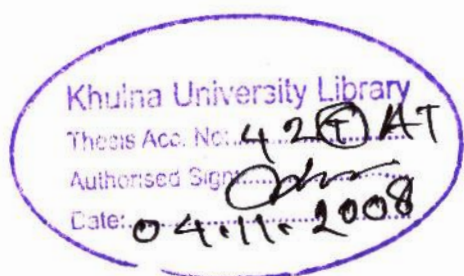


**EFFECT OF NITROGEN LEVELS AND SPACING ON THE
PERFORMANCE OF TRANSPLANT AMAN RICE CV. BR 23**



A TTHESIS

By

DIPTI RANI MONDAL

Examination Roll No: MS 050809

A thesis submitted to the Agrotechnology Discipline of Khulna
University, Khulna in partial fulfillment of the requirements
for the degree of Master of Science (M.S.) in Agronomy



Agrotechnology Discipline
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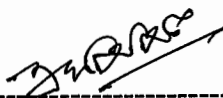
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**DEDICATED
TO MY
BELOVED PARENTS**

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The Author

ABSTRACT

An experiment was conducted at the Agrotechnology Field Laboratory of Khulna University, during *Aman* season 2007 to study the effect of nitrogen and spacing on the yield of the transplant *aman* rice cv. BR 23. The experiment comprised of four nitrogen levels viz. 0, 50, 100, 150 kg N ha⁻¹ and three spacings viz. 15 cm × 10 cm, 20 cm × 15 cm, 25 cm × 20 cm. The experiment was laid out in a Factorial Randomized Complete Block Design (RCBD) with three replications. Nitrogen level significantly influenced growth, yield and yield components except harvest index. Maximum number of effective tillers hill⁻¹(12.31), weight of 1000-grain (22.84 g), grain yield (4.574 t ha⁻¹), and straw yield (4.619 t ha⁻¹) were obtained with 100 kg N ha⁻¹. The largest panicle length (26.02 cm), unfilled grains panicle⁻¹(22.84) was obtained with 150 kg N ha⁻¹. It was observed that wider spacing (25 cm × 20 cm) produced the higher panicle length (26.08), unfilled grains panicle⁻¹(21.44). Medium spacing 20 cm × 15 cm produced the highest number of effective tillers hill⁻¹(12.47), filled grains panicle⁻¹(109.8), weight of 1000-grain (22.60 g), grain yield 4.40 (t ha⁻¹) straw yield 4.34 (t ha⁻¹) and harvest index (50.53%). Results also showed that, 100 kg N ha⁻¹ and 20 cm × 15 cm spacing was the optimum combination to produce maximum yield of transplanted *aman* rice cv. BR 23.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for nearly half of the world's population. About 40% of the world's population consume rice as a major source of calorie (Banik, 1999). In Bangladesh rice is cultivated in 10.71 million hectares of land having the average yield of 2.15 t ha⁻¹ (BBS, 2000). The average yield of rice is quite lower as compared to those of leading rice producing countries of the world like Japan, China, Korean Republic and USA. Rice constitutes 95% of the food grain production in Bangladesh (Julfiquar *et al*, 1998). To feed the increasing population of Bangladesh it is urgently needed to increase the production of rice through vertical means instead of horizontal avenues. Scientists have been continuing their effort to improve the varietal characters through both conventional and mutation breeding. Modern high yielding varieties (HYV) require appropriate use of fertilizers, optimum spacing, proper water management and timely use of plant protection measures to obtain higher yield from a limited land. Hence, special attention should be given for increasing the yield unit⁻¹ area through effective management practices. Among the different management practices, use of optimum nitrogen levels of fertilizers and optimum spacing are important.

Among the fertilizer elements, nitrogen plays a key role in supporting plant activity and increasing the rice yield. Many workers reported a significant response of rice to nitrogen in different soils in Bangladesh (Bhuiya *et al*, 1998; Hossain *et al*, 1989 and Islam and *et al*, 1990).

Nitrogen fertilizer plays an important role regarding growth and yield of rice (Prasertsak and Fukai, 1997). Nitrogen fertilizers extend grain filling duration that favour

accumulation of more photosynthate in the grain and hence, increases grain weight. Physiological basis of variation in rice yield is due to grain filling duration and grain growth (Jones *et al*, 1979; Sadeque, 1985). Almost all the soils of Bangladesh are low in organic matter and hence of nitrogen (Haque and Bhuiya, 1980). Therefore, judicious application of nitrogen fertilizer for efficient utilization after of this element by the rice plant is essential.



Population density has profound influence on grain yield of rice (Islam, 1986). There had been several studies on the yield density relationship (Donald, 1963; Wiley and Heath, 1969) using a wide variety of crops, but the of optimum population density for maximum yield has not been figured out (Duncan, 1986). Growth, yield and yield components of rice are also greatly influenced by plant spacing. Closer spacing hampers intercultural operations, more competition arises among plants for nutrient, air and light as a result the plant becomes weaker and thinner, consequently reduces yield. Under wider plant spacing the farmer cannot get desired hill per unit area which ultimately reduces yield per unit area. Optimum plant spacing ensures the plants to grow properly both in their aerial and under ground parts through efficient utilization of solar radiation and nutrients (Miah *et al*, 1990). In Bangladesh, modern rice varieties are generally transplanted with 25 cm $\times$ 15 cm spacing (Mahumud, 2006). BRRI (1982) reported that rice yield was significantly higher in 10 cm $\times$ 10 cm spacing than in either 30 cm $\times$ 30 cm or 20 cm $\times$ 15 cm spacing.

