EFFECTS OF DIFFERENT RETRANSPLANTING DATES AND SEEDLING NUMBERS PER HILL ON GROWTH, YIELD AND NUTRIENT CONTENT OF LATE AMAN RICE (cv. Binasail)

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CERTIFICATE

This is to certify that the thesis entitled "EFFECTS OF DIFFERENT RETRANSPLANTING DATES AND SEEDLING NUMBERS PER HILL ON GROWTH, YIELD AND NUTRIENT CONTENT OF LATE AMAN RICE (cv. Binasail)" submitted to the DEPARTMENT OF AGRICULTURAL CHEMISTRY, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in AGRICULTURAL CHEMISTRY, embodies the results of a piece of bona fide research work carried out by MD. ELIYACHUR RAHMAN, Registration. No. 04-01436, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

I further certify that any help or sources of information received during the course of this investigation has duly been acknowledged.

Dated:

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Dedicated to
My
Beloved Parents

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ABSTRACT

An experiment was conducted at the experimental field of the farm of Sher-e-Bangla Agricultural University during the period from August to December, 2011 to study the effect of different seedling number hill^{-1} on the growth, yield and nutrient content of re-transplanted Aman rice (Binasail) using RCBD (Randomized Completely Block Design) with three replications. During the experiment, three different number of seedling hill^{-1} (3 seedlings hill^{-1}, 4 seedlings hill^{-1} and 5 seedlings hill^{-1}) and four transplanting and re-transplanting dates (transplanting at 16 September, re-transplanting at 23 September, re-transplanting at 30 September and re-transplanting at 07 October) were used as treatments. The highest number of total tillers hill^{-1}, effective tillers hill^{-1}, non-effective tillers hill^{-1}, spikelet panicle^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1} , maximum 1000-grain weight and the longest panicle was found from 4 seedlings hill^{-1} treatment while plant height was highest in both 4 seedlings hill^{-1} and 5 seedlings hill^{-1}. The highest N and P content in straw were observed from 4 seedlings hill^{-1} but K content was highest in 3 seedlings hill^{-1} treatment. In case of planting dates, re-transplanting at 23 September showed highest results for most of the growth and yield parameters while re-transplanting at 07 October gave the lowest. But non-effective tillers hill^{-1} and unfilled grains panicle^{-1} were highest in re-transplanting at 07 October and lowest in re-transplanting at 23 September and transplanting at 16 September. For N, P and K contents in straw, the highest results were recorded in transplanting at 16 September followed by re-transplanting at 23 September while re-transplanting at 07 October gave the lowest. Due to the interaction effects of two factors, 4 seedlings hill^{-1} and re-transplanting at 23 September gave better results followed by 3 seedlings hill^{-1} and re-transplanting at 23 September and 3 seedlings hill^{-1} and transplanting at 16 September for most of the parameters while poorest performances were observed for 5 seedlings hill^{-1} treatment and re-transplanting at 07 October and 3 seedlings hill^{-1} and re-transplanting at 07 October.

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LIST OF ABBREVIATIONS

%	=	Percent
@	=	At the rate
°C	=	Degree Celcius
AEZ	=	Agro Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
cv.	=	Cultivar (s)
DMRT	=	Duncan's Multiple Range Test
et al.	=	And Others
FAO	=	Food and Agriculture Organization
g	=	Gram
IRRI	=	International Rice Research Institute
LSD	=	Least Significant Difference
SAU	=	Sher-e-Bangla Agricultural University
t/ha	=	Tonne per Hectare
RCBD	=	Randomized Complete Block Design
DAT	=	Days After Transplanting

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Agriculture in Bangladesh is predominantly rice based and Bangladesh is the fourth rice producing country in the world. It is grown in 6.46 million hectares of land with a total production of 12.55 million tons in the year 2005-2006. Although rice is the staple food of her people, the average yield of rice in our country is around 2.45 t ha^{-1} which is less than the world average (3.1 t ha^{-1}) and frustratingly below the highest yield recorded (9.65 t ha^{-1}) in Australia (FAO, 2008). Bangladesh lacks arable land to extend rice production. Besides, rice production is decreasing day by day due to high population pressure, continuing drought and flood in farming areas, and conversion of farmlands to grow cash crops instead of rice. Because of these problems, the price of rice raised up to 49 to 60 percent in recent year. Therefore, it is an urgent need of the time to increase rice yield in Bangladesh.

Horizontal expansion of rice area in Bangladesh is not possible due to limited land resources, as land availability for crop production has been declining day by day because of population pressure. So, the only avenue left is to increase the production of rice through increasing crop intensity. Although the soil and climate of Bangladesh are favorable for rice cultivation through out the year but per hectare yield of this crop is much below the potential yield level. The reasons are manifolds, some are varietals, some are technological and some are ecological. Modern high yielding varieties require higher price of seeds, fertilizers, irrigation and pesticides. Our farmers are poor, so they can not always afford their costs. Hence, special attention should be given for increasing potential yield of crops per unit area by applying improved management practices.

Number of seedlings hill^{-1} is an important factor for successful rice production because it influences the tiller formation, solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and development of rice plant. In densely populated rice field the inter-specific competition between the plants is high in which sometimes results in gradual shading and lodging and thus favour increased production of straw instead of grain. If less seedlings per hill used, the potential yield can not be realized, if more seedlings is used it might not be cost effective. It becomes imperative therefore to find out the optimum number of seedlings required per hill for producing more shoots, number of fertile grains and ultimately maximum yield.

On the contrary every year thousands of hectares of lands are bared and remain uncultivated due to different reasons, we can increase our rice production by utilizing these lands. But flash flood in Aman season is one of the main reasons of uncultivated crop field. These lands become water free in the late season of the Aman. In this aspect late variety of Aman rice and re-transplanting of rice seedling can help the farmers of Bangladesh.

In Bangladesh when the photosensitive Aman rice varieties were transplanted in the late season during September-October their sensitivity to flowering in the months of October-December mostly depends on the planting dates. The phenological events of photosensitive varieties depend on the particular air temperature. BRRI (1989) and Yoshida (1981) reported that rice plants require a particular temperature for its phenological affairs such as panicle initiation, flowering, panicle exertion from flag leaf sheath and maturity and these are much influenced by the planting dates during transplanting (T) Aman season. Deviation from the optimum planting time may cause incomplete and irregular panicle exertion, increased spikelet sterility (Mangor, 1984). The optimum planting time of T. Aman rice is in August. But sometimes transplanting is delayed due to various causes such as rainfall, flood and socioeconomic factors. This late planting exposes the reproductive phases as well as phonological events of crop in an unfavourable temperature regime thereby causing high spikelet sterility and poor growth of the plant (BRRI, 1989). Halappa *et al.* (1974) reported that the performance of rice is greatly influenced by the date of transplanting due to the effect of cold hazard and incidence of biotic stress. Faria and Folegatt (1962) reported that grain yield was high for sowing in October (5.4 to 6.0 t/ha) and lower for sowing in December (1.6 to 4.8 t/ha) due to the low temperature at seed filling stages, mostly for the late cultivar. However, information regarding the effect of late planting in Aman rice is not adequate and re-transplanting is a newer idea in which rice seedling is uprooted from the seed bed and transplanted in another flood free land with 3-4 cm soil and under the soil layer a polyethylene sheet is provided for arrestation of root growth towards lower soil.

Keeping these views in mind, the present study was designed and conducted with the following objectives:

a. To study the effect of number of seedlings $hill^{-1}$ on the growth and yield performance at different re-transplanted Late Aman rice

b. To observe the N, P and K content of rice straw as affected by the number of seedlings $hill^{-1}$ at different re-transplanted Aman rice.

Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

Growth and development of rice plants are greatly influenced by the environmental factors i.e. air, day length or photoperiod, temperature etc., variety used and agronomic practices like transplanting time, spacing, number of seedlings, depth of planting, fertilizer management etc. Among the factors, which are responsible for the yield of rice, late transplanting of Aman rice is one of them. Number of seedlings per hill has a great influence on the growth, yield and yield components of rice. Research works related to number of seedlings per hill and late transplanting on the growth, yield and yield components of Aman rice have been reviewed in this chapter.

Shah *et al.* (1991) from a field experiment with cv 'K 39' using 3, 4, 5 and 6 seedlings per hill found that plant height increased with decreased seedlings per hill, on the other hand they were also found that tillers number increased with increased number of seedlings per hill from 3 to 6. Mishra (1992) reported that maximum leaf area index (7.37) at flowering stage with 1 seedling per hill.

Siddhu *et al.* (1988) found that rice crop transplanted with 2 seedlings per hill produced higher number of tillers per hill, number of leaves per hill and dry matter production per m^2 as compared to 1 seedling per hill.

Budhar *et al.* (1989) observed that there was no significant difference in plant height with 2 or 4 seedlings per hill. Zhang and Hung (1990) reported from China, that there was significant increase in the plant height due to increase in number of seedlings from 1 to 5 per hill. 5 seedlings per hill recorded significantly more plant height (84.4 cm) than the 1 (79.0cm), 2 (82.2 cm), 3 (81.8 cm) and 4 (80.4cm) seedlings per hill.

According to Cai *et al.* (1991), tillers number also increased with increased in seedlings number from 1 to 3 per hill. Chaudhury (1991) conducted a field trial at Bhubaneswar and found that significantly maximum leaf area index (9.95) with 6 seedlings per hill followed by 4 seedlings per hill at 80 days after transplanting. However, 6 seedlings per hill recorded significantly more dry matter accumulation over the 2 and 4 seedlings per hill at 20, 60 DAT and harvesting stages.

A field experiment was conducted by Srivastava *et al.* (1999) at Raipur with rice hybrid 'PA 6201' and cv. 'R 320-300' and revealed that crop transplanted with 2 seedlings per hill recorded significantly more effective tillers per m^2 (316) as compared to transplanted with 1 (308) and 3 seedlings per hill (309).

Sidhhu *et al.* (1988) conducted a field experiment at P.A.U., Ludhiana and found that rice transplanted with 2 seedlings per hill produced maximum grain yield (10.6 t/ha) than the 1 seedlings per hill. Zhang and Hung (1990) reported from China, that there was significant decrease in number of panicles per plant, length of panicle, fertile spikelets per panicle and 1000-grain weight due to increase in number of seedlings per hill from 2 to 5. Chaudhury (1991) recorded significantly higher panicle length (28.98 cm) and number of fertile grains (90.77) with planting of 2 seedlings per hill as compared to planting of 4 and 6 seedlings per hill in cv. 'Rambha'.

Shah *et al.* (1991) studied the effect of number of seedlings (3, 4, 5 and 6 seedlings per hill) on rice cv. 'K 39' and revealed that 1000-grain weight and number of panicle per plant were highest with 3 seedlings per hill whereas grain yield was highest with transplanted 5 seedlings per hill.

Bali *et al.* (1995) worked at Jammu & Kashmir and found that number of grains per panicle, 1000-grain weight and straw yield were significantly higher with 3 seedlings per hill. However, grain yield did not significantly influenced due to 3 and 6 seedlings per hill but found an increase of 17.1 and 13.4 per cent over the 9 seedlings per hill, respectively. The results of field trials conducted at three locations (Faizabad, Varanasi and Kaul) during *Kharif* 1995, revealed that there was no appreciable grain yield difference the treatments receiving 1 or 2 seedlings per hill in hybrid rice (DRR, 1995).

Trials continued at Maruteru, Pantnagar, Faizabad, Varanasi and Kharagpur during 1995 on the other hand indicated that planting 2 seedlings per hill registered the highest grain yield at all the locations except Varanasi where yield differences were not significant (DRR, 1996). Banik *et al.* (1997) reported that rice transplanted with 4 seedlings per hill produced grain yield of 42.16 quintal per hectare, which was 3.23, 4.49 and 19.91 per cent more than the grain yield obtained with 2, 6 and 8 seedlings per hill, respectively.

BRRI (1989) and Yoshida (1981) reported that rice plants require a particular temperature for its phenological affairs such as panicle initiation, flowering, panicle exertion from flag leaf sheath and maturity and these are much influenced by the planting dates during T. Aman season.

BRRI (1989) further reported that the optimum planting time of T. Aman rice is in August. But sometimes transplanting is delayed due to various physical and socioeconomic factors. This late planting exposes the reproductive phases as well as phonological events of crop in an unfavorable temperature regime thereby causing high spikelet sterility and poor growth of the plant.

Faria and Folegatt (1962) reported that grain yield was high for sowing in October (5.4 to 6.0 t/ha) and lower for sowing in December (1.6 to 4.8 t/ha) due to the low temperature at seed filling stages, mostly for the late cultivar.

Nahar *et al.* (2009) in a field experiment during the Aman (monsoon) season of 2008 studied the effect of low temperature stress influenced by date of transplanting on yield attributes and yields of two rice varieties. The experiment consisted of two varieties (BRRI dhan46 and BRRI dhan31) and 4 transplanting dates (01, 10, 20 and 30 September, 2008). BRRI dhan46 had significantly higher values of yield attributes (effective tillers hill^{-1}, panicles hill^{-1}, panicle length, spikelets panicle^{-1}, filled grains panicle^{-1} and 1000-grain weight) and yields than the BRRI dhan31 in late transplanted conditions. There were significant reductions in yield attributes and yields after delayed transplanting. Spikelet sterility was increased by late transplanting due to low temperature at panicle emergence stage. Yield reduction of BRRI dhan46 due to late transplanting at 10 September, 20 September and 30 September were 4.44, 8.88 and 15.55%, respectively compared to 01 September transplanting. In case of BRRI dhan31 the reduction was more significant which were 6.12, 20.48 and 36.73%, respectively.

Pal *et al.* (2002) conducted an experiment to find out the effect of method of planting (row and haphazard) and five hill arrangements [1 (25x12 cm^2), 2 (25x6 cm^2), 3 (25x4 cm^2), 4 (25x3 cm^2) and 5 (25x2.4 cm^2)] on the yield of late transplanted Aman rice (cv. BR23) grown under different planting dates (1st, 15th and 30th Sept.). Yield components namely number of effective tillers m^{-2}, number of grains and that of total spikelets panicle^{-1}, weight of 1000 grains were notably decreased with the delay in transplanting which in turn resulted in the decreased grain yield. The grain yield gradually decreased from 1st September transplanting onwards and became the lowest when the crop was transplanted on 30th September.

Biswas and Salokhe (2001) in their experiments in Bangkok clay soil tried to investigate the influence of planting date, tiller separation and plant density on the yield and yield attributes of parent and clone plants of two transplanted rice varieties. The 15 July transplanting of mother crop and collected vegetative tillers and re-transplanting on 15 August showed significantly high grain yield (3·8 t/ha). The photoperiod-insensitive variety RD23 gave higher yield (3·8 t/ha) than the photoperiod-sensitive variety KDML105 (3·0 t/ha). Tiller separation upto 4 tillers/hill did not adversely affect the mother crop. Vegetative tillers transplanted with 2–4 tillers/hill gave a similar yield as the mother crop in both the seasons. Vegetative tillers gave a higher yield than nursery seedlings transplanted on the same date. The yield components, *i.e.* weight of 1000 grains, grains/panicle and percent filled grains, showed better responses with early transplanting of KDML105 in the mother crop and vegetative tillers except for panicle number and panicle length of vegetative tillers with RD23. The results suggest that in some flood-prone lowlands, where the transplanted crop is damaged by natural hazards, vegetative propagation using tillers separated (maximum 4/hill) from the previously established transplanted crop is beneficial for higher productivity.

Miah *et al.* (1993) reported that plant height differed significantly among BR 3, BR 11, BR 22, Nizershail, Pajam, and Badshabhog varieties in Aman season (Jul-Dec). Tiller number varied widely among the varieties and the number of tillers/plant at the maximum tiller number stage ranged between 14.3 and 39.5 in 1995 and 12.2 and 34.6 in 1996.

Rahman *et al.* (2007) conducted an experiment at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during, T. Aman season 2002, to investigate the effect of number of seedling/hill and nitrogen level on growth and yield component of BRRI dhan32. The treatments were the variation numbers of seedling/hill viz. 1, 2, 3 and 4 seedling/hill and four levels of nitrogen viz 0, 60, 80 and 100 kg N/ha. Number of seedlings/hill significantly influenced growth and yield components except 1000-grain weight. It was found that the highest number of grains/panicle (100.92) and grain yield (5.37 t/ha) were resulted from transplanting of 3 seedlings/hill and the lowest grain yield (4.38 t/ha) was obtain from the transplanting of 1 seedling/hill. The highest straw yield (7.02 t/ha) was obtain from the transplanting of 4 seedlings/hill and the lowest one (5.64 t/ha) from the transplanting of 1 seedling/hill. Nitrogen level significantly influenced growth and yield components. The maximum grains/panicle (100.80) and the highest grain yield (5.34 t/ha) were obtained with 80 kg N/ha. The highest straw yield (6.98 t/ha) was obtained at the highest nitrogen level (100 kg N/ha). Result showed that 3 seedlings/hill and 80 kg N/ha was optimum to produced maximum yield of BRRI dhan32.

From the above reviews it is cleared that number of seedlings $hill^{-1}$ and late transplanting have profound influence on the yield and yield contributing characters of Aman rice. Thus there may have enough scope investigating the number of seedlings $hill^{-1}$ and transplanting date in favor of yield improvement of Aman rice cv. Binasail.

Chapter 3
Methods and Materials

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the experiment field of the farm of Sher-e-Bangla Agricultural University, during the period from August to December 2011. This chapter deals with a detail description of the site, soil, land preparation, intercultural operations, data recording and procedure of statistical analysis etc.

3.1 Description of experimental site

3.1.1. Location and site

The experimental field is located at the Sher-e-Bangla Agricultural University (SAU), Dhaka-1207. The experimental area belongs to Modhupur Tract (Agro-Ecological Zone 28). The land area was situated at 23°41' N latitude and 90°22' E longitude at an altitude of 8.6 meter above the sea level.

3.1.2 Soil

The soil of the experimental field belongs to the general soil type, shallow red brown terrace soil under Tejgaon series. Top soils were clay loam in texture, olive gray with common fine medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period.

3.1.3 Climate

The experimental area was under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the Rabi season (November-March).

