 11.00) at 30, 50 DAT and at harvest respectively, above ground dry matter weight plant^{-1} (2.39, 5.18 and 32.87 g) at 30, 50 and at harvest respectively, were recorded in 10 days seedling (S_1). The maximum number of siliqua plant^{-1} (188.68), length of siliqua (8.94 cm), seeds siliqua^{-1} (29.67), 1000-seed weight ((3.88 g), seed yield (2.08 t ha^{-1}), stover yield (3.23 t ha^{-1}), maximum biological yield (5.30 t ha^{-1}) and harvest index (39.12 %) were recorded in 10 days seedling (S_1). Whereas, 15 days old seedling (S_2) recorded the minimum plant height (9.85) at 10 DAT. At 30, 50 DAT and at harvest respectively, the minimum plant height (56.44, 93.00 and 98.48 cm) was recorded in 20 days old seedling (S_3). The minimum number of branches plant^{-1} (2.67, 7.90 and 9.33) and above ground dry matter weight plant^{-1} (1.79, 4.52 and 30.41 g) at 30, 50 and at harvest respectively were recorded in 20 days seedling (S_3). The minimum number of siliqua plant^{-1} (174.77), length of siliqua (8.32), seeds siliqua^{-1} (26.17), 1000-seed weight (3.33 g), seed yield (1.71 t ha^{-1}), stover yield (3.23 t ha^{-1}), biological yield (4.94 t ha^{-1}) and harvest index (34.56 %) were recorded in 20 days seedling (S_3).

In the case of different fertilizer dose applied in mustard, the maximum plant height (11.36, 65.09, 103.11 and 108.51 cm) at 10, 30, 50 DAT and at harvest respectively, number of branches plant^{-1} (3.34, 9.78 and 11.56) at 30, 50 DAT and at harvest respectively, above ground dry matter weight plant^{-1} (2.65, 5.59 and 33.38 g) at 30, 50 DAT and at harvest respectively were recorded in 125% of recommended dose of fertilizer (F_3) treated plot. The maximum number of siliqua plant^{-1} (203.56), length of siliqua (9.150 cm), number of seeds siliqua^{-1} (29.67), 1000-seed weight (3.96 g), seed yield (2.17 t ha^{-1}), stover yield (3.29 t ha^{-1}), biological yield (5.47 t ha^{-1}) and harvest index (39.69 %) were recorded in 125% of recommended dose of fertilizer (F_3) treated plot. Whereas the minimum plant height (9.52, 50.39, 89.73 and 96.08 cm) at 10, 30, 50 DAT and at harvest respectively, number of branches plant^{-1} (3.11, 7.78 and 8.99) at 30, 50 DAT and at harvest respectively, above ground dry matter weight plant^{-1} (1.82, 4.36 and 29.29 g) at 30, 50 DAT and at harvest, respectively were recorded in 0 % of recommended dose of fertilizer (Control) treated plot (F_0). The minimum number of siliqua plant^{-1} (162.62), length of siliqua (8.06 cm), number of seeds siliqua^{-1} (24.45), 1000 seeds weight (3.39 g), seed yield (1.72 t ha^{-1}), stover yield (3.15 t ha^{-1}), biological yield (4.74 t ha^{-1}) and harvest index (36.35 %) were recorded in 0 % of recommended dose of fertilizer (Control) treated plot (F_0).

In the case of interaction effect, transplanting 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot recorded the maximum plant height (12.66, 68.43, 110.82 and 115.06 cm) at 10, 30, 50 DAT and at harvest respectively. The maximum number of branches plant^{-1} (3.67, 10.77 and 13.00) at 30, 50 DAT and at harvest respectively, above ground dry matter weight plant^{-1} (2.78, 5.79 and 34.71 g) at 30, 50 DAT and at harvest respectively were recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. The maximum number of siliqua plant^{-1} (219.33), length of siliqua (9.51 cm), number of seeds siliqua^{-1} (32.67), 1000-seed weight (4.16 g) and seed yield (2.37 t ha^{-1}) were recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. The maximum stover yield (3.37 t ha^{-1}) was recorded in 10 days old seedling (S_1) along with 75% of recommended dose of fertilizer (F_1) treated plot. The maximum biological yield (5.72 t ha^{-1}) and harvest index (41.46 %) were recorded in 10 days old seedling (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot. Whereas transplanting 20 days old seedling along with 0 %