Therefore, the present study was undertaken to observe the effect of different levels of nitrogen on the growth and yield performance of rice (*cv.* BR 23) at plant spacings

CHAPTER II

REVIEW OF LITERATURE

Rice is the principal food crop for the peoples of Bangladesh. A good number of research works have been done on various aspects of its growth and yield at different ecological situations. Nitrogen fertilizer plays a significant role on growth and yield of *aman* rice. Yield of this crop is also dependent on row spacing. Quite a good number of research works have been carried out at home and abroad. Therefore, for a clear understanding on the effect of levels of nitrogen and spacing on the yield of BR 23, some pertinent available information have been made and presented in this chapter.

Effect of nitrogen levels

Nitrogen is one of the most important factors affecting rice production. Among various nutrients, nitrogen has the strongest influence on the growth and yield of rice. Nitrogen is one of the major nutrients, which is required in adequate amounts at early, mid tillering and panicle initiation and at ripening stage for better grain development (Matsushima, 1976).

Nitrogen is the important nutrient, representing two thirds or more of total nutrient consumption in Asia (Barker and Robert, 1985). The amount of N that a rice plant absorbs to produce a unit of grain yield is nearly constant at 19-21 kg N t⁻¹ brown rice. Accordingly, the plant must absorb a larger amount of N to produce higher grain yield (Murayama, 1979).

High and low level of nitrogen supply does not always bring about higher yield. So optimum level of N supply is required to get satisfactory yield. Adequate nitrogen

fertilizer is required during period immediately after transplanting of seedling (Haque and Bhuiya, 1980; De Datta, 1978).

Effect on Plant Characters

Plant Height

Plant characters may be influenced by different levels and time of fertilization. Thakur (1991) obtained the highest plant height when 40%, 30% and 30% N were applied as basal, at maximum tillering and panicle initiation stages, respectively. Similar report was given by Haque and Khan (1981). In a field trial Singh and Singh (1986) found that plant height increased with increasing rates of nitrogen from 0 to 120 kg N ha⁻¹ applied as urea or urea super granules.

Reddy and coworkers (1988) and Oh and coworkers (1990) noted the positive effect of nitrogen on plant height in rice. Taller plants were produced by higher amount of nitrogen applications. Plant height decreased significantly with the reduction in the amount of nitrogen top dressing (Bhuiyan and coworkers, 1990). Idris and Matin (1990) noted that plant height increased up to 120 kg N ha⁻¹ compared to control and thereafter decreased at 140 kg N ha⁻¹. The highest plant height was recorded from 80 kg N ha⁻¹ and lowest one from 0 kg N ha⁻¹.

Sharma (1995) stated that a basal nitrogen application increased the plant height significantly.

Talukder (1973) reported that plant height increased with increasing rates of urea-N application. Wagh and Throat (1988) found that N application date had significant effect on plant height.



Reduction in plant height has often been cited as the most important factor in determining the nitrogen responsiveness and higher yields of the modern rice varieties. The shorter culm means lower respiration loss by the culm and therefore improved the net grains in the photosynthesis respiration balance (IRRI, 1977). Intermediate plant height when planted in areas of less dependable water control give more stable yields than short statured varieties. However, increase in the plant height normally results in decrease in resistance to lodging. Intermediate tall varieties produce moderately high stable yields about 4 t ha⁻¹ at any levels of nitrogen (IRRI, 1976).

Hussain and Sharma (1991) reported that application of nitrogen up to 140 kg ha⁻¹ increased plant height. At 80 kg and 10 kg N ha⁻¹ the variation in plant height was non-significant. The highest plant height was obtained from 120 kg N ha⁻¹ and the lowest one from the control. Dahatonde (1995) concluded that N fertilizer significantly enhanced the plant height.

Awan and coworkers (1984) found that the higher doses of N application increased the plant height and number of panicles m⁻². Singh and Sharma (1987) found that the higher N application increased the plant height.

Number of total tillers hill⁻¹

Tillering of rice plant is strongly influenced by nitrogen supply (IRRI, 1968; BRRI, 1989 and 1990a). Takahashi and Sasiprapa (1976) observed that N absorbed by the plant from tillering to panicle initiation tended to increase the number of tillers. Oshima (1962) found that the number of tillers increased with the increasing levels of applied nitrogen during the vegetative stage.

Dixit and Singh (1980) observed that increasing rate of nitrogen application increased number of tillers plant⁻¹. Nossai and Vargas (1982) stated that number of tillers hill⁻¹ and panicle length increased linearly with increased N level. Ram and coworkers (1984) recorded that N application increased the number of tillers hill⁻¹. Reddy (1986) concluded that application of 120 kg N ha⁻¹ to rice increased paddy yield, plant height, root length and number of tillers hill⁻¹.