3.2.1 Planting material

Rice variety Binasail was taken as test crop for this experiment. The variety is Transplanted Late Aman in type. The plant grows up to 125 cm height. Seed to seed duration is 150 days. The appropriate time for seed sowing is late June to late July and transplanting should be done with in August to early September. The variety is harvested from Mid November to Mid December and approximate yield is 5.5 t/ha (BINA, 1987).

3.2.2 Experimental treatment

The treatments included in the experiment were two factorials.
Design: RCBD with two factorials
Factor A: Number of seedlings hill^{-1} : 3

S_1 =3 seedlings hill^{-1}
S_2= 4 seedlings hill^{-1}
S_3 = 5 seedlings hill^{-1}

Factor B: Re-transplanting dates: 4

T_1 : 16 September (First Transplanting in the main field and beside the main field)
T_2 : 23 September (Re-transplanting after 7 days)
T_3 : 30 September (Re-transplanting after 14 days)

T_4 : 07 October (Re-transplanting after 21 days)]

Treatment combination = 3 x 4 = 12

Replication: 3

3.3 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Each replication was divided into 12 plots. The total numbers of unit plots were 36. The plot size was 2.0 m x 2.0 m. The distances between plot to plot and replication to replication were 1 m and 0.5 m, respectively. The layout of the experimental plot has been shown in Appendix 1.

3.4 Raising of seedlings

Seeds of Binasail were collected from BINA (Bangladesh Institute of Nuclear Agriculture), Mymensingh. The seedlings were raised at the wet seed bed in SAU farm. The seeds were sprouted by soaking for 72 hours. The sprouted seeds were sown uniformly in the well-prepared seed bed in first week of August, 2011.

3.5 Land preparation

The experimental field was opened with a power tiller and later on, the land was ploughed and cross-ploughed three times by country plough followed by laddering to obtain the desirable tilth. The corners of the land were spaded. All kinds of weeds and stubbles were removed from the field and the land was made ready. Whole experimental land was divided into sub plots. Finally basal doses of nitrogen, phosphorus, potassium and sulphur fertilizers were applied in sub plots and the plots were made ready by thorough spading and leveling before transplantation.

3.6 Fertilizer application

At the time of first ploughing cow dung at the rate of 1 t/ha was applied. The plots were fertilized with 87, 60, 50, 16 and 3 kg/ha urea, triple super phosphate (TSP), muriate of potash (MP), sulphur and gypsum respectively (BINA, 1987). All the fertilizers except urea were incorporated with the soil one day before transplanting.

3.7 Transplanting of seedlings

3.7.1 Uprooting and transplanting of seedlings on the main field and polythene sheet

Six weeks old seedlings were uprooted from the seed bed carefully and transplanted at the main field according to T_1 treatment with row to row distance 22.22 cm and hill to hill distance 18.18 cm. Number of seedlings per hill were maintained according to S_1, S_2 and S_3 treatments. For re-transplanting, the uprooted seedlings were placed on polythene sheet with 3-4 cm soil and at beside the plot on 16 September 2011.

3.7.2 Uprooting and re-transplanting of seedlings in main plot

From the polythene based hills were uprooted again and re-transplanted in the main field as per treatments (S_1, S_2, S_3 and T_2, T_3 & T_4) with row to row distance 22.22 cm and hill to hill distance 18.18 cm.

3.8 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.8.1 Weed control

During plant growth stage hand weedings were done according to needs.

3.8.2 Irrigation and drainage

Irrigation water was applied keeping a standing water of about 2-3 cm during the whole growing period.

3.8.3 Plant protection measure

During the growing period some plants were infested by rice stem borer (*Scirpophaga incertulus*) which was successfully controlled by applying Diazinon 60 EC @ 20 mL per 10 Liter of water for spraying. No prominent infestation of insect-pests and diseases were observed in the field.

3.9 Harvest and post harvest operation

The crop was harvested after the grains attained maturity. The grains were threshed, cleaned and sun dried to record grain yield/plot.

3.10 Sampling and data collection

Data collections from the experiment on different growth stages were done under the following heads as per experimental requirements.

3.10.1 Plant height (cm)

Then heights of the pre-selected 10 hills were taken by measuring the distance from base of the plant to the tip of the flag leaf after heading. The collected data were finally averaged.

3.10.2 Number of effective and non-effective tillers hill^{-1}: Number of effective and non-effective tillers was counted from 10 preselected hills after harvesting and finally averaged.

3.10.3 Number of filled grains and unfilled grains panicle^{-1}: Number of filled grains and unfilled grains were counted from 10 panicles from each plot. Lack of any food materials inside the spikelets were denoted as unfilled grains.

3.10.4 Thousand grain weight (g): One thousand grains were randomly collected from each plot and were sun dried and weighed by an electronic balance.

3.10.5 Grain yield (t/ha): Four square meter (m^2) area (each plot) were harvested. The grains were threshed, cleaned, dried and then weighed in kg. Thereafter it was converted as ton per hectare (t/ha).

3.10.6 Determination of total Nitrogen

The macro Kjeldahl method was used to determine the total nitrogen in straw of plant samples. Three steps were involved in this method. These are as follows:

1. Digestion : In this step the organic nitrogen was converted to ammonium sulphate by sulphuric acid and digestion accelerators (Catalyst Mixture) at a temperature of 360-440^{0}C.

$$N + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

2. Distillation : In this step, the solution was made alkaline for the distillation of ammonia. The distillated ammonia was received in boric acid solution.

$$(NH_4)_2SO_4 + NaOH \longrightarrow Na_2SO_4 + NH_3 + H_2O$$

$$NH_3 + H_3BO_3 \longrightarrow (NH_4)_2BO_3 + H_2O$$

3. Titration : To determine the amount of NH_3, ammonium borate was titrated with standard sulfuric acid.

$$(NH_4)_2BO_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4 + H_3BO_3$$

Reagents : 4 % Boric Acid solution, Mixed Indicator (Bromocresol Green And Methyl Red), 4 % Sodium Hydroxide solution, standard Sulfuric Acid solution and 0.05 N Na_2CO_3 solution.

Procedure :

About 0.25 g of oven-dried straw sample was weighed and then transferred into a 250 ml Pyrex conical flask. Then 5.0 g catalysts mixer (K_2SO_4: CuSO4.5H_2O: Se =100: 10: 1) was added in to the flask. About 25 ml H_2SO_4 was also added in to the flask. The flask was heated until the solution become clear and then allowed to cool. After digestion, 40% NaOH was added in to the conical flask and attached quickly to the distillation set. Then the flask was heated continuously. In the meantime, 25mL of 4% boric acid solution and 2-4 drops of mixed indicator was taken in 5%. receiver conical flask. After distillation, the distillate was collected into receiver conical flask. The distillate was titrated with standard H_2SO_4 taken from a burette until the green color completely turns to pink. The same procedure was followed for a blank sample.

The result was calculated using the following formula –

$\% N = (T\text{-}B) \times N \times 1.4/S$

T = Titration value for sample (ml.), B -= Titration value for blank (ml)

N = Normality of H_2SO_4, S = Weight of the sample (g),

1.4 = Conversion factor

3.10.7 Determination of Phosphorus (P)

Principle:

By ascorbic acid blue color method the phosphorus content in rice straw was determined. This method is based on the principle that in an acid molybdate solution containing orthophosphate ($H_2PO_4^-$) ions, a phosphomolybdate complex forms that can be reduced by ascorbic acid and other reducing agents to a molybdenum blue color.

$(NH_4)_6Mo_7O_{24}.4\ H_2O + H_2SO_4 = (NH_4)_2MoS_4$

$(NH_4)_2MoS_4 + H_2PO_4^- = (NH_4)_3PMo_{12}O_{40}$ [Ammonium phosphorus molybdate, oxidized, colorless]

$(NH_4)_3PMo_{12}O_{40} + C_6H_8O_6 =$ Ammonium phosphorus molybdate (Reduced, Blue color)

Reagents:

1. Mixed reagent:

Solution A: About 12.0g ammonium molybdate [$(NH_4)_6Mo_7O_{24}.4\ H_2O$] was dissolved in 250 ml distilled water.

Solution B: At first 0.2908g antimony potassium tartarate [$K(SbO)C_4H_4O_6.1/2H_2O$] was dissolved in 1000 ml of 5N H_2SO_4 (148 ml conc.

H_2SO_4/Liter) the two solutions were mixed together thoroughly. Then the volume was made to 2000 ml distilled water.

2. Color developing reagent:

About 0.53g (or.1.06g or 2.65g) of ascorbic acid was added to 100 ml (or 200 ml or 500 ml) of the mixed reagent.

Preparation of plant extract:

0.25 g of dry rice straw/grain were weighed, and then transferred into 250 ml Pyrex conical flasks. Then 10 ml 2:1 nitric-perchloric acid mixture was added into each flask and allowed to stand overnight or until the vigorous reaction phase is over. After the preliminary digestion, the conical flasks were placed on a hot plate in digestion chamber and then temperature was raised to 150°C for 1 hour. The temperature was increased slowly upto 300^0C After the digestion the conical flasks were lifted out of the digester and allowed to cool at room temperature. The solution was taken in 100 ml volumetric flask through funnel and volume with distilled water upto the mark (Jackson, 1973).

Procedure:

20 ml of the extract was pipette out in a 100 ml volumetric flask. Then 20 ml color developing reagent was added slowly and carefully to prevent loss of sample due to excessive foaming. After the evolution of CO; has ceased the flask was shake gently to mix the contents. Distilled water was added to make the volume up to the

mark of the flask. By spectrophotometer, the color intensity (% absorbance) was measured at 660 nm.

3.10.8 Determination of Potassium (K)

Principle: If a solution containing metallic salt (or some other metallic compound) is aspirated in a flame; the metal ion emits radiation at a characteristic wavelength having the definite color (e.g. potassium emits brick red color when aspirated in a flame). The intensity of the radiation emitted by the element (or metal ion) is directly proportional to the concentration of that element in solution.

Procedure:

Plant samples (for straw) were prepared by digestion as for phosphorus. Then the amount of potassium was estimated from prepared sample with the help of a flame photometer at 589 nm.

3.11 Statistical Analysis

The data were compiled and tabulated in proper form and were subjected to statistical analysis. Analysis of variance was done following the computer package MSTAT-C program developed by Russel, 1986. The mean differences among the treatments were adjusted by Duncan's Multiple Range Test at 5% level of significance (Gomez and Gomez, 1984).

Chapter 4
Results and Discussion

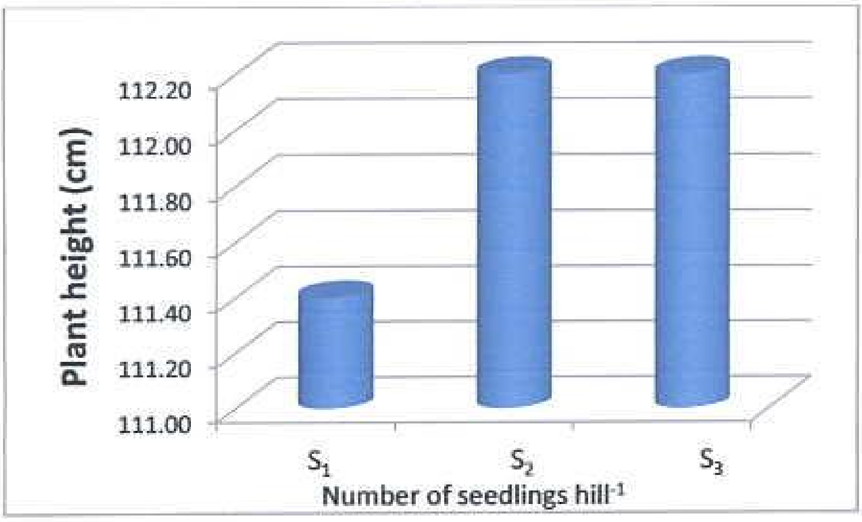
CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises of presentation and discussion of the results obtained from the study to see the effect of number of seedling hill^{-1} on the growth, yield and nutrient content of re-transplanted Aman rice (Binasail). Effects of different treatments on growth, yield and nutrient contents are presented here under the following headings-

4.1 Plant height (cm)

Plant height of Binasail showed no significant variation due to the different number of seedlings hill^{-1} (Figure 1 and Appendix 2). The tallest plant (112.17 cm) was obtained from 4 seedlings hill^{-1} (S_2) while 3 seedlings hill^{-1} (S_1) gave the shortest plant (111.42 cm) which is not far behind from S_2.

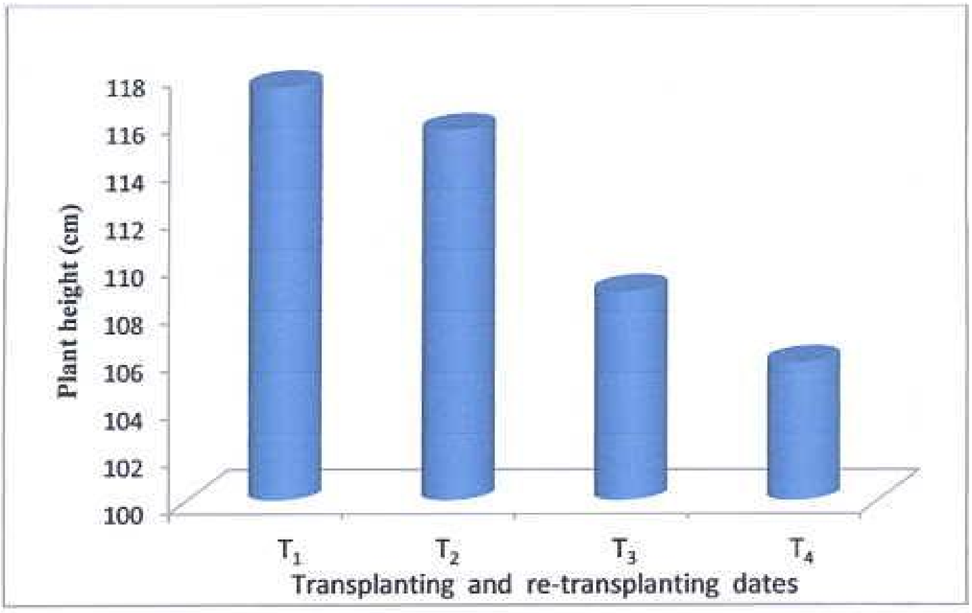


S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 1. Effect of number of seedlings hill^{-1} on plant height (mean of one transplanting and three re-transplanting dates)

It was observed from the results presented in Figure 2 that the transplanting and re-transplanting dates have significant influence on plant height. The tallest plant (117.36

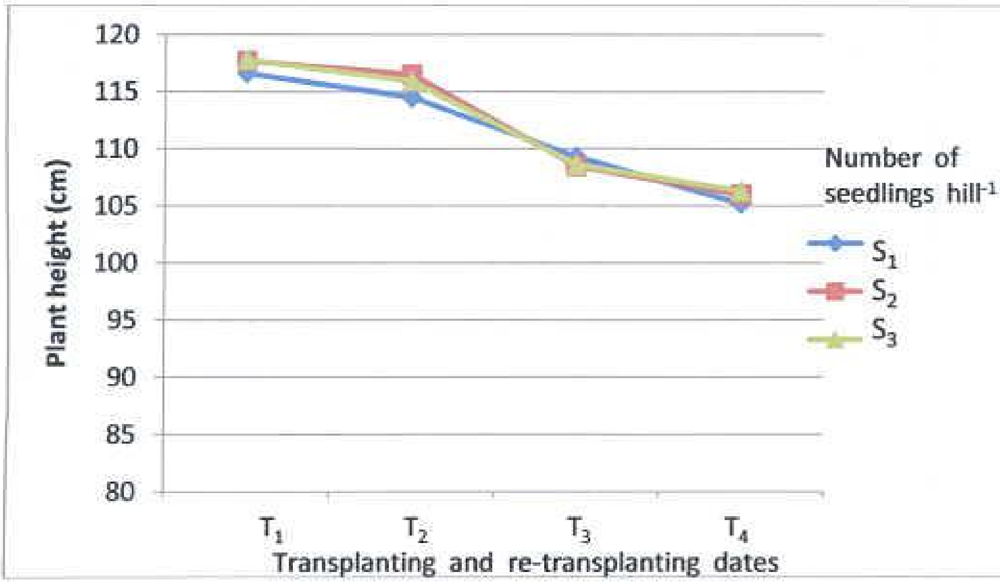
cm) was obtained from T_1 (transplanted on 16th September) which was statistically similar with T_2 (re-transplanted on 23 September). On the other hand, re-transplanted on 07 October (T_4) produced the shortest one (105.8 cm) (Appendix 3).



T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 2. Effect of transplanting and re-transplanting dates on plant height (mean of three different number of seedlings hill^{-1})

The results presented in Figure 3 show that the plant height differs significantly due to the interaction effect of number of seedlings hill^{-1} and planting dates of Late Aman cultivar (Binasail). The tallest plant (117.8 cm) was obtained from S_3T_1 (5 seedlings hill^{-1} and transplanted on 16 September) which was statistically similar with S_2T_1, S_1T_1, S_2T_2, S_3T_2 and S_1T_2 (Appendix 4). On the other hand, S_1T_4 (3 seedlings hill^{-1} and re-transplanted on 07 October) produced the shortest one (105.20 cm).