of recommended dose of fertilizer (F_0) treated plot recorded the minimum plant height (9.04 cm) at 10, DAT. At 30 DAT the minimum plant height (49.71 cm) was recorded in 15 days old seedling (S_2) along with 0 % of recommended dose of fertilizer (F_0) treated plot. At 50 DAT and at harvest respectively, 20 days old seedling (S_3) along with 0 % of recommended dose of fertilizer (F_0) treated plot recorded the minimum plant height (83.90 and 86.42 cm) at 50 DAT and at harvest respectively. The minimum number of branches plant^{-1} (2.67, 7.25 and 8.33) at 30, 50 DAT and at harvest respectively, above ground dry matter weight plant^{-1} (1.54, 3.91 and 28.56) at 30, 50 DAT and at harvest respectively were recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot. The minimum number of siliqua plant^{-1} (159.07), length of siliqua (7.70 cm), number of seeds siliqua^{-1} (20.67), seeds siliqua^{-1} (2.90 g), seed yield (1.43 t ha^{-1}), were recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot. The minimum stover yield (2.86 t ha^{-1}) was recorded in 10 days old seedling (S_1) along with 0% of recommended dose of fertilizer (F_0) treated plot. The minimum biological yield (4.73 t ha^{-1}) and harvest index (30.23 %) were recorded in 20 days old seedling (S_3) along with 0% of recommended dose of fertilizer (F_0) treated plot (Control).

Conclusion

Based on the above results of the present study, the following conclusions may be drawn,

Among different agess of seedling, transplanting 10 days old seedlings recorded the maximum number of siliqua plant^{-1} (188.68), length of siliqua (8.94 cm), seeds siliqua^{-1} (29.67), 1000-seed weight (3.88 g), seed yield (2.08 t ha^{-1}), stover yield (3.23 t ha^{-1}), maximum biological yield (5.30 t ha^{-1}) and harvest index (39.12 %).

In case of different fertilizer doses, application of 125% of recommended dose of fertilizer recorded the maximum number of siliqua plant^{-1} (203.56), length of siliqua (9.150 cm), number of seeds siliqua^{-1} (29.67), 1000 seeds weight (3.96 g), seed yield (2.17 t ha^{-1}), stover yield (3.29 t ha^{-1}), biological yield (5.47 t ha^{-1}) and harvest index (39.69 %).

In case of interaction effect, the maximum number of siliqua plant^{-1} (219.33), length of siliqua (9.51 cm), number of seeds siliqua^{-1} (32.67), 1000-seed weight (4.16 g) and seed yield (2.37 t ha^{-1}), biological yield (5.72 t ha^{-1}) and harvest index (41.46 %) were recorded using 10 days old seedlings (S_1) along with 125% of recommended dose of fertilizer (F_3) treated plot.

Thus for cultivation of mustard, transplanting 10 days old seedling along with 125% of recommended dose of fertilizer (F_3) application would performed well for higher seed production of mustard.

Recommendations

Further experiment may be conducted on system of mustard intensification (SMI) with different fertilizer Interaction and different seedling ages in different locations in Bangladesh.