An experiment conducted at BRRI (1992) indicated under upland culture, rice plant began tillering earlier but the tillering duration was similar under both upland and low land cultures resulting remarkable in a higher number of tillering m⁻², under upland culture than that in lowland culture at the maximum tillering stage. The tiller number m⁻², however sharply decreased after the maximum tillering stage and almost the similar value as obtained in lowland culture (BRRI, 1988)

Jasim and coworkers (1984) reported that nitrogen application increased the number of tillers hill⁻¹. Tiller hill⁻¹ increased with increasing nitrogen rates. Final tiller number per hill was a liner function of the maximum tiller at booting stage (Khanam, 1994).

Wagh and Thorat (1988) reported from an experiment with rice cv. R-24 grown under different hill spacings and nitrogen rates that nitrogen application significantly increased the tiller number over all hill spacings. Kamal and coworkers (1988) observed that the highest rate of nitrogen fertilizer had maximum tillers hill⁻¹, which was significantly higher, any of the other treatments.

Hossain and coworkers (1989) observed that the number of tillers hill⁻¹ increased up to 16.4 hill⁻¹ with increasing nitrogen rate in rice cv. Basmati. Idris and Matin (1990) found

that maximum tillers hill^{-1} was produced by 140 kg N ha^{-1} which was statically identical with 60, 80, 100 and 120 kg N ha^{-1} . The minimum tillers hill^{-1} was produced from the control.

Number of effective tillers hill^{-1}

Sahrawat and coworkers (1999) observed that nitrogen level significantly affected tiller number. Kumar and coworkers (1995) stated that an increased N level from 80 to 120 kg ha^{-1} significantly increased total tillers hill^{-1} . Mirza and Reddy (1989) also observed that increased in N levels significantly increased the total hill^{-1} . Nitrogen application from 0 to 120 kg ha^{-1} in three split dressings increased number of tillers hill^{-1} (Reddy *et al* 1988)

Dubey and coworkers (1991) reported that application of 90 kg N ha^{-1} resulted in higher number of productive tillers hill^{-1} . Ghosh and coworkers (1991) observed that application of N increased the number of productive tillers hill^{-1} . Pandey and coworkers (1991) concluded that higher grain yield from the increase in nitrogen level might be attributable to increase in the productive tillers hill^{-1} .

BINA (1996) stated that the effect of different levels of nitrogen was significant only for number of tillers hill^{-1} , productive tillers hill^{-1} , straw yield and crop duration. The highest number of total and productive tillers hill^{-1} was obtained from the highest level (120 kg ha^{-1}) of N application. Chandra and Pandey (1996) found that application of 120 kg ha^{-1} resulted in significant increase in number of productive tillers hill^{-1} compared to 60 kg N ha^{-1} . Islam and coworkers (1996) reported that number of effective tillers hill^{-1} increased with top dressing nitrogen.

At Bangladesh Agricultural University, Mymensingh, Akanda and coworkers (1986) found that nitrogen application in three doses such as 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation gave the highest number of panicles hill⁻¹.

Dry matter production

Rajarathinam and Balasubramaniyan (1999) found that N levels significantly influenced the dry matter production. Kumar and coworkers (1995) reported that an increase in N level significantly increased the dry matter accumulation of rice. There are many reports on the increase of total dry matter due to increased fertilizer application particularly nitrogen (Prasad, 1981).

Panicle length

Sadaphal and coworkers (1981) carried out an experiment with three levels of nitrogen (40, 80, 120 kg ha⁻¹) along with different methods of nitrogen application and found that 120 kg ha⁻¹ produced the highest panicle length and 40 kg ha⁻¹ had the lowest.

Singh and Singh (1984) observed that number of panicles m⁻² and grains panicle⁻¹, panicle length, panicle weight were all significantly higher at 75 kg N ha⁻¹ than in the control plots. The additional increase in panicle m⁻² and grains panicle⁻¹ was also significant when the rate of application was increased from 75 to 150 kg N ha⁻¹. Sharma and Mishra (1986) recorded the maximum length of panicle and maximum number of tillers hill⁻¹ from the highest nitrogen dose.

Rafey and coworkers (1989) showed that increasing N levels increased panicle length, number of grains panicle⁻¹ and 1000-grains weight significantly. Sharma and Mittra

(1989) noted the pronounced effect of N on yield attributing traits. Plants receiving high N doses produced long and heavy panicles.

Idris and Matin (1990) concluded that the rate of nitrogen application influenced panicle length positively. The highest panicle length was recorded from 60 kg N ha⁻¹ and the lowest from control. Azad and coworkers (1995) stated that panicle length increased significantly with the increasing level of nitrogen from 0 to 75 kg ha⁻¹.