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

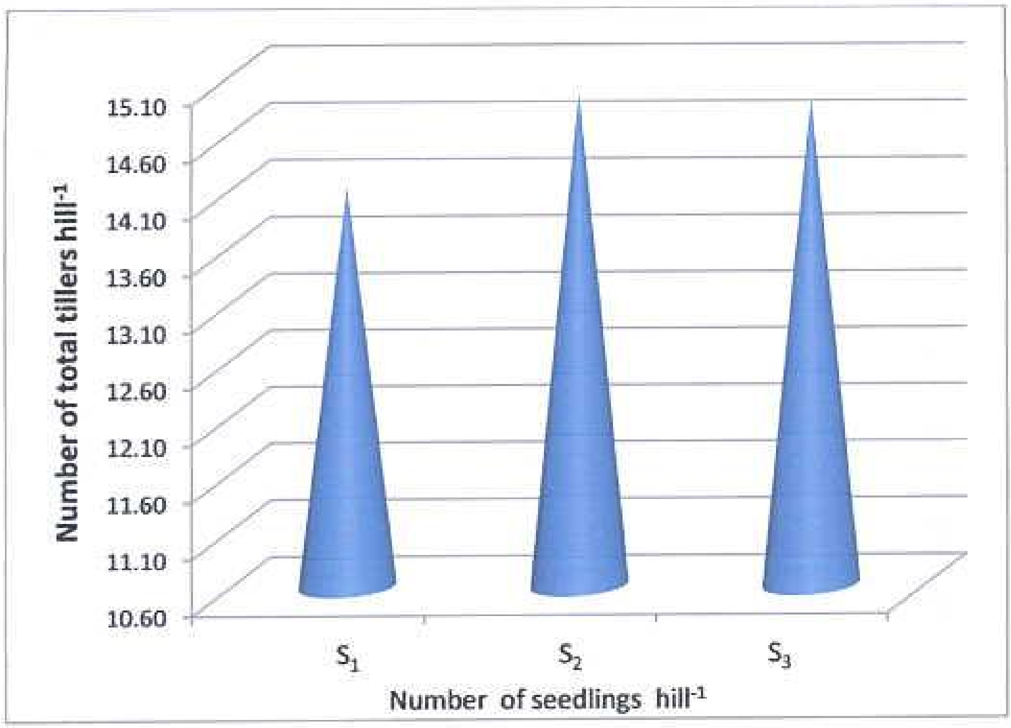
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 3. Effect of number of seedlings hill^{-1} on plant height under different transplanting and re-transplanting dates

Swain (1981) found that decrease in number of seedlings per hill from 2 with 50 hills per m^2 to 1 with 100 hills per m^2 had no significant effect on plant height. Budhar *et al.* (1989) observed that there was no significant difference in plant height with 2 or 4 seedlings per hill. BRRI (1989) reported that the optimum planting time of T. Aman rice is in August. But sometimes transplanting is delayed due to various physical and socioeconomic factors. This late planting exposes the vegetative and reproductive phases as well as phonological events of crop and poor growth of the plant.

4.2 Number of tillers hill^{-1}

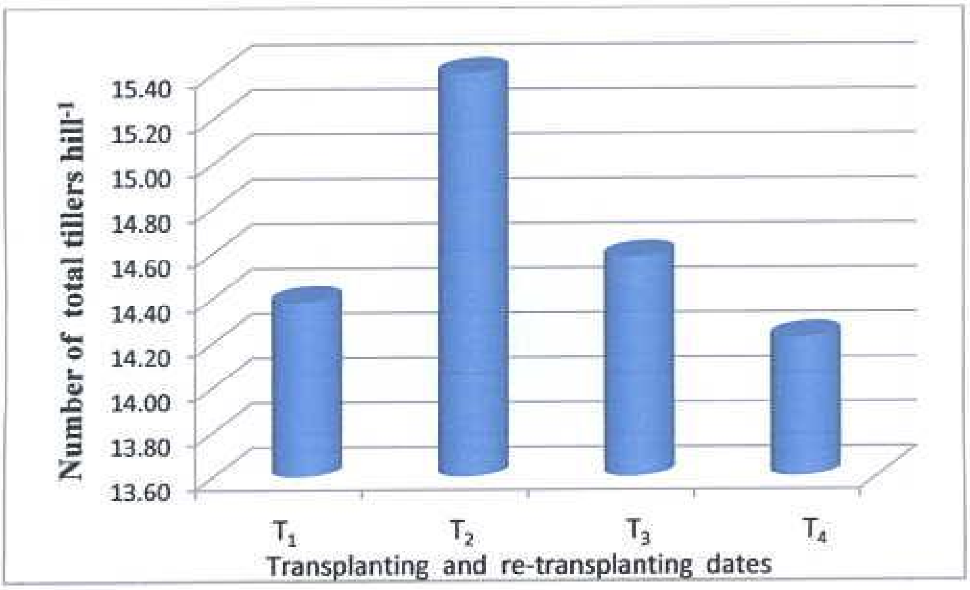
Number of tillers hill^{-1} of rice plant Binasail was not significantly affected by different number of seedlings hill^{-1} (Figure 4 and Appendix 2). Though the highest number of tillers hill^{-1} was found from 4 seedlings hill^{-1} (14.94) whereas 3 seedlings hill^{-1} gave 14.12 tillers hill^{-1}.



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 4. Effect of number of seedlings hill^{-1} on number of total tillers per hill (mean of one transplanting and three re-transplanting dates)

Total tiller number hill^{-1} varied insignificantly due to the effect of transplanting and re-transplanting dates (Figure 5). But numerically the highest number of tillers hill^{-1} (15.40) was obtained from T_2 (re-transplanted on 23 September) while re-transplanted on 07 October (T_4) gave the lowest result (14.22) (Appendix 3).



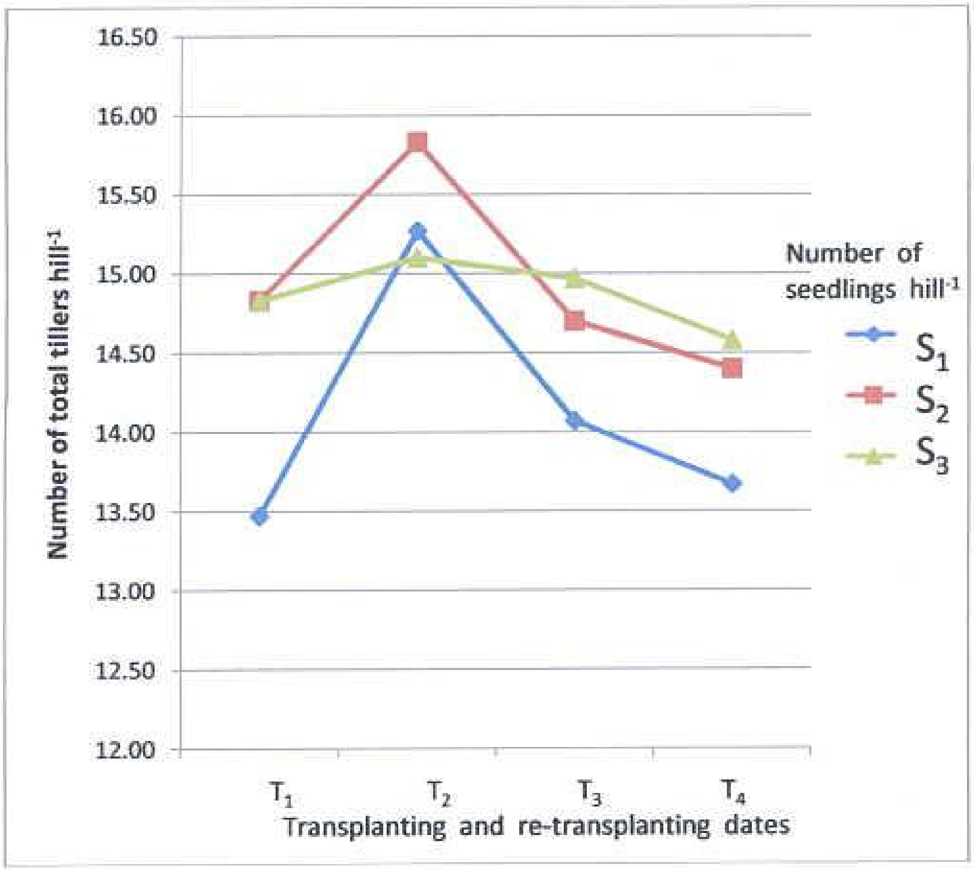
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 5. Effect of transplanting and re-transplanting dates on number of total tillers hill^{-1} (mean of three different number of seedlings hill^{-1})

No significant variation was found in number of total tiller number hill^{-1} due to the interaction effect of number of seedlings hill^{-1} and planting dates (Figure 6 and Appendix 4). But the highest number of tiller number hill^{-1} (15.83) was found from S_2T_2 while S_1T_1 gave lowest result (13.47).

Siddhu *et al.* (1988) found that rice crop transplanted with 2 seedlings per hill produced higher number of tillers per hill, number of leaves per hill and dry matter production per m^2 as compared to 1 seedling per hill. Baird *et al.* (1985) also reported that tillers density increased significantly with increasing seedling rate and established plant stand throughout the growing season. Raghuvanshi *et al.* (1986) noticed that there was no significant difference in number of functional leaves per hill and dry weight of leaves with transplanting of 3 or 5 seedlings per hill. Mangor (1984) found that late transplanting can affect on plant growth negatively and as a result tiller number hill^{-1} was reduced.

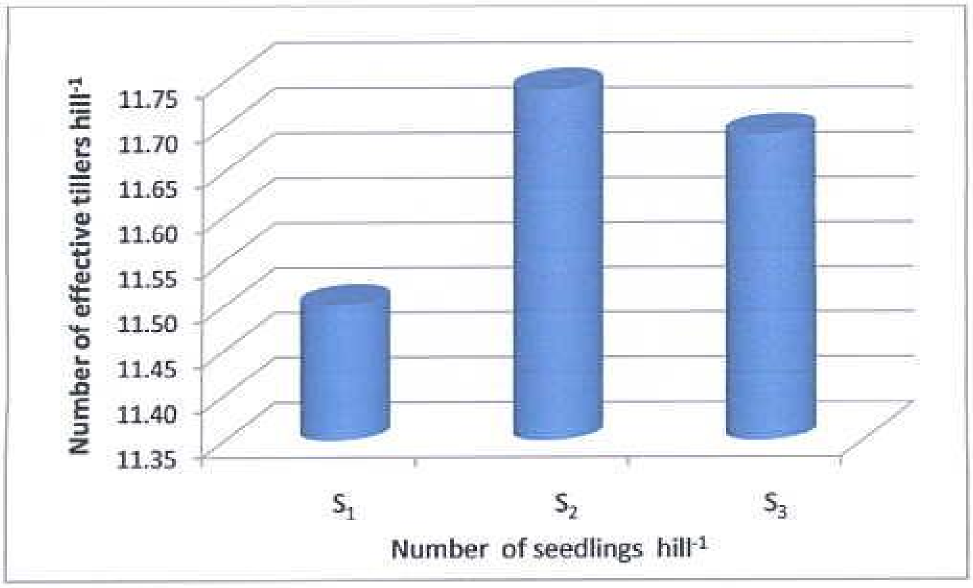


S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 6. Effect of number of seedlings hill^{-1} on total tiller number hill^{-1} under different transplanting and re-transplanting dates

4.3 Number of effective tillers hill^{-1}

The effective tiller hill^{-1} was not significantly differed due to the effect of number of seedlings hill^{-1} (Figure 7). Though the highest number of effective tillers hill^{-1} (11.74) was found from S_2 (4 seedlings hill^{-1}) while S_1 (3 seedlings hill^{-1}) gave the lowest number of effective tillers hill^{-1} (11.50) (Appendix 2).

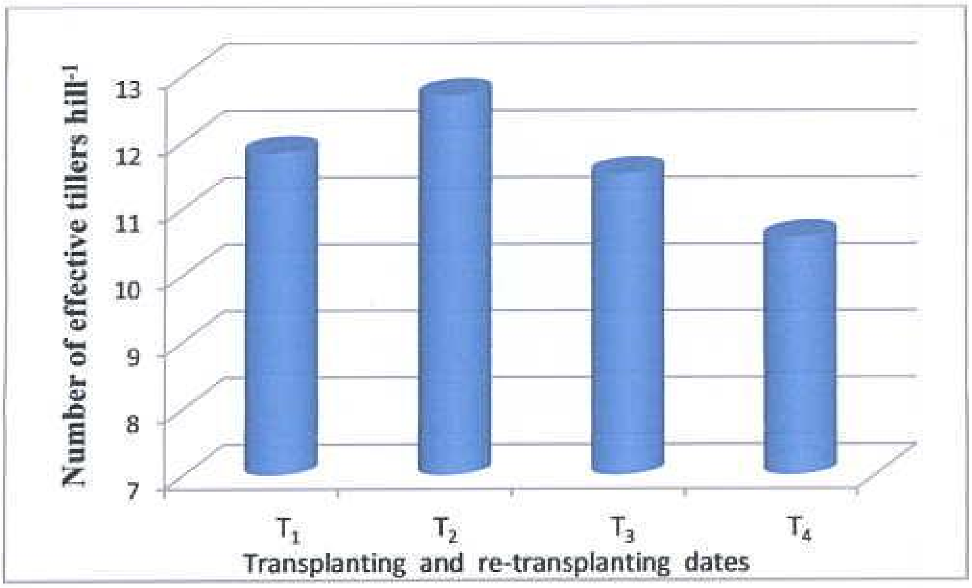


S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 7. Effect of number of seedlings hill^{-1} on the number of effective tillers hill^{-1} (mean of one transplanting and three re-transplanting dates)

There was significant influence on number of effective tillers hill^{-1} shown by transplanting and re-transplanting dates (Figure 8). The highest number (12.68) of effective tillers hill^{-1} was obtained from T_2 (re-transplanted on 23 September) while re-transplanted on 07 October (T_4) gave the lowest number of effective tillers hill^{-1} (10.56) (Appendix 3).

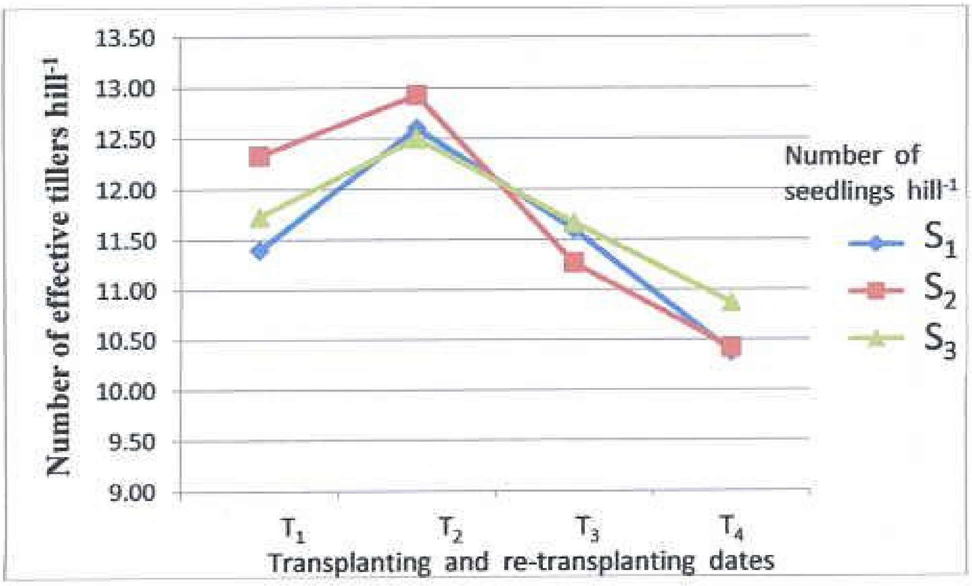
Interaction of number of seedlings hill^{-1} and planting dates showed significant influence on the number of effective tillers hill^{-1} (Figure 9). The highest number of effective tillers (12.93) hill^{-1} was found from S_2T_2 which was statistically similar with S_1T_2 (12.60). On the other hand, S_1T_4 gave lowest number of effective tillers per hill^{-1} (10.38) which was statistically similar with S_2T_4 (10.42) (Appendix 4).



T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 8. Effect of transplanting and re-transplanting dates on number of effective tillers hill^{-1} (mean of three different number of seedlings hill^{-1})



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 9. Effect of number of seedlings hill^{-1} on number of effective tillers hill^{-1} under different transplanting and re-transplanting dates

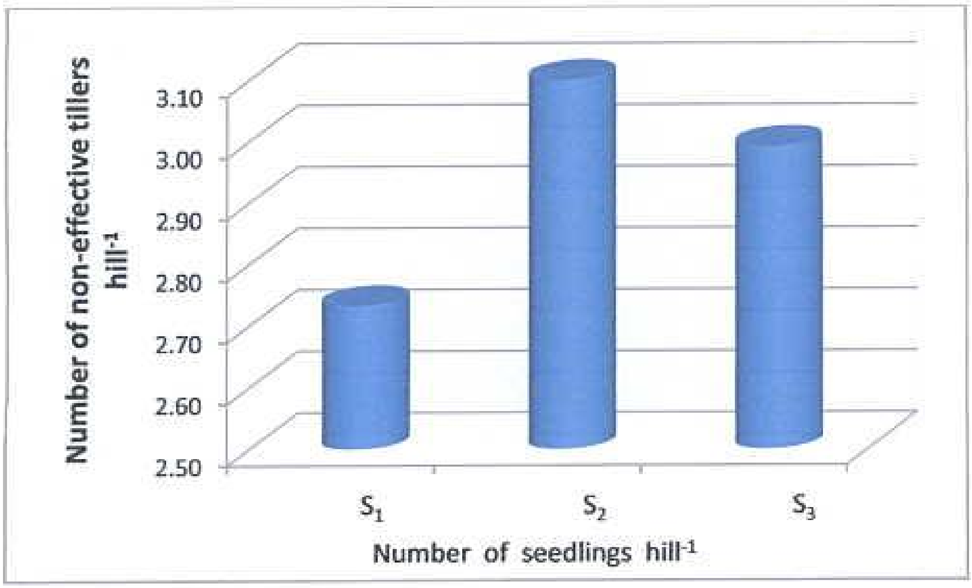
Srinivasulu (1997) conducted a field experiment with two hybrids 'APHR 1' and 'APHR 2' and one cv. 'Chaitanya' at Bapatla and Concluded that the crop transplanted with 2 seedlings per hill produced significantly higher productive tillers per m^2 (292) than the crop transplanted with 1 seedling per hill. A field experiment was conducted by Shrivastava *et al.* (1999) at Raipur with rice hybrid 'PA 6201' and cv. 'R 320-300' and revealed that crop transplanted with 2 seedlings per hill recorded significantly more effective tillers per m^2 (316) as compared to transplanted with 1 (308) and 3 seedlings per hill (309).

Nahar *et al.* (2009) conducted a field experiment during the Aman (monsoon) season of 2008. They found that low temperature stress had significantly lower values of yield attributes such as effective tillers $hill^{-1}$ in the BRRI dhan31 in late transplanted conditions.