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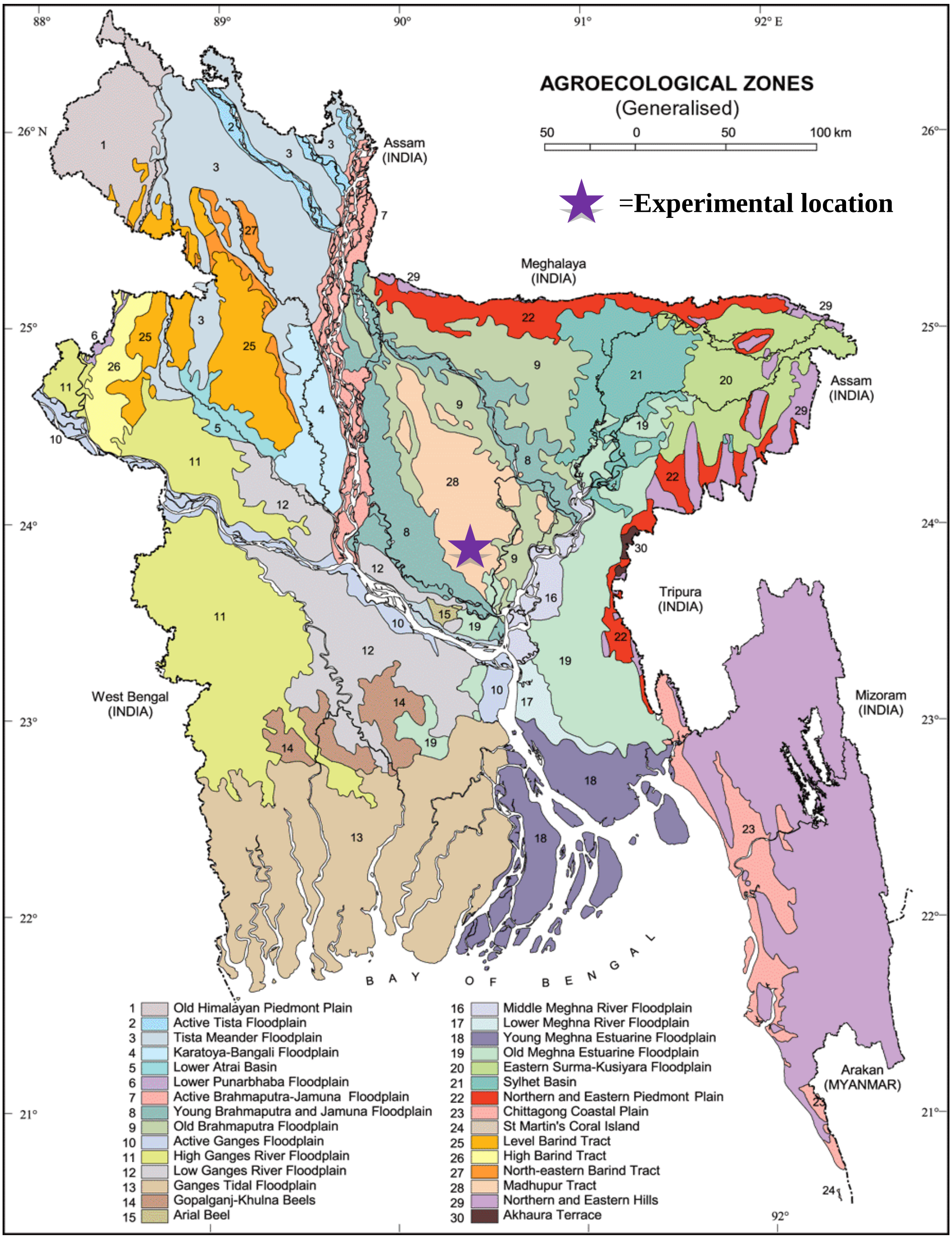
APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	Characteristics
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Location	Sher-e-Bangla Agricultural University Agronomy Research Field, Dhaka
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Clay	29 %
Sand	26 %
Silt	45 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10
Organic carbon (%)	0.45
Organic matter (%)	0.78
pH	5.6
Total nitrogen (%)	0.03