Number of grains panicle⁻¹

Refey and coworkers (1989) observed that filled grains panicle⁻¹ increased with increasing rates of nitrogen from 0 to 60 kg N ha⁻¹. The maximum filled grains panicle⁻¹ was produced by 60 kg N ha⁻¹ and the minimum from the control treatment. Kim and coworkers (1990) observed that high dose of nitrogen gave increased number of panicles and spikelets panicle⁻¹. Hussian and Sharma (1991) reported that application of nitrogen increased grain number panicle⁻¹. The highest number of grains panicle⁻¹ was produced by 80 kg N ha⁻¹ and the lowest was produced by the control treatment.

Nazimi and coworkers (1995) described that rice crop were strongly influenced by urea at 46 kg N ha⁻¹ decreased unfilled grains panicle⁻¹ and on the other hand, increased filled grains panicle⁻¹.

Anrade and Amorim Neto (1996) concluded that increasing rates of applied N increased plant height, panicle m⁻², grains panicle⁻¹ and grain yield significantly. Chandra and Pandey (1996) stated that a significant increase in grains panicle⁻¹. Tillers m⁻² and the grain yield were obtained from application of 120 kg N ha⁻¹ compared to 60 kg N ha⁻¹.

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Many researchers reported that the number of filled grains m^{-2} increased significantly with the increasing level of nitrogen application (Singh 1984). In order to obtain a high grain yield, applying a heavy dressing of nitrogen, phosphorus and potassium to the field is a requisite more than anything. Different from phosphate or potassium, even a small amount of excess nitrogenous fertilizer immediately lowers the percentage of ripened grains. Yoshida and Parao (1976) reported that the decreased in the number of filled grains at higher N levels due to lodging or culm bending. In regard to the rice plant type, which is considered, to be closely related to the percentage of ripened grains under over-luxuriant growth conditions is proved to be important factors. After heading, nitrogen contributes to carbohydrate production. In most cases, as the amount of nitrogen which can be absorbed during the ripening period is very small compared to the nitrogen required of grains, a large amount of nitrogen is translocated from leaves to grains with the advance of ripening. The percentage of ripened grains generally tends to decrease with the increase in the number of grains.

Penar and Avila (1983) reported that the increasing rates of N fertilizers generally increased the number of panicles m^{-2} , number of grains panicle m^{-2} and also the plant height. Wada (1969) found that the number of panicles per unit area is most effectively increased by topdressing of N at the tillering stage. They also needed nitrogen at the reproductive and ripening stages for optimum of number of spikelets panicle⁻¹ and percentage filled spikelets.



Weight of 1000-grains

Awan and coworkers (1984) found that weight of 1000-grains increased by the application of higher dose of nitrogen fertilizer. Mondal and coworkers (1987) observed that increasing rates of N from 40 to 160 kg ha⁻¹ increased the 1000-grains weight.

Bhuiya and coworkers (1998) carried out an experiment with rice cv. BR 10 and reported that application of nitrogen 0-61 kg N ha⁻¹ increased the weight of 1000-grains and then the weight of 1000-grains decreased at the rate of 86 kg N ha⁻¹. The weight of 1000-grains was the highest at 60 kg N ha⁻¹ and the lowest at 0 kg N ha⁻¹. Rafey and coworkers (1989) found that application of nitrogen 0-60 kg ha⁻¹ increased 1000-grains weight linearly. The highest weight of 1000-grains was obtained from 60 kg N ha⁻¹ and the lowest from the control.

Islam and coworker (1990) reported that there was an increasing trend in the weight of 1000-grains with an increase in the levels of nitrogen up to 80 kg N ha⁻¹.

Lawal and Lawal (2002) observed that application of fertilizer up to 80 kg N ha⁻¹ significantly increased number of ear bearing tillers m⁻² and grain yield.

Grain yield

A field experiment was concluded at BARI (1986) obtained highest grain yield (5.7 t ha⁻¹) by the application of 120 kg N ha⁻¹. Reddy (1986) in a field experiment with 5 rice cultivars observed that yields that yields of all 5 rice cultivars increased by the application of increasing rate of N from 0 to 120 kg N ha⁻¹.

Mondal and coworkers (1987) reported that increasing rates of N from 40 to 160 kg N ha⁻¹ increased the number of panicles per unit area and also increased the grain and straw yields with increasing levels of nitrogen.

Idris and Matin (1990) observed that grain yield increased gradually with an increase in N and was maximum at 120 kg N ha⁻¹. Dahatonde (1992) conducted a field trial with four rice cultivars and nitrogen was applied from 0 to 120 kg N ha⁻¹ and reported that yield increased up to 120 kg N ha⁻¹.

Hossian and coworkers (1995) observed that application of nitrogen up to 120 kg N ha⁻¹ increased the grain yield of rice. They noted significantly higher yields with 80 and 120 kg N ha⁻¹ than 0 and 40 kg N ha⁻¹.

Bhale and Salunke (1996) concluded that grain yield increased linearly up to 120 kg N ha⁻¹. Chandra and Pandey (1996) noted that application of 120 kg N ha⁻¹ gave significant increase in grain yield compared with 60 kg N ha⁻¹. Application of nitrogen significantly increased in growth, yield attributes, grain and straw yields as well as harvest index with 60 kg N ha⁻¹ (Dwivedi, 1997).