4.4 Number of non-effective tillers $hill^{-1}$

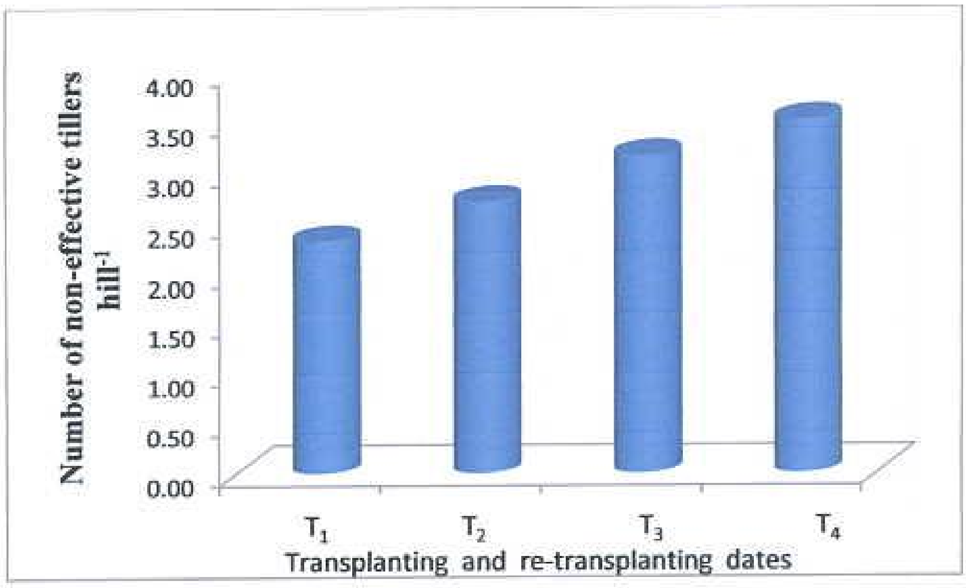
The effect of number of seedlings $hill^{-1}$ on the number of non-effective tillers $hill^{-1}$ was non-significant. But the higher number of non-effective tillers (3.10) $hill^{-1}$ was found from S_2 (4 seedlings $hill^{-1}$) while lowest was found from S_1 (3 seedlings $hill^{-1}$) (2.73) (Figure 10 and Appendix 2).

Transplanting and re-transplanting dates had significant influence on number of non-effective tillers $hill^{-1}$ (Figure 11). The highest number of non-effective tillers $hill^{-1}$ (3.53) was obtained from T_4 (re-transplanted on 07 October) while the lowest number of non-effective tillers $hill^{-1}$ (2.33) was obtained from T_1 (transplanted on 16 September) (Appendix 3).



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 10. Effect of number of seedlings *hill*$^{-1}$ on number of non-effective *tillers* hill^{-1} (mean of one transplanting and three re-transplanting dates)

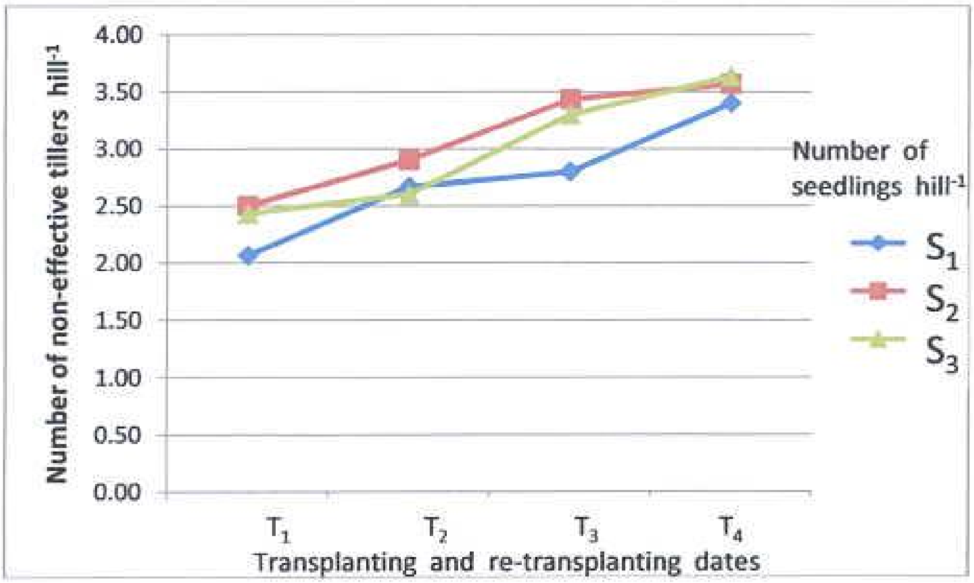


T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 11. Effect of transplanting and re-transplanting dates on number of non-effective tillers hill^{-1} (mean of three different number of seedlings hill^{-1})

Significant variation was found on number of non-effective tillers hill^{-1} due to the interaction effect of number of seedlings hill^{-1} and planting dates (Figure 12 and Appendix 4). The highest number of non-effective tillers (3.63) hill^{-1} was found from S_3T_4 (5 seedlings hill^{-1} and re-transplanted on 07 October) which was statistically similar with S_2T_4 (4 seedlings hill^{-1} and re-transplanted on 07 October). On the other hand, S_1T_1 gave lowest number of non-effective tillers (2.07) hill^{-1}.



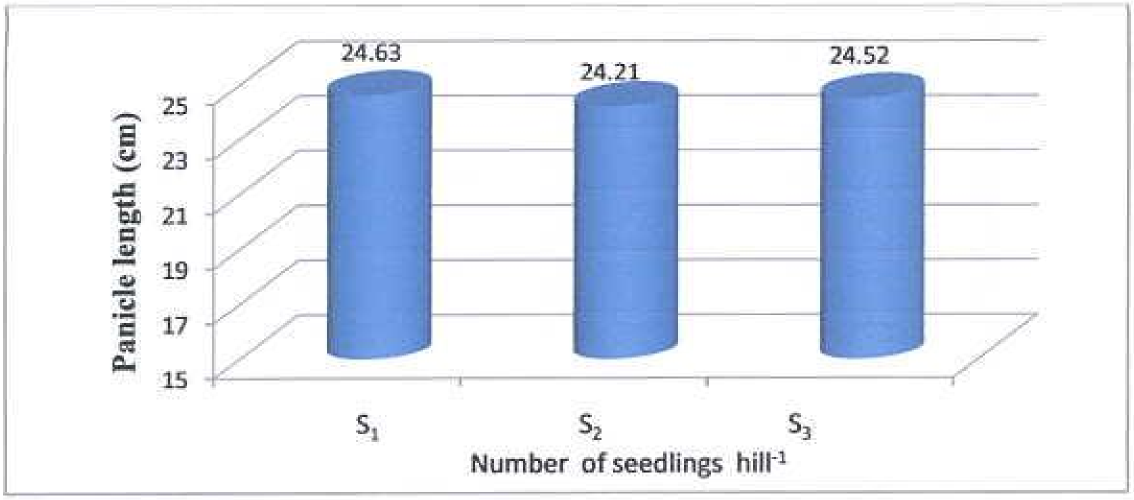
S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 12. Effect of number of seedlings hill^{-1} on number of non-effective tillers hill^{-1} under different transplanting and re-transplanting dates

The present study keep in with the study of Mangor (1984) who reported that deviation from the optimum planting time may cause incomplete vegetative stage and irregular panicle exertion. Therefore the number of ineffective tiller may increase.

4.5 Panicle length

The three different number of seedlings $hill^{-1}$ insignificantly influenced the panicle length of Binasail (Figure 13). Though the highest length of panicle (24.63 cm) was obtained from 3 seedlings $hill^{-1}$ (S_1), whereas 4 seedlings $hill^{-1}$ (S_2) produced the shortest one (24.21 cm) (Appendix 2).

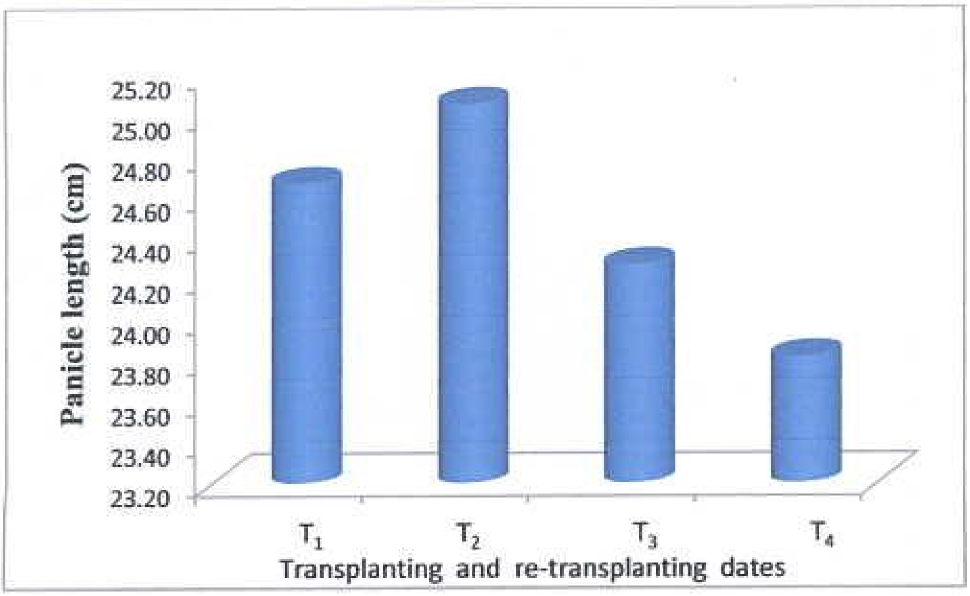


S_1= 3 seedlings $hill^{-1}$, S_2= 4 seedlings $hill^{-1}$, S_3= 5 seedlings $hill^{-1}$

Figure 13. Effect of number of seedlings $hill^{-1}$ on length of panicles (mean of one transplanting and three re-transplanting dates)

Significant influence was observed on panicle length (cm) due to the effect of transplanting and re-transplanting dates (Figure 14). The highest length of panicle (25.06 cm) was obtained from T_2 (re-transplanted on 23 September) while re-transplanted on 07 October (T_4) gave the lowest result (23.82 cm) (Appendix 3).

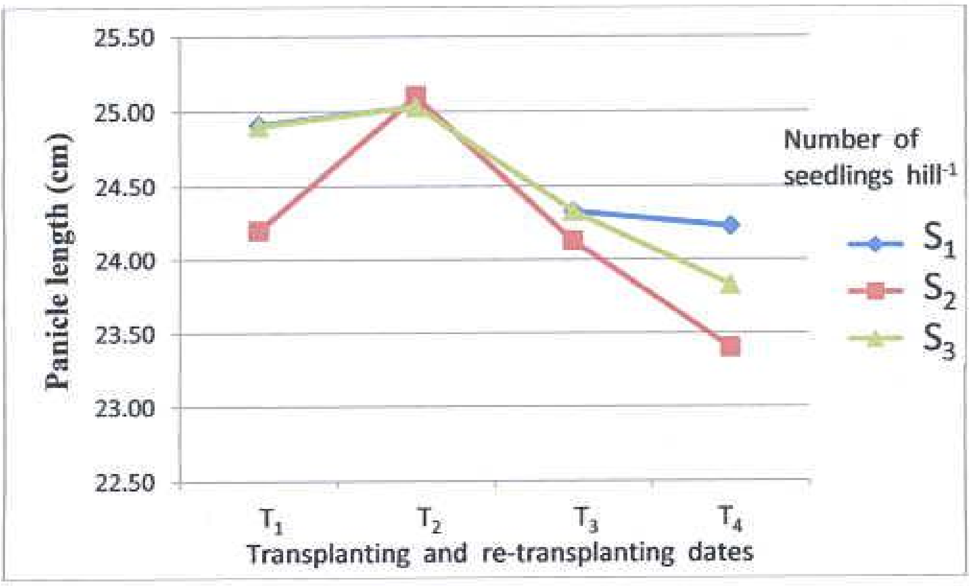
Panicle length varied significantly due to the interaction effect of three different number of seedlings $hill^{-1}$ and planting dates (Figure 15 and Appendix 4). The longest panicle (25.10 cm) was found from S_2T_2 (4 seedlings $hill^{-1}$ and re-transplanted on 23 September) and shortest (23.40 cm) was recorded in S_2T_4 (4 seedlings $hill^{-1}$ and re-transplanted on 07 October).



T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 14. Effect of transplanting and re-transplanting dates on panicle length (mean of three different number of seedlings hill^{-1})



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

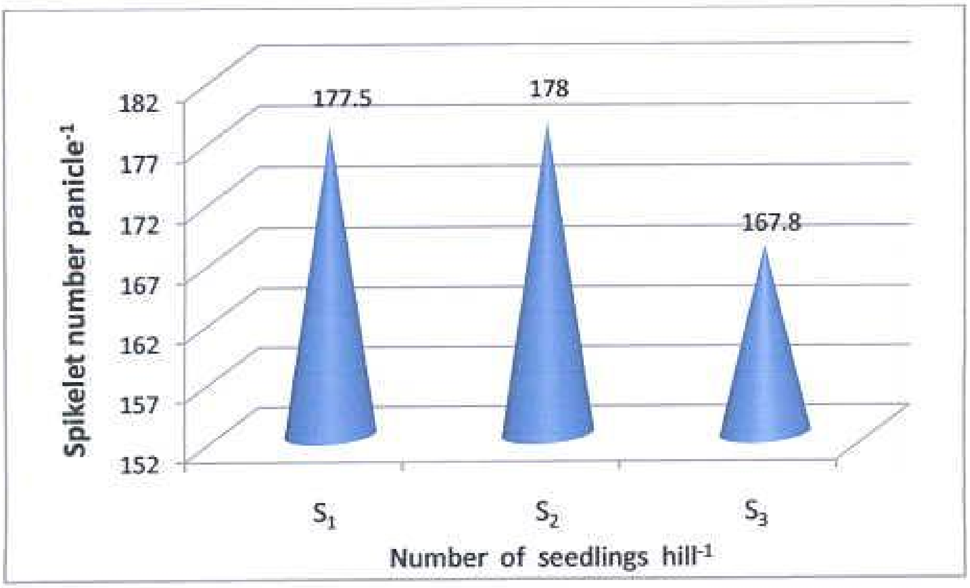
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 15. Effect of number of seedlings hill^{-1} on panicle length under different transplanting and re-transplanting dates

Gupta (1996) noticed that rice crop planted with 4 seedlings per hill recorded significantly higher length of panicle over the 2 and 6 seedlings per hill. Hasanuzzaman *et al.* (2009) in a study found that the length of panicle in late transplanted Aman rice ranged from 23.59 cm to 21.3 cm which matched with the present study.

4.6 Number of spikelet

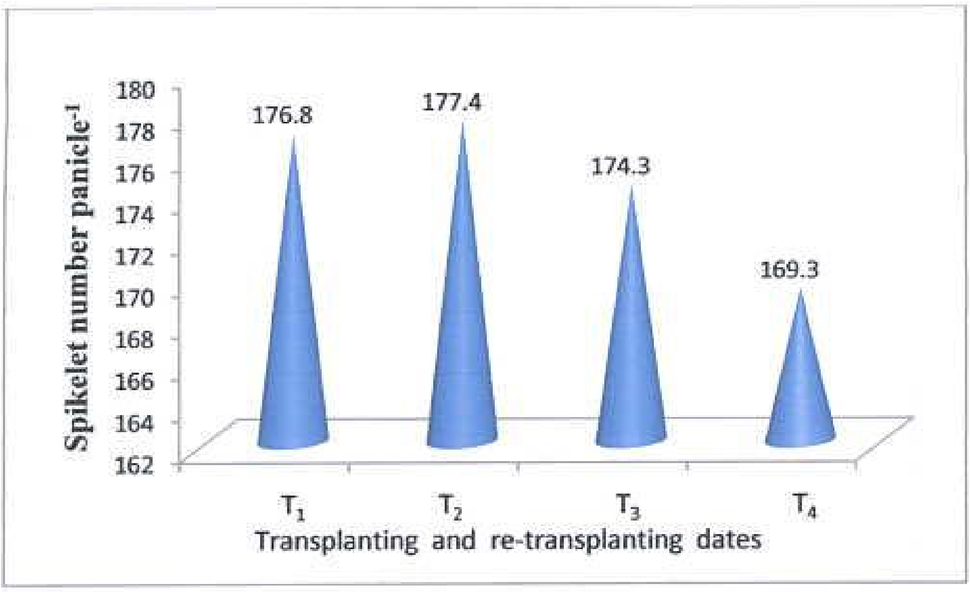
The number of spikelet panicle^{-1} of Binasail rice was not significantly affected by different number of seedlings hill^{-1} (Figure 16). But the highest number of spikelet (178.0) panicle^{-1} was recorded for 4 seedlings hill^{-1} (S_2) while 5 seedlings hill^{-1} gave the lowest spikelet (167.80) panicle^{-1} (Appendix 2).



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 16. Effect of number of seedlings hill^{-1} on number of spikelet panicle^{-1} (mean of one transplanting and three re-transplanting dates)

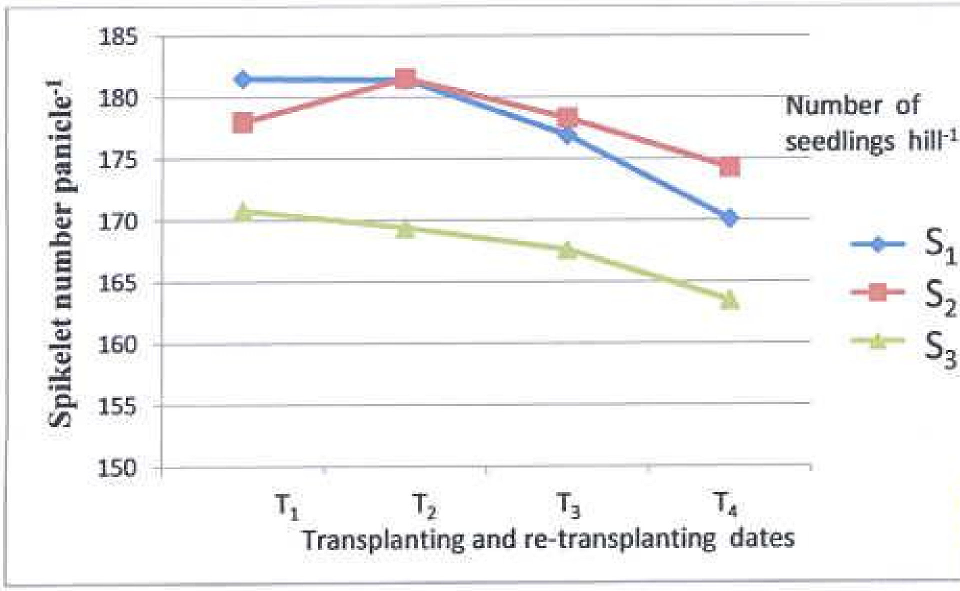
The number of spikelet panicle^{-1} differed non-significantly due to the different transplanting and re-transplanting dates (Figure 17). The highest number of spikelet (177.40) panicle^{-1} was obtained from T_2 (re-transplanted on 23 September) and the lowest (169.30) was recorded from T_4 (re-transplanted on 07 October) (Appendix 3).