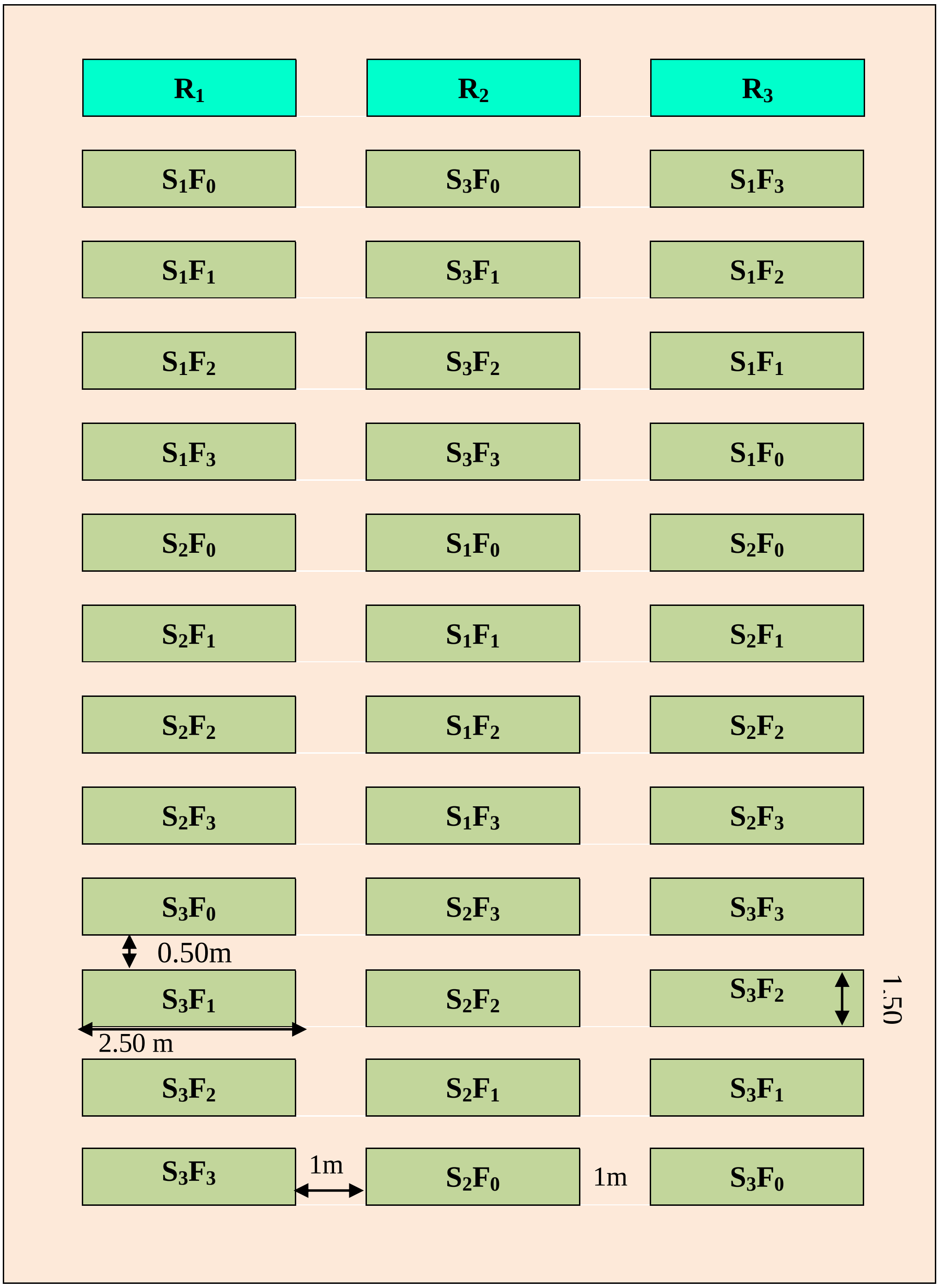
Sourse: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix III. Monthly meteorological information during the period from October, 2019 to February 2020.