Chopra and Chopra (2000) reported that studied the effect of row spacing and nitrogen levels on seed quality of Pusa Basmati-1 scented rice (*Oryza sativa* L.). Row spacing did not influence the yield attributes but seed and straw yields increased linearly up to 80 kg N ha⁻¹ and there after a marginal reduction in seed yield was observed at 120 kg N ha⁻¹.

Lawal and Lawal (2002) observed that 1000-grains weight and grain weight per panicle responded to N up to 120 kg N ha⁻¹.

Choudhuri and coworkers (1998) conducted experiment with three rice cultivars Haryana Basmati, Kasturi and Pusa Basmati giving 0-100 kg N ha⁻¹ and found that mean grain yields was the highest (2.90 t ha⁻¹) with 100 kg N

Singh and coworkers (1998) evaluated the influence of planting geometry (20 cm × 15 cm, 15 cm × 15 cm and 20 cm × 10 cm) and N levels (90 and 150 kg ha⁻¹) on the productivity of two hybrids (TNH 1 and THH2) in comparison with Rasi and Jaya as standard checks. They reported that planting densities did not significantly influence the productivity of test hybrid varieties but the yield response to N application was significant up to 150 kg N ha⁻¹. They concluded that a higher N application (150 kg ha⁻¹) were required to achieve higher grain yields in hybrid rice

Spanu and Pruneddu (1997) reported that rough rice yields increased with increasing N rate, ranging from 5.4 t ha⁻¹ with no N to 10.3 t ha⁻¹ with 250 kg N ha⁻¹. Singh and coworkers (1997) concluded that grain yield increased with up to 60 kg ha⁻¹.

Medhi and coworkers (1996) observed that addition of N, regardless of source increased grain yield significantly. The highest grain yield was recorded with 60 kg N ha⁻¹ from prilled urea.

Kumar and coworkers (1996) stated that grain yield increased with increased levels of nitrogen. The increase in grain yield @ 160 kg N ha⁻¹ over the control was 42.0 %.

Harie and coworkers (1996) pointed out that grain yield increased as nitrogen application increased from 0 to 150 kg ha⁻¹. Khade and coworkers (1996) concluded that application of 180 kg N ha⁻¹ improved the yield contributing characters and yield of rice.

Adhikary and Rahman (1996) observed significant effect of various doses of nitrogen on the grain yield of rice. They recorded the highest grain yield (4.52 t ha^{-1}) from 100 kg N ha^{-1} followed by 120 kg N ha^{-1} (4.46 t ha^{-1}), 80 kg N ha^{-1} (4.40 t ha^{-1}) and 40 kg N ha^{-1} (3.41 t ha^{-1}) respectively.

Hossian and coworkers (1995) observed that application of nitrogen up to 120 kg N ha^{-1} increased the grain yield of rice. Application of 40, 80 and 120 kg N ha^{-1} increased grain yield 24, 33 and 44% over the control respectively. They noted significantly higher yields with 80 and 120 kg N ha^{-1} than 0 and 40 kg N ha^{-1} .

Dahatonde (1995) noticed that grain yield increased with N application up to 100 kg N ha^{-1} and was not significantly affected by the P and K application.

Raju and Reddy (1992) noticed that nitrogen and phosphorus fertilization had a significant effect on yield and yield components. Application of 80 and 120 kg N ha^{-1} markedly improved the grain yield by 31.7 and 45.9%, respectively. Rahman (1992) obtained the highest grain yield 6.7 t ha^{-1} 100 kg N ha^{-1} and 4.8 t ha^{-1} with control.

Mongia (1992) showed that application of urea in 3 splits (50% basal + 25% tillering + 25% floral initiation stages) gave the highest yields with 60 kg N ha^{-1} .

BRRI (1992) reported that both grain and straw yield of rice increased significantly with 80 kg N ha^{-1} . Application of nitrogen from 120 to 160 kg N ha^{-1} significantly reduced the

yield which was assumed to be due to excessive vegetative growth followed by lodging after flowering.

Hussain and Sharma (1991) disclosed that the grain yield of rice increased significantly up to the application of 80 kg N ha⁻¹ and thereafter declined.

Islam and coworkers (1990) observed that the grain yield of rice increased significantly up to 80 kg N ha⁻¹ and thereafter the yield response were not found so up to 120 kg N ha⁻¹. Singandhupe and Rajput (1989) concluded that increasing N rates from 0 to 150 kg ha⁻¹ increased the yield from 3.79 to 6.24 t ha⁻¹.

Mishra and coworkers (1988) stated that application of increasing N rates 0, 30 and 60 kg ha⁻¹ on the 7 rice cultivars increased the average paddy yield 3.46 to 4.84 and 5.34 t ha⁻¹, respectively. Yield was not further increased with 90 kg N ha⁻¹. There was no significant difference among the yields of the cultivars. The interaction between cultivars and nitrogen rates was significant.