T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 17. Effect of transplanting and re-transplanting dates on number of spikelet panicle^{-1} (mean of three different number of seedlings hill^{-1})

It was revealed from the results presented in Figure 18 and Appendix 4 that interaction effect of number of seedlings hill^{-1} and planting dates have no significant effect on number of spikelet panicle^{-1}. Though the highest number of spikelet panicle^{-1} (181.5) was recorded from S_1T_1 while the lowest (163.5) was recorded from S_3T_4.



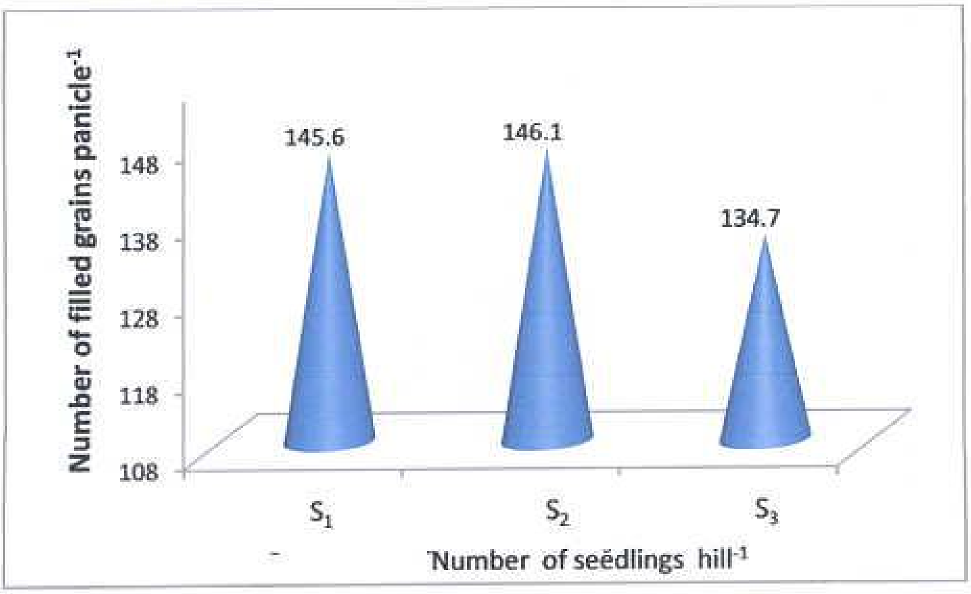
S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 18. Effect of number of seedlings hill^{-1} on number of spikelet panicle^{-1} under different transplanting and re-transplanting dates

Zhang and Hung (1990) reported from China, that there was significant decrease in number of panicles per plant, length of panicle, fertile spikelets per panicle due to increase in number of seedlings per hill from 2 to 5. Pal *et al.* (2002) found that the number of spikelet panicle^{-1} gradually decreased with the late in transplanting date.

4.7 Number of filled grain

No significant variation was recorded due to the different number of seedlings hill^{-1} for number of filled grain panicle^{-1}. The maximum number of filled grains (146.10) panicle^{-1} was recorded for 4 seedlings hill^{-1} (S_2) and lowest from 5 seedlings hill^{-1} (134.70) (Figure 19 and Appendix 2).

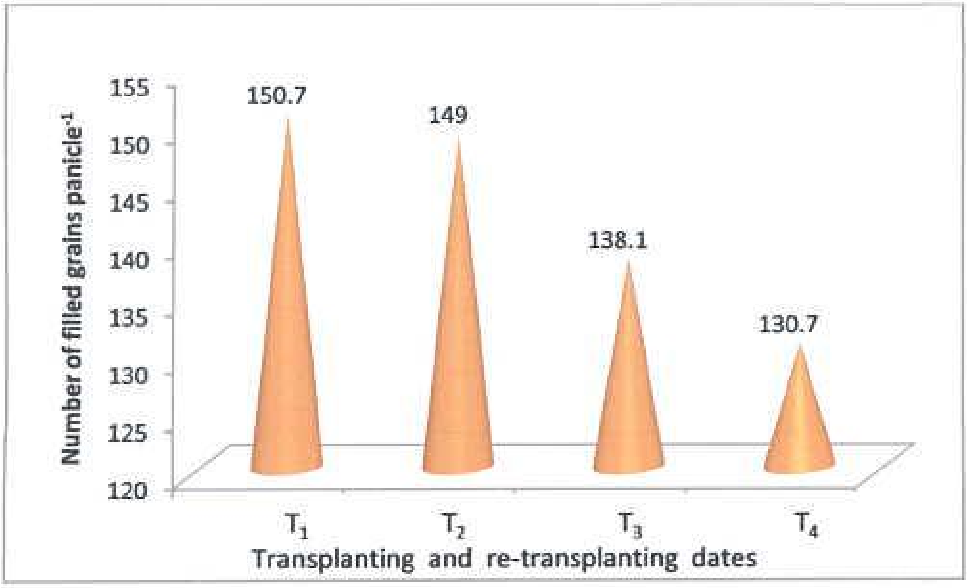


S_1- 3 seedlings hill^{-1}, S_2- 4 seedlings hill^{-1}, S_3- 5 seedlings hill^{-1}

Figure 19. Effect of number of seedlings hill^{-1} on number of filled grains panicle^{-1} (mean of one transplanting and three re-transplanting dates)

Significant influence was observed on number of filled grain panicle^{-1} due to the different transplanting and re-transplanting dates (Figure 20 and Appendix 3). The highest number of filled grain (150.7) panicle^{-1} was obtained from T_1 (transplanted on 16 September) and the lowest (130.7) was recorded from T_4 (re-transplanted on 07 October).

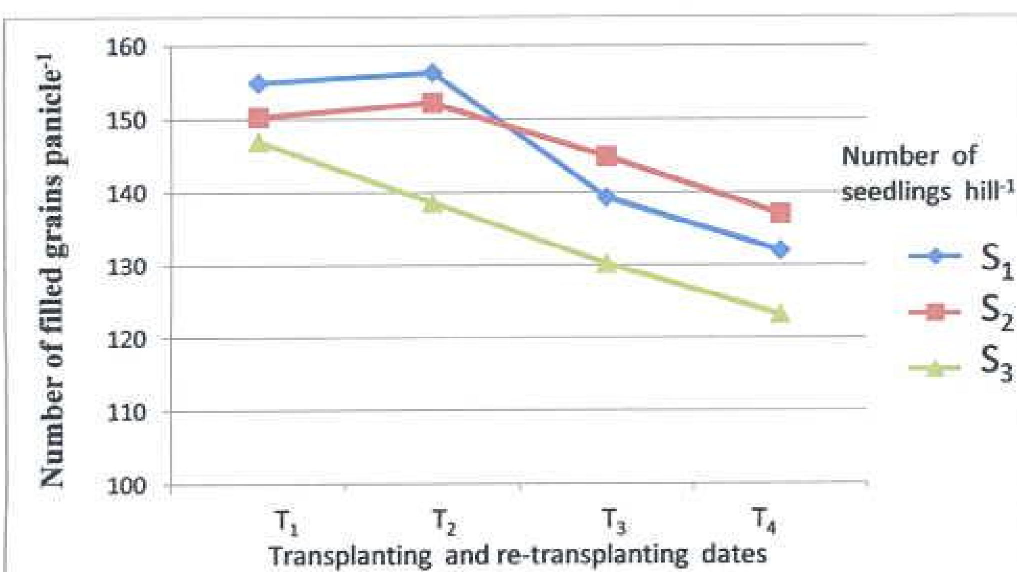
It was revealed from the results presented in Figure 21 that interaction effect of number of seedlings hill^{-1} and planting dates have significant effect on number of filled grain panicle^{-1}. The highest number of filled grain (156.3) panicle^{-1} was recorded from S_1T_2 which was statistically similar with S_1T_1 and S_2T_2 while the lowest (123.2) was recorded from S_3T_4 (Appendix 4).



T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 20. Effect of transplanting and re-transplanting dates on number of filled grain panicle^{-1} (mean of three different number of seedlings hill^{-1})



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

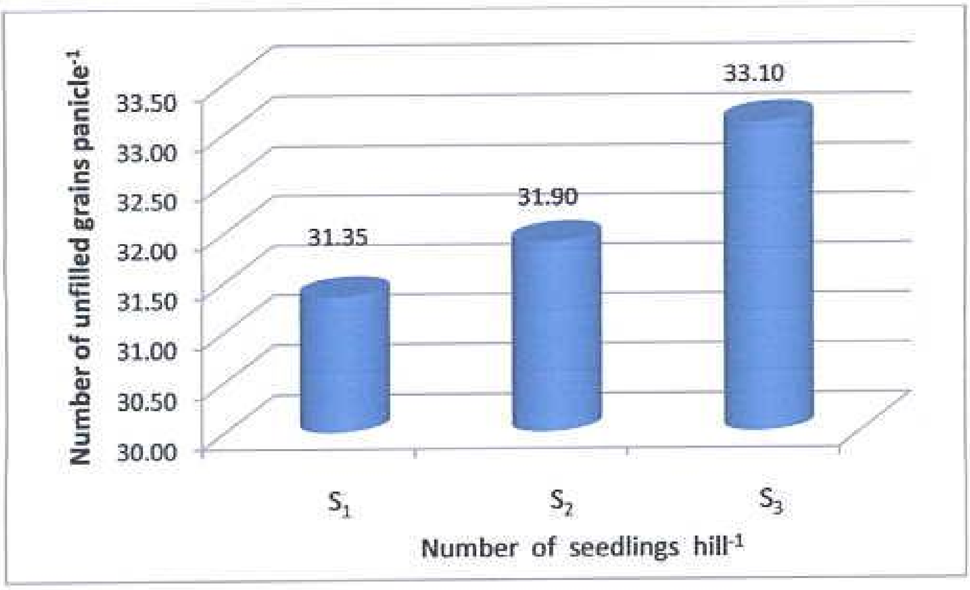
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 21. Effect of number of seedlings hill^{-1} on number of filled grain panicle^{-1} under different transplanting and re-transplanting dates

Gupta (1996) noticed that rice crop planted with 4 seedlings per hill recorded significantly higher grains per panicle over the 2 and 6 seedlings per hill. Nahar *et al.* (2009) found low temperature causes various types of injuries in rice plants, but the most important one is spikelet sterility. In their experiment they found, production of filled grains decreased with the delay of transplanting which was due to occurrence of low temperature at anthesis and spikelet primordial formation.

4.8 Number of unfilled grain

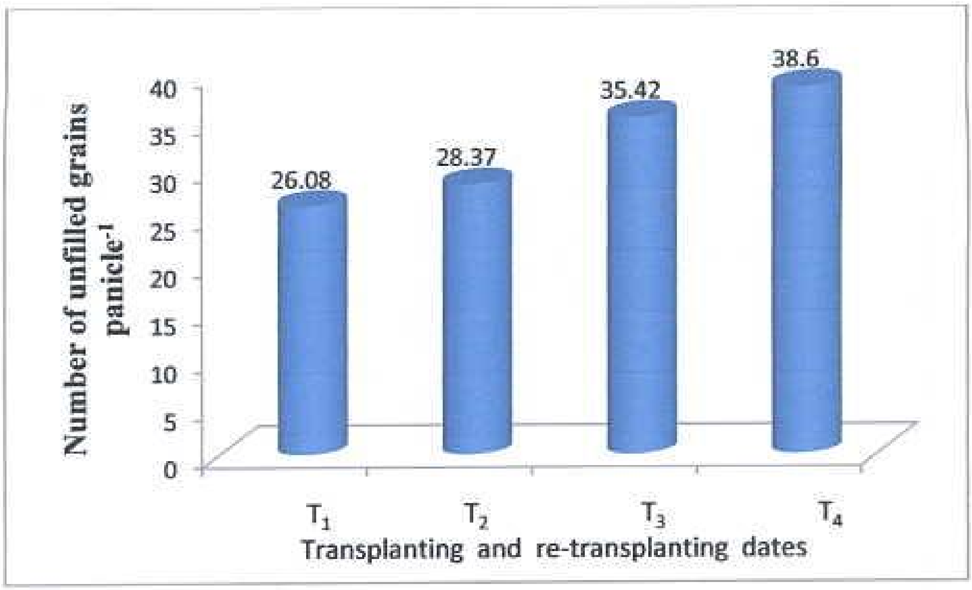
No significant difference was observed in case of number of unfilled grain panicle^{-1} among the three different number of seedlings hill^{-1} (Figure 22). But the maximum number of unfilled grains (33.10) panicle^{-1} was recorded for 5 seedlings hill^{-1} and lowest from 3 seedlings hill^{-1} (31.35) (Appendix 2).



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 22. Effect of number of seedlings hill^{-1} on unfilled grain panicle^{-1} (mean of one transplanting and three re-transplanting dates)

Transplanting and re-transplanting dates have significant influence on number of sterile or unfilled grain panicle^{-1} (Figure 23). From T_4 (re-transplanted on 07 October), the highest number of unfilled grain panicle^{-1} (38.60) was obtained whereas the lowest (26.08) was recorded from T_1 (transplanted on 16 September) (Appendix 3).

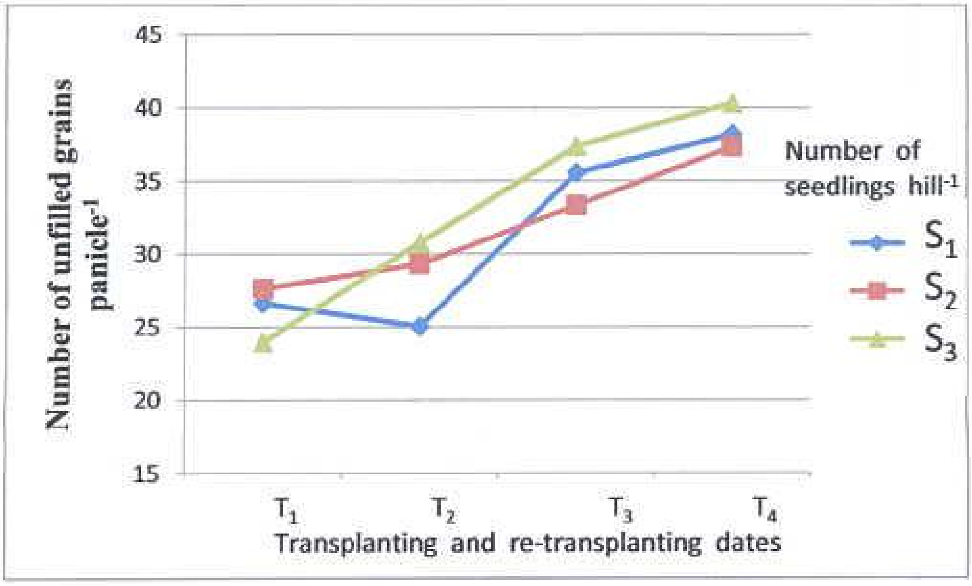


T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 23. Effect of transplanting and re-transplanting dates on number of unfilled grain panicle^{-1} (mean of three different number of seedlings hill^{-1})

Interaction of number of seedlings hill^{-1} and planting dates showed significant influence on number of unfilled grain panicle^{-1}. From S_3T_4 (5 seedlings hill^{-1} and re-transplanted on 07 October) the highest number of unfilled grain panicle^{-1} (40.30) was obtained whereas the lowest (23.97) was recorded from S_3T_1 (Figure 24 and Appendix 4).



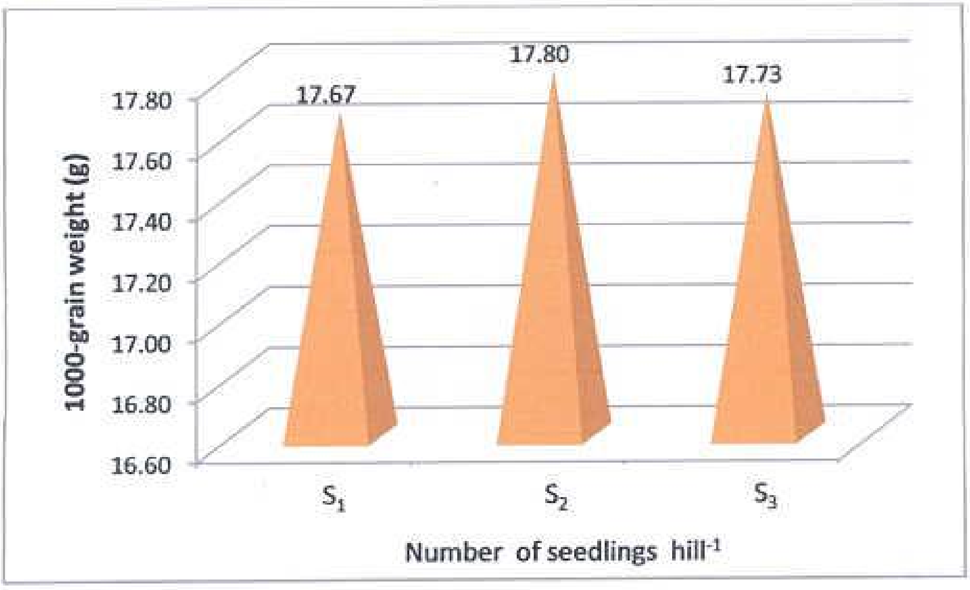
S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 24. Effect of number of seedlings hill^{-1} on number of unfilled grain panicle^{-1} under different transplanting and re-transplanting dates

Shah *et al.* (1987) observed that the number of seedlings per hill markedly influenced the number of grains per panicle. Shimizu and Kumo (1967) reported a wide range of abnormal spikelets, all of which were induced under the low temperature treatments at the young panicle primordial differentiation stage. As the temperature in Bangladesh is lower in December it induced in increased sterile grain.