Year	Months	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	October	31.2	23.9	76	52
	November	29.6	19.8	53	00
	December	28.8	19.1	47	00
2020	January	25.5	13.1	41	00
	February	25.9	14	34	7.7

(Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Layout of the experimental field



LEGENDS	
S_1 = 10 days old seedling	F_0 = 0% (Control / No fertilizer added)
S_2 = 15 days old seedling	F_1 = 75% of recommended doses of fertilizer
S_3= 20 days old seedling	F_2 = 100% of recommended doses of fertilizer
	F_3 = 125% of recommended dose of fertilizer

Appendix V. Analysis of variance of the data of plant height of mustard as influenced by seedling age, fertilizer doses and their interaction at different DAT

Mean square values of plant height at					
Sources	**Df**	**10 DAT**	**30 DAT**	**50 DAT**	**At harvest**
Replication (R)	2	4.19E-29	4.083	4.083	16.00
Seedling (S)	2	15.99*	54.462*	182.095*	247.59*
Fertilizers (F)	3	6.49*	335.684*	285.613*	245.68*
S×F	6	1.02*	11.703*	51.623*	43.60*
Error	22	0.18	3.538	9.538	16.00
Total	35				

*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data of number of branches plant^{-1} of mustard as influenced by seedling age, fertilizer doses and their interaction at different DAT

Mean square values of number of branches plant^{-1}				
Sources	**Df**	**30 DAT**	**50 DAT**	**At harvest**
Replication (R)	2	0.00250	0.04750	0.4098
Seedling (S)	2	3.05928*	9.12678*	9.0347*
Fertilizers (F)	3	0.10429*	7.11657*	10.4934*
S×F	6	0.04734*	0.60834*	1.0270*
Error	22	0.01068	0.13114	0.2388
Total	35			

*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data of above ground dry matter weight of mustard as influenced by seedling age, fertilizer doses and their interaction at different DAT

Mean square values of above ground dry matter weight at				
Sources	**Df**	**30 DAT**	**50 DAT**	**At harvest**
Replication (R)	2	0.00583	0.00259	0.0833
Seedling (S)	2	1.44602*	1.79447*	18.7324*
Fertilizers (F)	3	1.21957*	2.29548*	28.4271*
S×F	6	0.07159*	0.03480*	0.6341*
Error	22	0.01129	0.01328	0.8106
Total	35			

*: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data of number of siliqua plant-^{1}, length of siliqua (cm), number of seeds siliqua^{-1} and 1000 seeds weight (g) of mustard as influenced by seedling age, fertilizer doses and their interaction at different DAT

Mean square values of					
Sources	**Df**	**Number of siliqua plant^{-1}**	**Length of siliqua**	**Number of seeds siliqua^{-1}**	**1000 seeds weight**
Replication (R)	2	5.08	0.04389	1.2849	0.01861
Seedling (S)	2	580.92*	1.14631*	40.1789*	0.96745*
Fertilizers (F)	3	2698.49*	1.88039*	77.3860*	0.65071*
S×F	6	236.40*	0.06236*	4.6171*	0.13140*
Error	22	32.99	0.02166	1.0749	0.01407
Total	35				

*: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data of seed yield, stover yield, biological yield (t ha^{-1}) and harvest index (%) of mustard as influenced by seedling age, fertilizer doses and their interaction at different DAT

Mean square values of					
Sources	**Df**	**Seed yield**	**Stover yield**	**Biological yield**	**Harvest index**
Replication (R)	2	0.00186	0.00093	0.00416	0.2130
Seedling (S)	2	0.45101*	0.02643*	0.41061*	79.6722*
Fertilizers (F)	3	0.32180*	0.14149*	0.83089*	20.6175*
S×F	6	0.01241*	0.07699*	0.04254*	12.1563*
Error	22	0.00379	0.00566	0.01195	0.5754
Total	35				

*: Significant at 0.05 level of probability

PLATES

Plate 1: Photograph showing uprooting seedling of mustard from the seed bed

Plate 2: Photograph showing experimental field after transplanting seedlings of different ages of mustard in the experimental field

Plate 3: Photograph showing data recoding for experiment

Plate 4: Photograph showing weeding in mustard field

Plate 5: Photograph showing flowering and siliqua formation in mustard

Plate 6: Photograph showing general view of experimental plot with sign board