Straw yield

Idris and Matin (1990) conducted a trial with in rice at BAU Mymensingh and found that straw yield increased with the application of N from 0 kg to 120 kg N ha⁻¹ and observed that at 140 kg N ha⁻¹ and the lowest form control. Islam and coworkers (1990) observed that straw yields increased correspondingly with increased in nitrogen applications. The effects of 40 kg, 80 kg and 120 kg N ha⁻¹ applications were statistically identical.

Hussian and Sharma (1991) carried out experiments during rainy the seasons of 1988 and 1989 in India and reported that straw yields increased significantly up to 120 kg N



ha⁻¹. Patel and Mishra (1994) reported that application of 0, 30, 60, 90 kg N ha⁻¹ increased grain and straw yields, N uptake and N requirement. N rate had no significant effect on panicle length, percentage of sterility and harvest index.

Khanda and Dixit (1996) stated that the grain and straw yield were significantly influenced by the increased levels of nitrogen. The maximum mean grain and straw yields were 4.58 and 6.21 t ha⁻¹ respectively.

Effects of nitrogen on biological yield and harvest index

Prasad (1981) found that the increasing rate of nitrogen application 0 to 120 and 200 kg ha⁻¹ increased biological yield and decreased harvest index. Park (1987) observed that high N rates tend to increase biological yield and decreased harvest index.

The review presented above concludes that the levels of N fertilizer have differential influence on the growth, yield and N uptake of transplant *aman* rice. The varieties differ on the growth and development due to application of different levels of N- fertilizers. As a result, the yields and its contributing characters are greatly affected.

Effect of spacing

Plant height

Akita and Tanaka (1992) found that at panicle formation plant height was the highest at 49 hills m⁻² but at heading and maturity the tallest plants were found at low plant densities. When planted on the square system the number of culm at panicle formation was greatest at 100 hills m⁻² but at heading it was greatest at 64 hills m⁻².

Tillering pattern



Muhammad and coworkers (1987) reported that when rice *cv.* Bashmoti 370 was grown with 2 seedlings hill⁻¹ and 6, 11, 25 or 44 hills m⁻² then the number of tillers hill⁻¹ and 1000-grain weight decreased with increasing plant density.

Haque and Nasiruddin (1988) conducted an experiment where deep water rice was established at initial densities of 50, 100, 150, 200, 225 or 350 seedlings m⁻². Tillering increased linearly with density up to the pre-flood stage with an average total of 5.8 tillers plant⁻¹ in low density plots, 3 tillers plant⁻¹ in medium density plots. Tiller number decreased at peak flooding by 13.62, 21.4 and 20.2 percent in low, medium and high density plots, respectively. Panicle density at maturity varied only from 186 to 224 panicles m⁻² resulting in similar yields at the different plant densities.

Srinivasan and Purushothaman (1990) reported that in rice *cv.* Ponni and Bhavanis when transplanted at 15 cm, 20 cm or 25 cm × 10 cm the increased number of productive tillers and higher total plant DM at higher plant density in main and ratoon crops.

Shrirame and coworkers (2000) reported that maximum leaf area hill⁻¹ and total number of tillers hill⁻¹ were higher at the wider spacing. Shah and coworkers (1991) found that numbers of tillers m⁻² and straw yield were highest with 10 cm × 10 cm spacing.

Panicle number and length

Thangamuthu and Subramanian (1983) studied the effect of plant population on yield and yield components of rice *cv.* C043 and found that 20 cm × 15 cm spacing produced the highest grain yield of 5.2 and 6.6 t ha⁻¹ during the wet and dry seasons, respectively. The number of panicles m⁻² was higher in conventional planting at 15 cm × 10 cm

spacing during the wet season but was higher at 15 cm × 20 cm spacing during the dry season.

Liou (1987) found that the closer spacing of 12.50 cm × 12.50 cm decreased the panicle length of rice plants as compared to 25 cm × 25 cm or 50 cm × 50 cm.

Rao and coworkers (1990) reported that in case of rice cv. LET 8579, transplanted at 10 cm × 10 cm, 15 cm or 15 cm × 15 cm or 20 cm × 15 cm row spacing. Grain yield was highest (2.9 t ha⁻¹) at 20 cm × 10 cm spacing and decreased with closer spacing due to few filled spikelets panicle⁻¹ and lower panicle weight, yield was also found to be decreased at wider spacing despite of slightly higher panicle weight.

Yield

Murty and Murty (1980) found that values for dry matter production, spikelets m⁻², paddy yield and LAI were highest at a spacing of 10 cm × 10 cm and progressively decreased with increased spacing. Hwu and Thsena (1982) stated that increasing spacing increased the number of spikelets panicle⁻¹.

Tredevi and Kwatra (1983) studied the growth and grain yield of rice cultivar Patel-85 transplanted on 30 June, 15 and 30 July and 14 August at a spacing of 15 cm × 15 cm, 15 cm × 22.5 cm, 15 cm × 30 cm and 22.5 cm × 22.5 cm. The spacing 15 cm × 15 cm was found significantly superior to other spacing, giving the highest yield when planted on 30 June at 15 cm × 15 cm (8.75 t ha⁻¹).