4.9 1000-grain weight

1000-grain weight (g) was comparatively higher (17.80 g) in S_2 (4 seedlings hill^{-1}) than the S_3 (5 seedlings hill^{-1}) and S_1 (3 seedlings hill^{-1}) (17.73 and 17.67 g) (Figure 25 and Appendix 2). Gupta (1996) noticed that rice crop planted with 4 seedlings per hill recorded significantly higher 1000-grain weight over the 2 and 6 seedlings per hill.

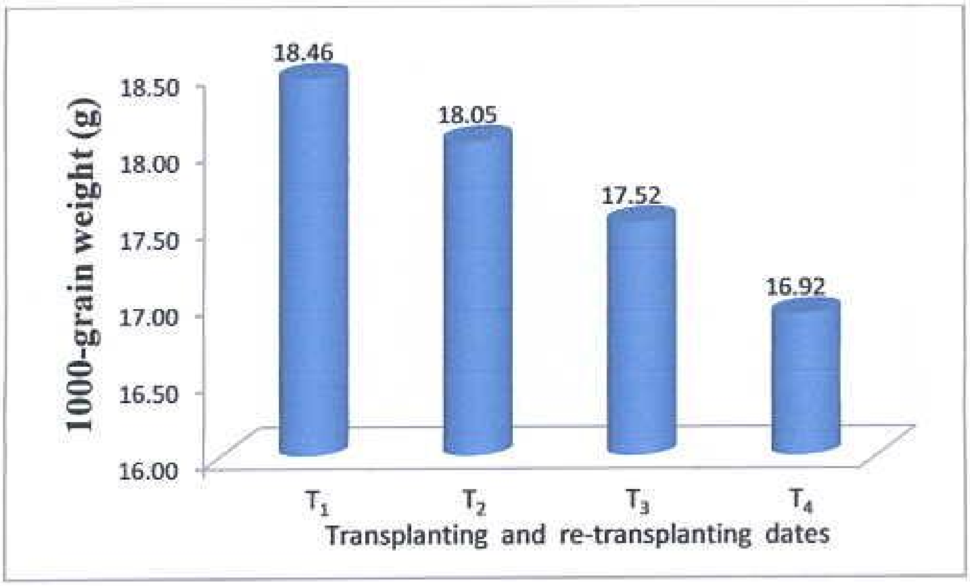


S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 25. Effect of number of seedlings hill^{-1} on 1000-grain weight (mean of one transplanting and three re-transplanting dates)

1000-grain weight of Late Aman (Binasail) rice significantly influenced by different transplanting and re-transplanting dates (Figure 26). The highest 1000-grain weight (18.46 g) was recorded from T_1 (transplanted on 16 September). On the other hand, re-transplanted on 07 October (T_4) showed the lowest result (16.92 g) (Appendix 3).

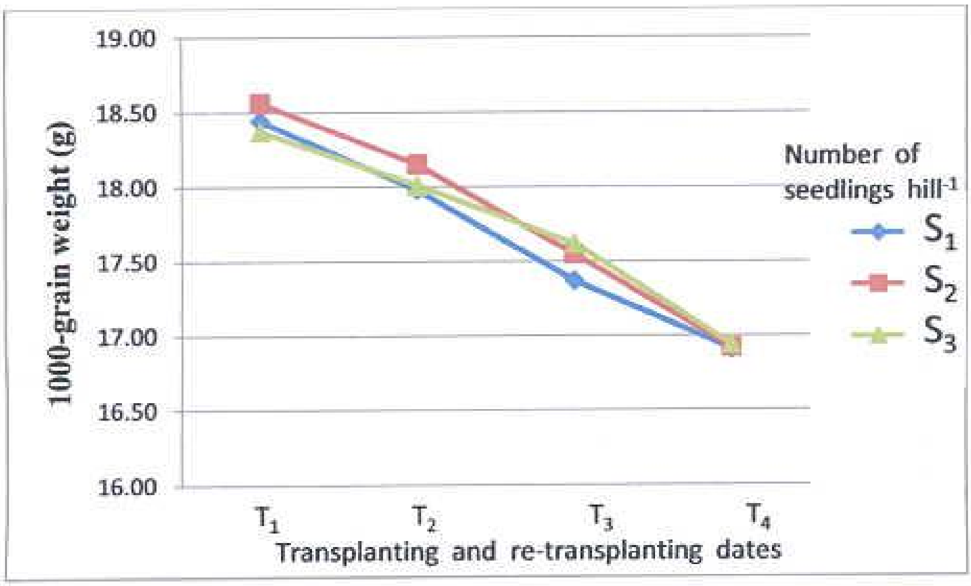
1000-grain weight of Late Aman (Binasail) rice significantly influenced by the interaction effect of number of seedlings hill^{-1} and planting dates (Figure 27). The highest 1000-grain weight (18.56 g) was recorded from S_2T_1 which was statistically similar with S_1T_1. On the other hand, S_1T_4 showed the lowest result (16.91 g) which was statistically similar with S_2T_4 and S_3T_4 (Appendix 4).



T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 26. Effect of transplanting and re-transplanting dates on 1000-grain weight (mean of three different number of seedlings hill^{-1})



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

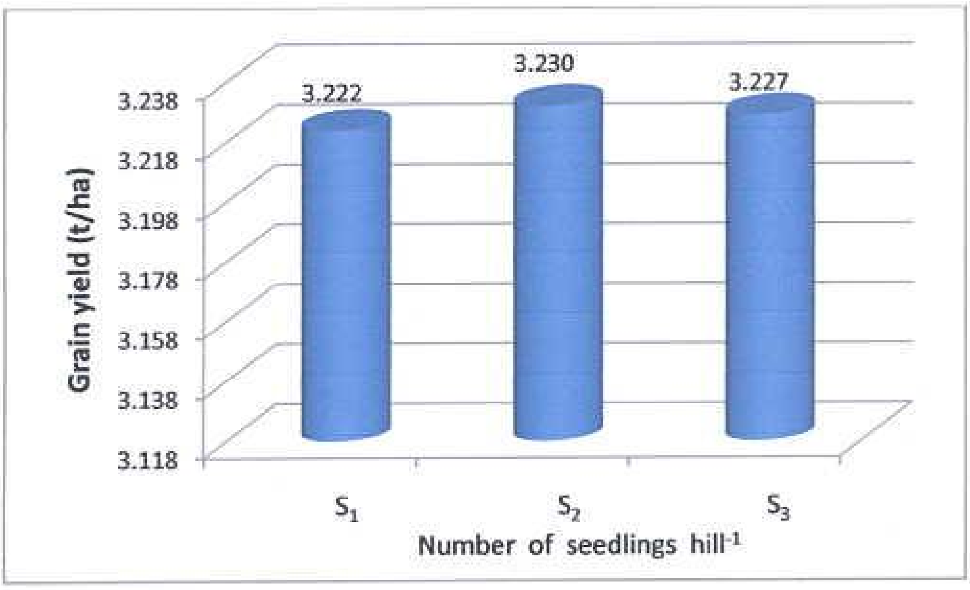
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 27. Effect of number of seedlings hill^{-1} on 1000-grain weight under different transplanting and re-transplanting dates

4.10 Grain yield

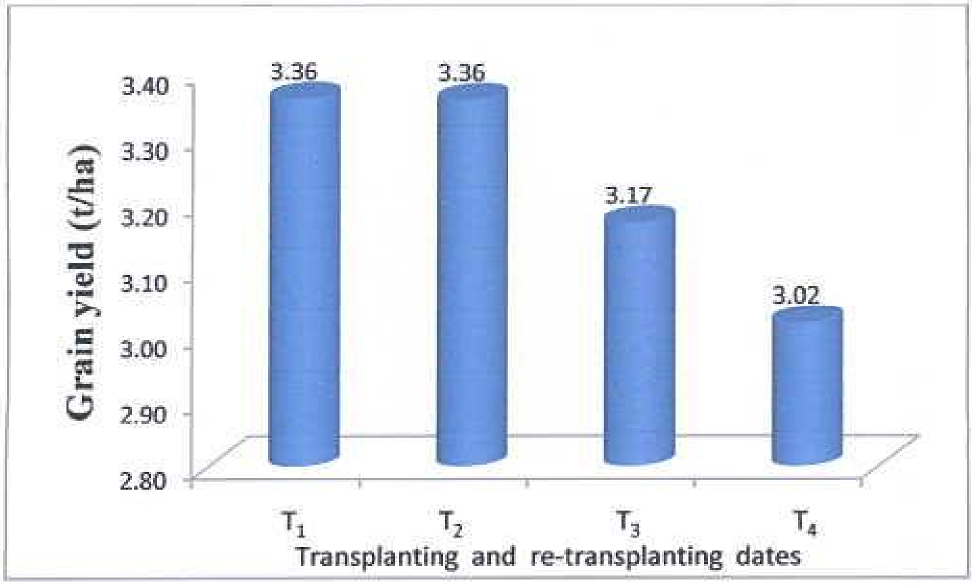
Grain yield (t/ha) of Binasail was significantly different (3.21 t/ha) in three different number of seedlings hill^{-1} due to the mean effect of different transplanting and re-transplanting dates (Figure 28 and Appendix 2). The highest grain yield (3.23 t/ha) was obtained from S_2 (4 seedlings hill^{-1}) and the lowest result (3.22 t/ha) was recorded from S_1 (3 seedlings hill^{-1}).



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 28. Effect of number of seedlings hill^{-1} on grain yield (mean of one transplanting and three re-transplanting dates)

Transplanting and re-transplanting dates have significant influence on grain yield (Figure 29). The highest grain yield (3.36 t/ha) was obtained from T_1 (transplanted on 16 September) which was statistically similar with T_2 (re-transplanted on 23 September) while the lowest result (3.02 t/ha) was recorded from T_4 (re-transplanted on 07 October) (Appendix 3).

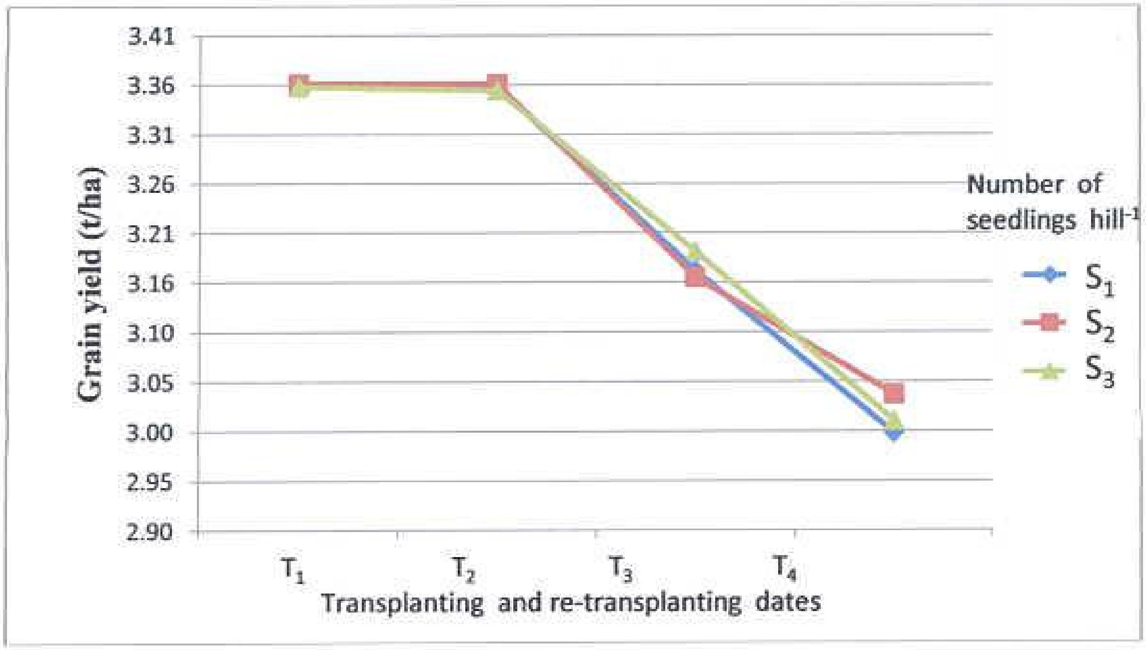


T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 29. Effect of transplanting and re-transplanting dates on grain yield (mean of three different number of seedlings hill^{-1})

From Figure 30 and Appendix 4, it is clear that interaction effect of number of seedlings hill^{-1} and planting dates have significant effect on grain yield of Late Aman (Binasail) rice. The highest grain yield (3.36 t/ha) was obtained from S_1T_1, S_2T_1 and S_2T_2 while the lowest result (3.03 t/ha) was recorded from S_1T_4.

Sawa *et al.* (1988) noticed that rice transplanted with 2 seedlings per hill produced maximum grain yield than transplanted with 1 seedling per hill. Shah *et al.* (1991) studied the effect of number of seedlings (3, 4, 5 and 6 seedlings per hill) on rice cv. 'K 39' and revealed that grain yield was highest with transplanted 5 seedlings per hill. Nahar *et al.* (2009) found that grain yield decreased significantly with the delay of transplanting date. BRRI (1989) also reported similar results.



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

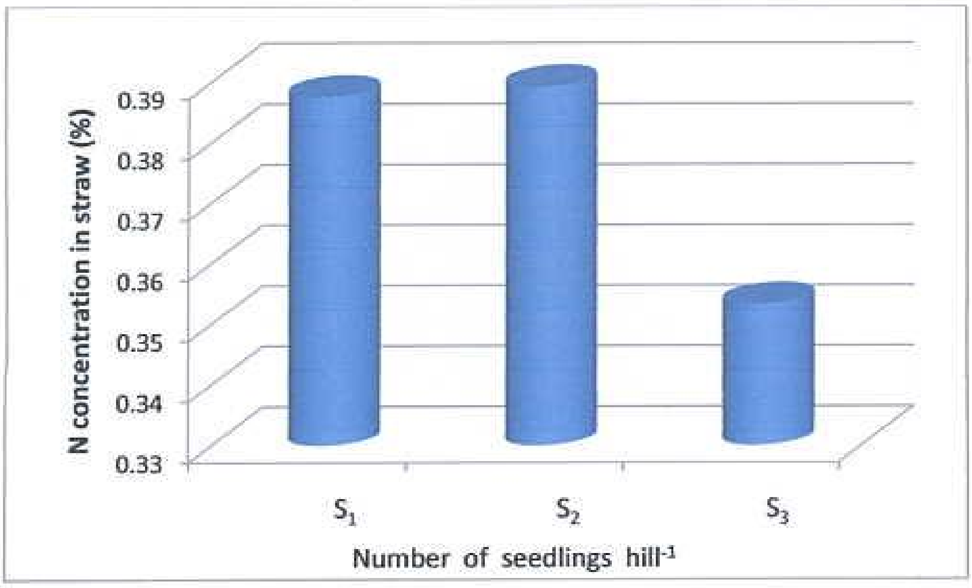
Figure 30. Effect of number of seedlings hill^{-1} on grain yield under different transplanting and re-transplanting dates

4.11 Chemical Composition

4.11.1 N content in straw

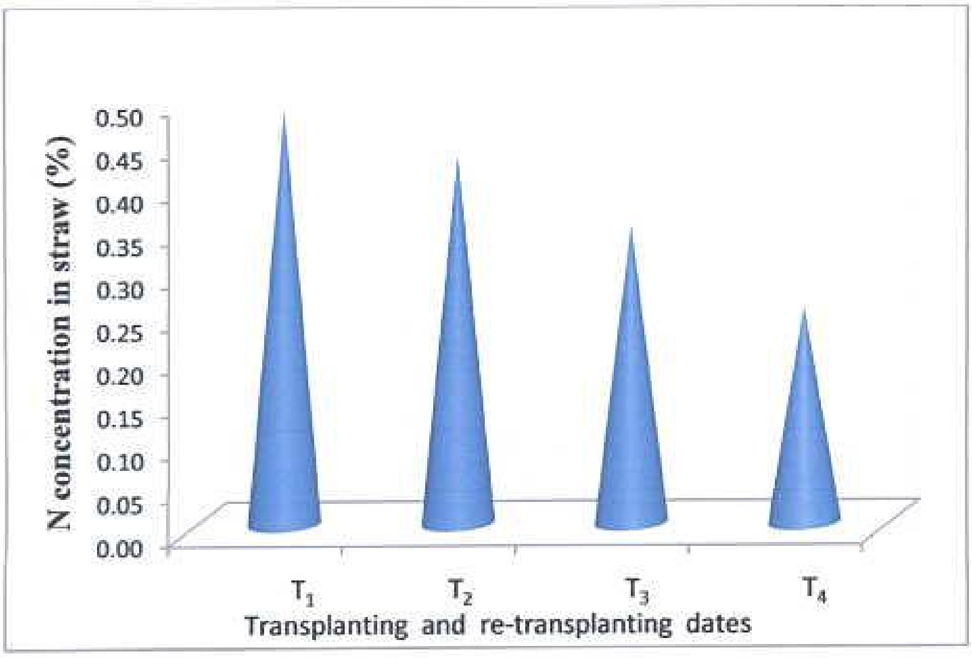
N content in straw showed statistically non-significant difference due to the difference in number of seedlings hill^{-1} (Figure 31). The highest N content (0.3892 %) was observed in straw from 4 seedlings hill^{-1} (S_2) and the lowest amount of N (0.3533 %) found in straw for S_3 *(5 seedlings hill^{-1})* (Appendix 5).

It was observed from the results presented in Figure 32 and Appendix 6 that, transplanting and re-transplanting dates have significant influence on N content in straw. The highest N content (0.48 %) in straw was observed from T_1 (transplanted on 16 September) while re-transplanted on 07 October gave the lowest result (0.2511 %).



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 31. Effect of number of seedlings *hill*$^{-1}$ on N content in *straw* (mean of one transplanting and three re-transplanting dates)

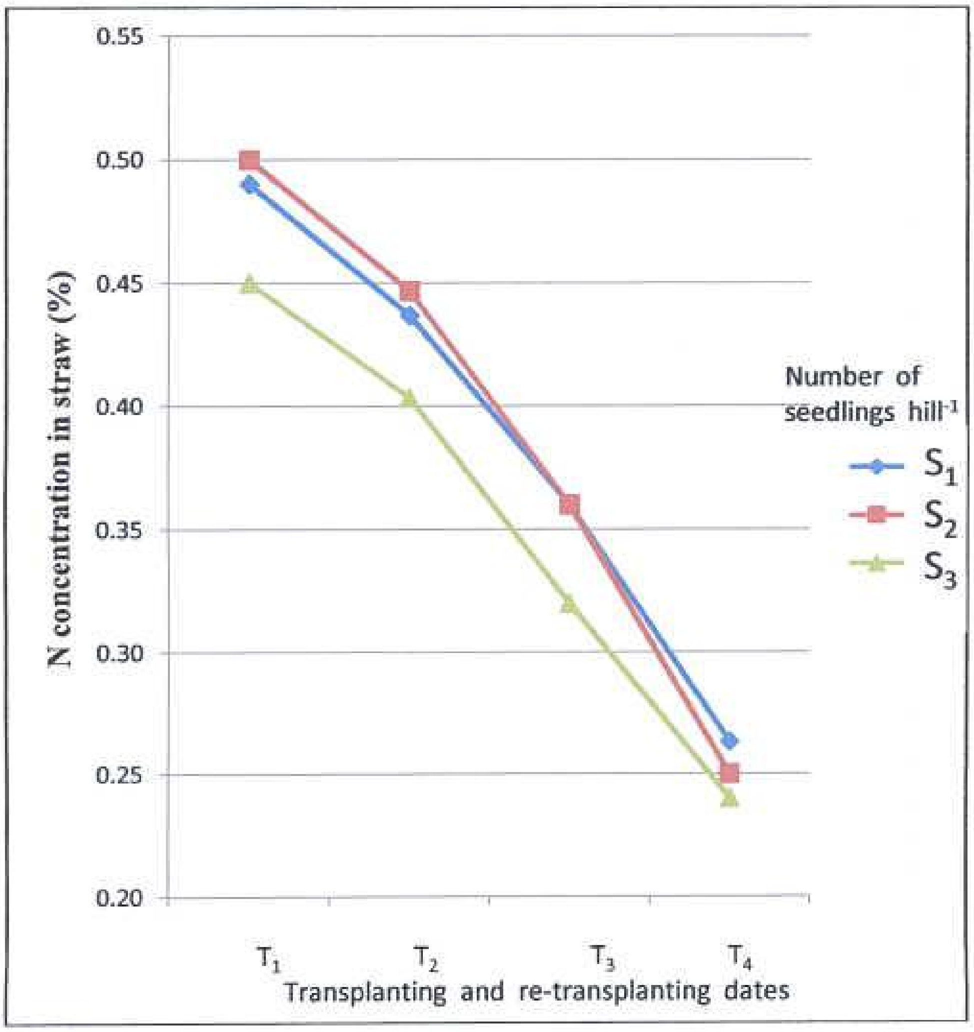


T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 32. Effect of transplanting and re-transplanting dates on N content in straw (mean of three different number of seedlings hill^{-1})

N content in straw varied significantly due to the interaction effect of urea application methods and planting dates (Figure 33). The highest N content in straw (0.50 %) was observed from S_2T_1 while the lowest result (0.24 %) was recorded from S_3T_4 (Appendix 7).

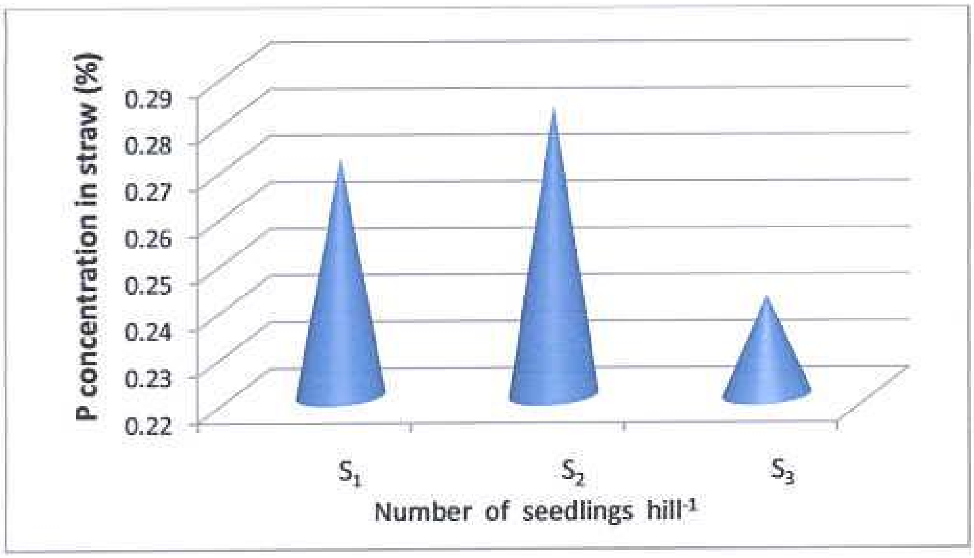


S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 33. Effect of number of seedlings hill^{-1} on N content in straw under different transplanting and re-transplanting dates

4.11.2 P content in straw

A significant variation was observed due to the difference in number of seedlings hill^{-1} for P content in straw (Figure 34). In straw, the highest P content (0.2822 %) was observed from S_2 (4 seedlings hill^{-1}) while for 5 seedlings hill^{-1} (S_3), the value was 0.2413 % (Appendix 5).

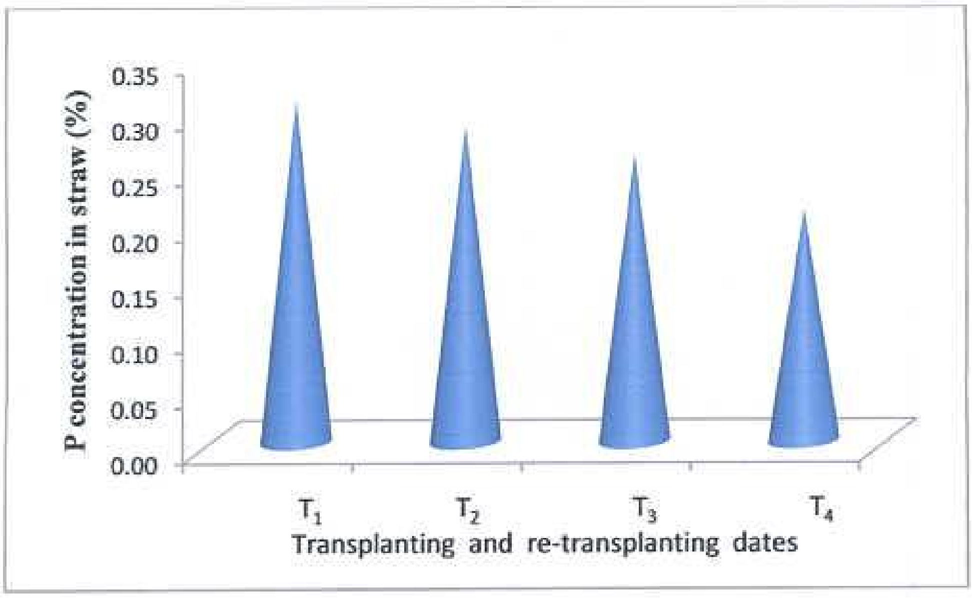


S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

Figure 34. Effect of number of seedlings hill^{-1} on P content in straw (mean of one transplanting and three re-transplanting dates)

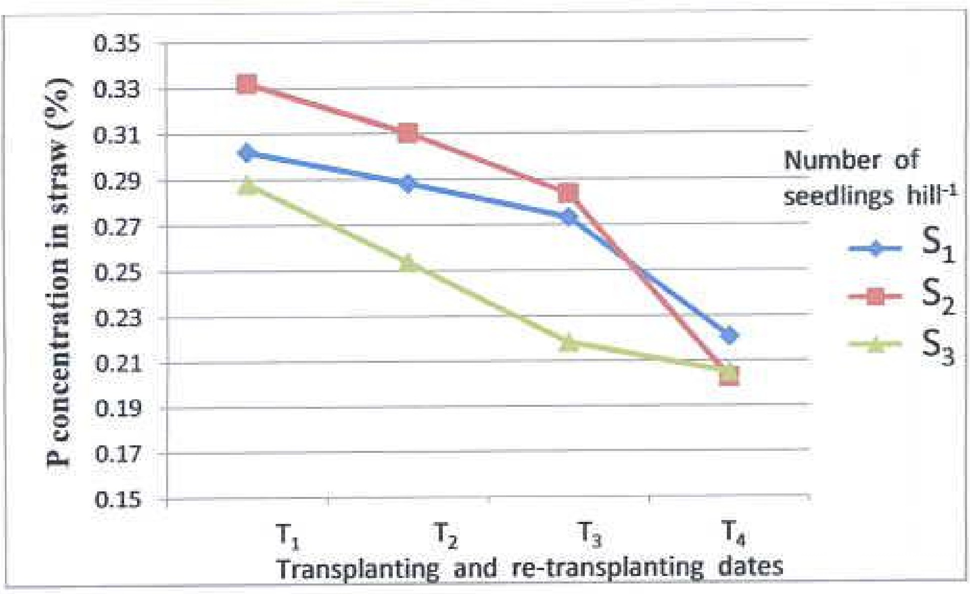
P content in straw varied significantly due to the effect of different transplanting and re-transplanting dates (Figure 35). P content in straw was recorded maximum (0.3074 %) in T_1 (transplanted on 16 September) while minimum (0.2094 %) at T_4 (re-transplanted on 07 October) (Appendix 6).

From Figure 36, it is clear that interaction effect of urea application methods and planting dates have significant effect on P content in straw. The highest P content (0.3320 %) was observed in straw from S_2T_1 while the S_2T_4 gave the lowest result (0.2027 %) (Appendix 7).



T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 35. Effect of transplanting and re-transplanting dates on P content in straw (mean of three different number of seedlings hill^{-1})

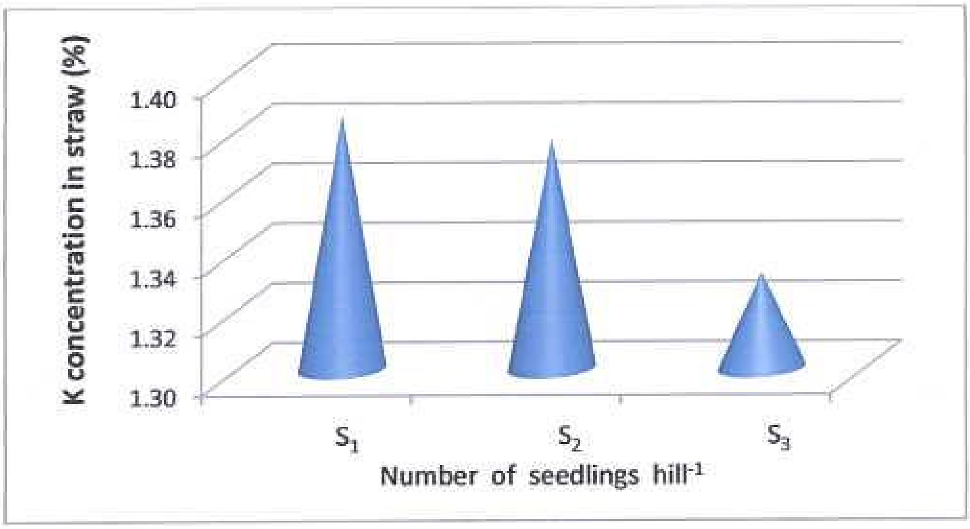


S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 36. Effect of number of seedlings hill^{-1} on P content in straw under different transplanting and re-transplanting dates

4.11.3 K content in straw

Potassium content (%) in straw of Binasail significantly differed by the different number of seedlings $hill^{-1}$ (Figure 37). The highest K content (1.385 %) in straw was observed from S_1 (3 seedlings $hill^{-1}$) while for S_3 (5 seedlings $hill^{-1}$), the K content was 1.332 % (Appendix 5).

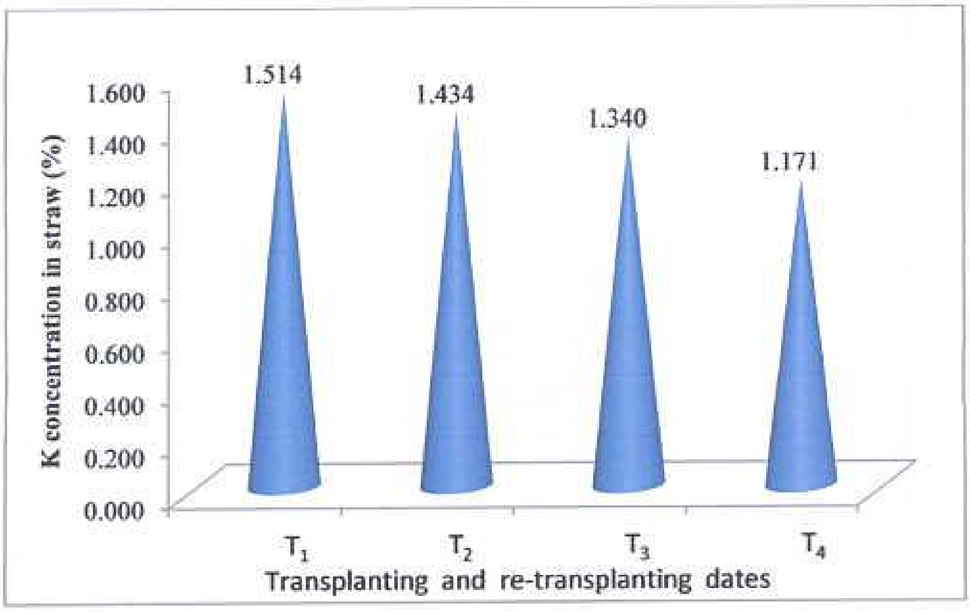


S_1= 3 seedlings $hill^{-1}$, S_2= 4 seedlings $hill^{-1}$, S_3= 5 seedlings $hill^{-1}$

Figure 37. Effect of number of seedlings $hill^{-1}$ on K content in straw (mean of one transplanting and three re-transplanting dates)

K content in straw also showed a statistically significant difference due to the different transplanting and re-transplanting dates (Figure 38). The highest K content (1.514 %) in straw was observed from T_1 (transplanted on 16 September) while re-transplanted on 07 October (T_4) gave lowest result (1.171 %) (Appendix 6).

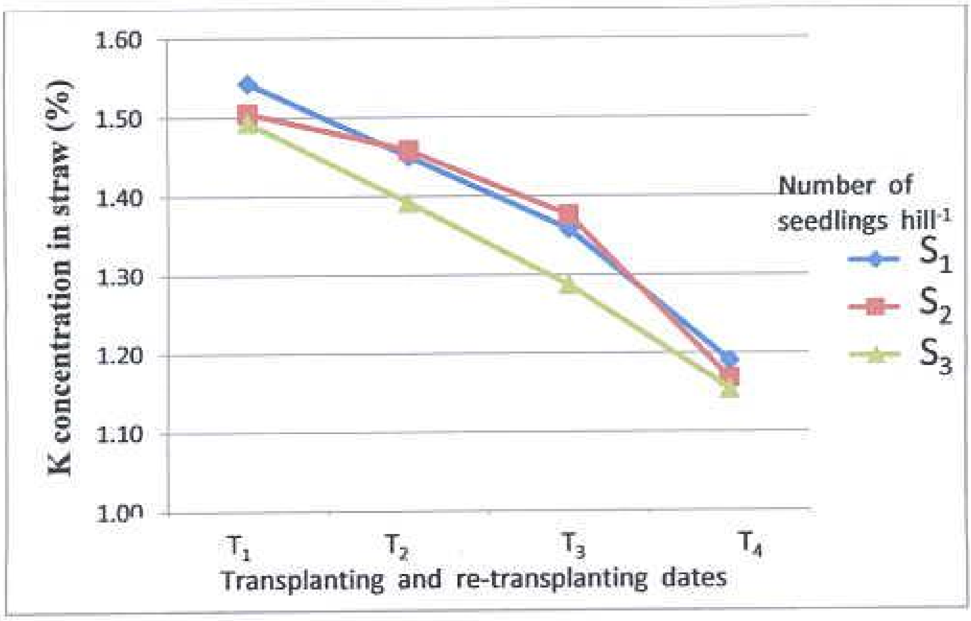
K content in straw varied significantly due to the interaction effect of number of seedlings $hill^{-1}$ and planting dates (Figure 39). The highest K content (1.543 %) in straw was observed from S_1T_1 while the S_3T_4 (5 seedlings $hill^{-1}$ and re-transplanted on 07 October) gave lowest content (1.154 %) of K in straw which was statistically similar with S_2T_4 and S_1T_4 (Appendix 7).



T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 38. Effect of transplanting and re-transplanting dates on K content in straw (mean of three different number of seedlings hill^{-1})



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3= 5 seedlings hill^{-1}

T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

Figure 39. Effect of number of seedlings hill^{-1} on K content in straw under different transplanting and re-transplanting dates

Chapter 5
Summary and Conclusions

CHAPTER 5

SUMMARY AND CONCLUSIONS

The present work was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from August to December, 2011 to find out the effects of different number of seedlings hill^{-1} on the growth, yield and N,P,K nutrients content of transplanted and re-transplanted Aman rice (Binasail). The experiment consisted of three different number of seedlings hill^{-1} (S_1- 3 seedlings hill^{-1}, S_2- 4 seedlings hill^{-1}, S_3- 5 seedlings hill^{-1}) and 4 transplanting and re-transplanting dates (T_1 = Transplanting on 16 September, T_2 = Re-transplanting on 23 September, T_3 = Re-transplanting on 30 September and T_4 = Re-transplanting on 07 October). The two factorial experiment was laid out in a RCBD design with three replications.