Karim (2005) conducted an experiment where fine grained rice *cv.* BR 23 was grown at 15 cm × 10 cm, 20 cm × 15 cm, 25 cm × 20 cm, spacings and five levels nitrogen were used. The highest grain yield, straw yield and harvest index were obtained with 20 cm × 15 cm, spacing. Results also showed that 50 kg N ha⁻¹ and 20 cm × 15 cm, spacing was the optimum combination to produce maximum yield of transplant aman rice *cv.* BRRI dhan 32.

Rathi and coworkers (1984) found that Patel 85 *cv.* gave the highest paddy yield and closer spacing (15 cm × 15 cm) yielded significantly higher than normal (22.5 cm × 22.5 cm) and wider (30 cm × 30 cm) spacings. A linear reduction in yield with increase in spacings was noticed.

Balasubramiyan (1985) conducted an experiment where rice *cv.* IR20 was planted with spacings of 10 cm × 10 cm, 15 cm × 10 cm, 15 cm × 20 cm or 20 cm × 10 cm and found that grain yield did not differ significantly due to plant spacings.

Wei and Liu (1986) reported that the higher planting density increased the grain yield of rice by 42 % due to increased number of panicles unit⁻¹ area. They found in an experiment with rice transplanted at the spacing of 15 cm × 15 cm, 15 cm × 22.5 cm and 15 cm × 30 cm or 22.5 cm × 22.5 cm. The spacings of 15 cm × 15 cm appeared to be significantly superior to other spacings. The highest yield (8.73 t ha⁻¹) was produced with the 15 cm × 15 cm spacing.

Rao and Raju (1987) found that a spacing of 10 cm or 15 cm between plants in rows of 15 cm apart gave similar grain yields. Chandrakar and Chandravanshi (1988) studied the effect of plant population on indica rice *cv.* Saari 17 and found that yield at a spacing of

20 cm × 20 cm was significantly higher than at 10 cm × 10 cm in 2 of the 3 years of trials.

Inamura and coworkers (1988) reported that rice cv. Asukminori and Fugue gave the highest yield transplanted at lower plant density.

Rao and coworkers (1990) observed that grain yield was the highest at 20 cm × 20 cm spacing and decreased with closer spacing due to few filled spikelets panicle⁻¹ and lower panicle weight and yield was also found to be decreased at wider spacing despite of slightly higher panicle weight. Kim and coworkers (1990) found that LAI, TDM and harvest index were increased by dense planting.

Shah and coworkers (1991) conducted an experiment where fine grained rice cv. K39 was grown 15 cm × 15 cm or 10 cm × 10 cm spacings and 3, 4, 5, or 6 seedlings hill⁻¹ were used. Plant height and harvest index were the greatest with 15 cm × 15 cm spacing, tiller number m⁻² and straw yield were highest with 10 cm × 10 cm spacing. The highest grain yield of 2.70 t ha⁻¹ was obtained at 15 cm × 15 cm spacing.

Karim and coworkers (1992) found from an experiment with Basmati 385 and breeding line 408 were grown at 118560, 160550 and 197600 plants ha⁻¹ in the cropping season that 1000- grains weight decreased with increasing plant density. Om and coworkers (1993) carried out a field experiment on *basmati-370* rice during the *Kharif* (monsoon) season of 1987 at Kaul at 15, 22.5 or 30 cm × 15 cm spacing gave grain yields of 4.08, 3.91 and 3.63 t ha⁻¹ respectively. Souza and Azevedo (1994) conducted an experiment where rice cv R10 Paranaiba was sown at the rates of 50, 75, 100 or 125 seeds m⁻² at row

spacings of 20, 35, 50 or 65 cm, the highest grain yield was achieved with 20 cm spacing.

Azad and coworkers (1995) conducted an experiment with rice seedlings transplanted at 20 cm × 10 cm, 25 cm × 10 cm or 30 cm × 20 cm spacing. Grain yield decreased with the widest plant spacing. Padmajrao (1995) observed that *cv.* Basmati 370 and IET 8580 were transplanted at 20 cm × 20 cm, 15 cm × 20 cm, 20 cm × 10 cm, spacing (25, 33 and 50 Plants m⁻² respectively) grain yield was highest at the closest plant spacing. AN experiment was conducted at BRRI (1991) on local variety Kumragair at 25 cm × 15 cm, 25 cm × 30 cm, 25 cm × 45 cm spacing. The results revealed that panicle production and grain yield differed significantly with spacing.

Chandra and coworkers. (1997) conducted an experiment on 12 Basmati rice varieties at Cuttaack in wet season during 1991 and 1992 at 20 cm × 15 cm, and 15 cm × 15 cm, spacings and varieties were Basmati-370. Kapurthak Basmati, Rasbor, Dheharun Basmati, IET11347, IET8579, Pusa615, Gaurav *cv.* II, Dubraj, Kalimuch and Madhuri. The closer spacing 15 cm × 15 cm, gave 10-12% higher yields of rough rice.