Different number of seedlings hill^{-1} showed statistically non-significant variation in case of growth parameters of transplanted and re-transplanted Aman rice (Binasail). But the tallest plant (110.17 cm) was obtained from 4 seedlings hill^{-1} while 3 seedlings hill^{-1} gave the shortest. The highest number of total tillers hill^{-1}, effective tillers hill^{-1}, non-effective tillers hill^{-1}, spikelet panicle^{-1} and filled grains panicle^{-1} was found from 4 seedlings hill^{-1}. Maximum number of unfilled grains panicle^{-1} was recorded in 5 seedlings hill^{-1} and the longest panicle was given by 3 seedlings hill^{-1}. 1000-grain weight was comparatively higher in 4 seedlings hill^{-1} than the 4 seedlings hill^{-1} and 3 seedlings hill^{-1} though there was no statistically significant differences. Grain yield of Binasail statistically differed for the three different number of seedlings $hill^{-1}$ due to the mean effect of different transplanting and re-transplanting dates. 4 seedlings $hill^{-1}$ gave the highest grain yield followed by 5 seedlings $hill^{-1}$. The highest N and P content in straw were observed from 4 seedlings $hill^{-1}$. On the other hand, the highest K content in straw was observed from 3 seedlings $hill^{-1}$.

Growth, yield and N, P, K nutrients content of transplanted and re-transplanted Aman rice (Binasail) varied significantly in most of the cases due to the effect of different planting dates. Plant height was highest in plots transplanted on 16 September which was statistically similar with re-transplanted on 23 September. Number of total tillers $hill^{-1}$, effective tillers $hill^{-1}$ and spikelet $panicle^{-1}$ and the panicle length were found highest in plots re-transplanted on 23 September. Filled grains $panicle^{-1}$ was highest in plots transplanted on 16 September which was statistically similar with plots re-transplanted on 23 September. The highest number of non-effective tillers $hill^{-1}$ and unfilled grains $panicle^{-1}$ were recorded in the last date of re-transplanting (re-transplanted on 07 October) while the lowest values were found in plots transplanted on 16 September. The highest 1000-grain weight and grain yield was recorded from plots transplanted on 16 September while on the other hand; re-transplanted on 07 October showed the lowest result. For N, P and K contents in straw, the highest results were recorded in plots transplanted on 16 September followed by re-transplanted on 23 September while re-transplanted on 07 October gave the lowest.

Plant height, number of effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, filled grains panicle^{-1} and unfilled grains panicle^{-1} and the panicle length differed significantly due to the interaction of number of seedlings hill^{-1} and planting dates of Late Aman cultivar Binasail. The tallest plant was obtained from 5 seedlings hill^{-1} and transplanted on 16 September which was statistically similar with 4 seedlings hill^{-1} and transplanted on 16 September, 3 seedlings hill^{-1} and transplanted on 16 September, 4 seedlings hill^{-1} and re-transplanted on 23 September, 5 seedlings hill^{-1} and re-transplanted on 23 September and 3 seedlings hill^{-1} and re-transplanted on 23 September. On the other hand, 3 seedlings hill^{-1} and re-transplanted on 07 October produced the shortest one. The highest number of effective tillers hill^{-1} was found from 4 seedlings hill^{-1} and re-transplanted on 23 September which was statistically similar with 3 seedlings hill^{-1} and re-transplanted on 23 September. On the other hand, 3 seedlings hill^{-1} and re-transplanted on 07 October gave lowest number of effective tillers per hill^{-1} which was statistically similar with 4 seedlings hill^{-1} and re-transplanted on 07 October. The highest number of non-effective tillers hill^{-1} was found from 5 seedlings hill^{-1} and re-transplanted on 07 October which was statistically similar with 4 seedlings hill^{-1} and re-transplanted on 07 October. The longest panicle was found from 4 seedlings hill^{-1} and re-transplanted on 23 September and shortest was recorded in 4 seedlings hill^{-1} and re-transplanted on 07 October. The highest number of spikelet panicle^{-1} was recorded from 3 seedlings hill^{-1} and transplanted on 16 September while the lowest was recorded from 5 seedlings hill^{-1} and re-transplanted on 07 October. The highest number of filled grain panicle^{-1} was recorded from 3 seedlings hill^{-1} and re-transplanted on 23 September which was statistically similar with 3 seedlings hill^{-1} and transplanted on 16 September and 4 seedlings hill^{-1} and re-transplanted on 23 September while the lowest was recorded from 5 seedlings hill^{-1} and re-transplanted on 07 October. Un-filled grain panicle^{-1} was highest in 5 seedlings hill^{-1} and re-transplanted on 07 October while the lowest was recorded from 5 seedlings hill^{-1} and transplanted on 16 September. The highest 1000-grain weight was recorded from 4 seedlings hill^{-1} and transplanted on 16 September which was statistically similar with 3 seedlings hill^{-1} and transplanted on 16 September. On the other hand, 3 seedlings hill^{-1} and re-transplanted on 07 October showed the lowest result which was statistically similar with 4 seedlings hill^{-1} and re-transplanted on 07 October and 5 seedlings hill^{-1} and re-transplanted on 07 October. The highest grain yield was obtained from 3 seedlings hill^{-1} and transplanted on 16 September, 4 seedlings hill^{-1} and transplanted on 16 September and 4 seedlings hill^{-1} and re-transplanted on 23 September while the lowest result was recorded from 3 seedlings hill^{-1} and re-transplanted on 07 October. It was also observed that grain yield of 3 seedlings hill^{-1} re-transplanted on 07 October gave almost 90 % of the grain yield of 3 seedlings hill^{-1} of normal transplant. N, P and K content in straw decreased with later dates of transplantation in case of all three different numbers of seedlings hill^{-1} treatments. The highest N and P content in straw were observed from , 4 seedlings hill^{-1} and transplanted on 16 September while the lowest results were recorded from 5 seedlings hill^{-1} and re-transplanted on 07 October and 4 seedlings hill^{-1} and re-transplanted on 07 October respectively. The highest K content in straw was observed from 3 seedlings hill^{-1} and transplanted on 16 September while the 5 seedlings hill^{-1} and re-transplanted on 07 October gave lowest content of K in straw.

It appeared from the above results that different number of seedlings $hill^{-1}$ and transplanting and re-transplanting dates have significant effect on growth, yield and nutrient (N, P, K) contents of T. Aman rice Binasail. 4 seedlings $hill^{-1}$ was more efficient compare to 3 and 5 seedlings $hill^{-1}$ except vegetative growth. With delay in transplanting the yield of Binasail reduced but still it was possible to get some sort of economic return by escaping the late flood.

The following recommendations may be made based on the results-

- 4 seedlings $hill^{-1}$ may be used instead of more or less seedlings to ensure proper and adequate nutrient supply for rice plants.
- In flood prone areas, it may be possible to get some yield by late re-transplanting of Binasail. If seedlings are re-transplanted after 21 days of normal transplanting, farmers may get about 90 % of the normal yield.

Chapter 6
References

CHAPTER 6

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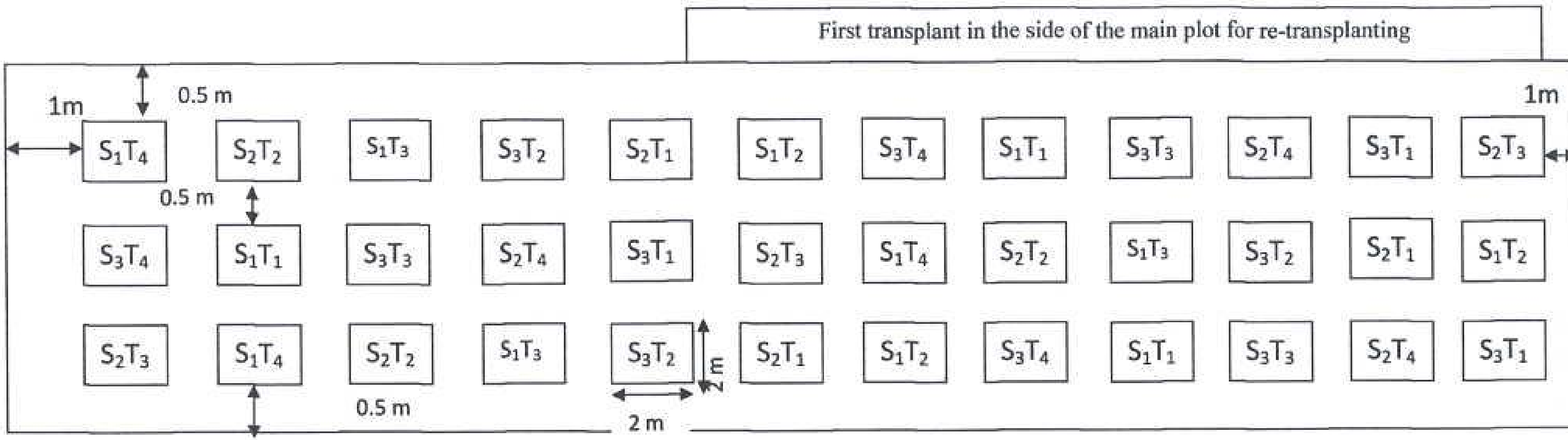
Chapter 7
Appendices

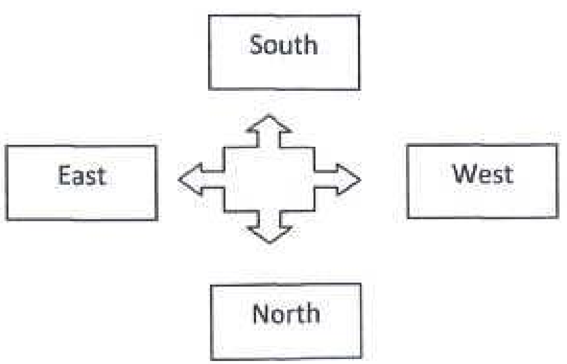
CHAPTER 7

APPENDICES

Appendix 1. Layout of the experimental field



S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3=5 seedlings hill^{-1}
T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September
T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October



Appendix 2. Effect of different number of seedlings hill^{-1} on various growth and yield parameters of Aman rice cv. Binasail (mean of 4 transplantation treatments)

Different seedling number treatments	Plant height	Number of total tillers hill^{-1}	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Panicle length	Spikelet number panicle^{-1}	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	1000-grain weight	Grain Yield (t/ha)
S_1	111.4	14.12	11.50	2.733	24.63	177.5	145.6	31.35	17.67	3.222 c
S_2	112.2	14.94	11.74	3.10	24.21	178.0	146.1	31.90	17.80	3.230 a
S_3	112.2	14.87	11.69	2.992	24.52	167.8	134.7	33.10	17.73	3.227 b
$LSD_{0.05}$	**3.611**	**1.632**	**1.542**	**0.6648**	**2.281**	**37.36**	**29.35**	**18.60**	**0.1562**	**0.001133**
Significant level	NS	NS	NS	NS	NS	NS	NS	NS	NS	**
CV %	2.17	6.58	8.03	23.25	4.14	4.11	3.52	8.17	1.31	0.67

S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3=5 seedlings hill^{-1}

** - Significant at 1 % level

NS- Non-significant

Appendix 3. Effect of different transplanting and re-transplanting dates on various growth and yield parameters of Aman rice cv. Binasail (mean of 3 different number of seedlings hill^{-1})

Transplanta-tion treatments	Plant height	Number of total tillers hill^{-1}	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Panicle length (cm)	Spikelet number panicle^{-1}	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	1000-grain weight (g)	Grain Yield (t/ha)
T_1	117.4 a	14.38	11.82 b	2.333 b	24.67 a	176.8	150.7 a	26.08 c	18.46 a	3.359 a
T_2	115.6 a	15.40	12.68 a	2.722 ab	25.06 a	177.4	149.0 a	28.37 bc	18.05 b	3.357 b
T_3	108.8 b	14.58	11.51 b	3.178 ab	24.27 ab	174.3	138.1 ab	35.42 ab	17.52 c	3.171 c
T_4	105.8 c	14.22	10.56 c	3.533 a	23.82 b	169.3	130.7 b	38.60 a	16.92 d	3.019 d
$LSD_{0.05}$	**2.059**	**1.244**	**0.8520**	**0.7278**	**0.7935**	**18.41**	**14.15**	**7.763**	**0.1502**	**0.00099**
Significant level	**	**NS**	**	**	**	**NS**	**	**	**	**
CV %	**2.17**	**6.58**	**8.03**	**23.25**	**4.14**	**4.11**	**3.52**	**8.17**	**1.31**	**0.67**

T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

** - Significant at 1% level, NS : Non-significant

Appendix 4. Effect of different number of seedlings $hill^{-1}$ on growth and yield parameters of Aman rice cv. Binasail due to different transplanting and re-transplanting dates

Different seedling number treatments	Transplantation treatment	Plant height	Number of total tillers $hill^{-1}$	Number of effective tillers $hill^{-1}$	Number of non-effective tillers $hill^{-1}$	Panicle length (cm)	Spikelet number $panicle^{-1}$	Number of filled grains $panicle^{-1}$	Number of unfilled grains $panicle^{-1}$	1000-grain weight (g)	Grain Yield (t/ha)
S_1	T_1	116.6 a	13.47	11.40 abc	2.067 b	24.91 ab	181.5	154.9 a	26.63 ab	18.44 a	3.360 a
	T_2	114.5 a	15.27	12.60 a	2.667 ab	25.03 a	181.4	156.3 a	25.03 ab	17.98 c	3.357 b
	T_3	109.3 b	14.07	11.60 abc	2.800 ab	24.33 ab	176.9	139.3 ab	35.57 ab	17.37 d	3.167 e
	T_4	105.2 c	13.67	10.38 c	3.400 ab	24.23 ab	170.1	132.0 ab	38.17 ab	16.91 e	3.00 i
S_2	T_1	117.7 a	14.83	12.33 ab	2.500 ab	24.20 ab	178.0	150.3 ab	27.63 ab	18.56 a	3.360 a
	T_2	116.5 a	15.83	12.93 a	2.900 ab	25.10 a	181.5	152.2 a	29.30 ab	18.15 bc	3.360 a
	T_3	108.5 bc	14.70	11.27 abc	3.433 ab	24.13 ab	178.3	144.9 ab	33.33 ab	17.55 d	3.160 f
	T_4	106.0 bc	14.40	10.42 c	3.567 a	23.40 b	174.3	137.0 ab	37.33 ab	16.92 e	3.040 g
S_3	T_1	117.8 a	14.83	11.73 abc	2.433 ab	24.90 ab	170.8	146.9 ab	23.97 b	18.37 ab	3.357 b
	T_2	115.9 a	15.10	12.50 ab	2.600 ab	25.03 a	169.4	138.6 ab	30.77 ab	18.01 c	3.353 c
	T_3	108.6 bc	14.97	11.67 abc	3.300 ab	24.33 ab	167.6	130.2 ab	37.37 ab	17.62 d	3.187 d
	T_4	106.3 bc	14.58	10.87 bc	3.633 a	23.83 ab	163.5	123.2 b	40.30 a	16.94 e	3.013 h
$LSD_{0.05}$		**3.567**	**2.156**	**1.476**	**1.261**	**1.374**	**31.89**	**24.52**	**13.45**	**0.2602**	**0.001715**
Significant level		**	NS	**	**	**	NS	**	**	**	**
CV %		**2.17**	**6.58**	**8.03**	**23.25**	**4.14**	**4.11**	**3.52**	**8.17**	**1.31**	**0.67**

S_1= 3 seedlings $hill^{-1}$, S_2= 4 seedlings $hill^{-1}$, S_3=5 seedlings $hill^{-1}$

T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

** - Significant at 1% level

NS- Non-significant

Appendix 5. Effect of different number of seedlings $hill^{-1}$ on nutrient content in grain and straw of Aman rice cv. Binasail (mean of 4 transplantation treatments)

Different seedling number treatments	**N concentration in straw (%)**	**P concentration in straw (%)**	**K concentration in straw (%)**
S_1	0.3875	0.2711 b	1.385 a
S_2	0.3892	0.2822 a	1.377 ab
S_3	0.3533	0.2413 c	1.332 b
$LSD_{0.05}$	**0.05069**	**0.001133**	**0.05069**
Significant level	NS	**	**
CV %	5.67	5.41	2.02

S_1= 3 seedlings $hill^{-1}$, S_2= 4 seedlings $hill^{-1}$, S_3=5 seedlings $hill^{-1}$

** - Significant at 1 % level

NS- Non-significant

Appendix 6. Effect of different transplanting and re-transplanting dates on nutrient content in grain and straw of Aman rice cv. Binasail (mean of 3 different number of seedlings hill^{-1})

Transplantation treatments	N concentration in straw (%)	P concentration in straw (%)	K concentration in straw (%)
T_1	0.4800 a	0.3074 a	1.514 a
T_2	0.4289 b	0.2841 b	1.434 b
T_3	0.3467 c	0.2584 c	1.340 c
T_4	0.2511 d	0.2094 d	1.171 d
$LSD_{0.05}$	**0.0009904**	**0.0009904**	**0.03132**
Significant level	**	**	**
CV %	**5.67**	**5.41**	**2.02**

T_1 : Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3 : Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

** - Significant at 1% level

NS- Non-significant

Appendix 7. Effect of different number of seedlings hill^{-1} on nutrient content in grain and straw of Aman rice cv. Binasail due to different transplanting and re-transplanting dates

Different seedling number treatments	Transplanta-tion treatments	N concentration in straw (%)	P concentration in straw (%)	K concentration in straw (%)
S_1	T_1	0.4900 b	0.3020 c	1.543 a
	T_2	0.4367 e	0.2883 d	1.450 b
	T_3	0.3600 g	0.2733 f	1.358 c
	T_4	0.2633 i	0.2207 h	1.190 e
S_2	T_1	0.5000 a	0.3320 a	1.505 ab
	T_2	0.4467 d	0.3103 b	1.458 b
	T_3	0.3600 g	0.2837 e	1.376 c
	T_4	0.2500 j	0.2027 k	1.168 e
S_3	T_1	0.4500 c	0.2883 d	1.493 ab
	T_2	0.4033 f	0.2537 g	1.392 c
	T_3	0.3200 h	0.2183 i	1.287 d
	T_4	0.2400 k	0.2050 j	1.154 e
$LSD_{0.05}$		**0.001715**	**0.001715**	**0.05425**
Significant level		**	**	**
CV %		**5.67 %**	**5.41 %**	**2.02 %**

S_1= 3 seedlings hill^{-1}, S_2= 4 seedlings hill^{-1}, S_3=5 seedlings hill^{-1}

T_1: Transplanted on 16 September, T_2 :Re-transplanted on 23 September

T_3: Re-transplanted on 30 September, T_4 : Re-transplanted on 07 October

** - Significant at 1% level