BRRI (1999) reported that BRRI varieties were grown in different Regional Research Stations at 10 cm × 10 cm, spacing and 30 cm × 30 cm, spacing using normal cultural practices. The grain yield, straw yield, total biomass, leaf area index, specific leaf weight and harvest index were recorded. Most of varieties gave highest grain yield in wider spacing.

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BRRI (2000) reported that crop production in less fertile soils could be overcome by increasing plant density. Plant densities corresponding to the plant spacing 40 cm × 20 cm, 25 cm × 20 cm, 25 cm × 10 cm, and 20 cm × 10 cm, were assigned in a plot receiving 100, 150, 200 or 250 kg N ha⁻¹. Grain yield increased with the increase of plant density up to 20 hills m⁻² corresponding to spacing 20 cm × 20 cm.



CHAPTER III

MATERIALS AND METHODS

Experimental site

The experiment was conducted in *aman* season (June – December) of 2007 at the Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna, situated in the Agro-ecological Zone (AEZ) No 13.

Soil and climate

The experimental field was typical rice growing lowland. It belongs to the Agroecological Zone (AEZ) No 13 i.e. Gangetic Tidal Floodplain. The experimental site was characterized by subtropical climate having moderately high temperature and heavy rainfall during the *kharif* season (April- September) and scanty rainfall with moderately low temperature during the *rabi* season (October-March). The meteorological data i.e. temperature, rainfall and relative humidity received at the experimental site during the investigation period have been presented in Appendix 1.

Design and layout

The experiment was laid out in a Factorial Randomized Complete Block Design (RCBD) with three replications. Four levels of nitrogen (Factor A) and 3 levels of spacing (Factor B) formed the treatment variables.

Factor A. Nitrogen levels: 4

$$N_0 = 0 \text{ kg N ha}^{-1}$$

$$N_1 = 50 \text{ kg N ha}^{-1}$$

$$N_2 = 100 \text{ kg N ha}^{-1}$$

$$N_3 = 150 \text{ kg N ha}^{-1}$$

Factor B. Spacing: 3

S₁: 15 cm × 10 cm

S₂: 20 cm × 15 cm

S₃: 25 cm × 20 cm

Raising of seedlings

Seedlings were raised in well prepared seedbed at the Agronomy Field Laboratory, Khulna University, Khulna. Before sowing in the nursery, seeds were water soaked for 24 hours and then were kept in gunny bags in dark condition. After sprouting they were sown in the wet seedbed on 26 June 2007. Proper care was taken to raise the seedlings in the seedbed.

Land preparation

The land was opened with a power tiller after harvest of the previous aus rice and then the land was ploughed and cross- ploughed three times by country plough followed by laddering on 27 July 2007. The corners of the field were spaded. All kinds of weeds and stubbles of the previous crops were removed from the field. Then the field was made ready for transplanting rice seedlings.

Fertilizer application

The whole amount of triple super phosphate, muriate of potash, gypsum and zinc sulphate were broadcast and incorporated into the soil at final land preparation at the rate of 100, 70, 60 and 10 kg ha⁻¹, respectively. Whole amount of urea was applied as top dressing in three equal splits in the form of urea. The first split was applied at 15 days after transplanting 35 and 55 days after transplanting respectively.

Seedling transplanting

Thirty four day old seedlings were transplanted on 29 July, 2007 with spacing given as per treatments. The seed bed was made soft by application of water both in the morning and evening one the day before uprooting the seedling. Seedlings were uprooted carefully without causing mechanical injury to the roots and were kept in shade.

Weeding

The experimental field was weeded thrice on 15, 35 and 55 (DAT) to keep the weed competition at a minimum level.

Gap filling

Within one week of transplantation, dead seedlings were replaced by transplanting new healthy seedling from the same source.

Irrigation and drainage

Irrigation water was applied as and when necessary for keeping 2-3 cm standing water during the growing period. The field was also finally drained out before 15 days of harvest to enhance maturity.

Plant protection

During the growth period some plots were attacked by stem borer .The pest was controlled by Furadan- 5 G which was applied at the active tillering stage @10 kg ha⁻¹.

Harvesting

Maturity of crops was determined when 90% of the grains become golden yellow. The crop was harvested at full maturity on 13 December, 2007 and the yields of both grain and straw were recorded after thoroughly drying them in sun. After harvest, grains were threshed, cleaned and sun dried to record the grain yield plot⁻¹. The grain was adjusted to

14% moisture content. The straw was also sun dried to record the straw yield plot⁻¹.

Grain and straw yields plot⁻¹ were converted to t ha⁻¹.

Data collection growth parameters:

Growth parameters such as plant height, number of tillers hill⁻¹, total dry matter hill⁻¹(g) were recovered at 30, 45, 60 DAT. Five random hills excluding two border lines and hills of each plot were sampled for this purpose. The procedures of data collection were as given below:-

Plant height (cm)

Total tillers hill⁻¹

Total dry matter hill⁻¹(g): At each sampling plants from five representative hills from inner rows of each plot was uprooted and thoroughly washed under tap water. Thereafter the plant samples were kept in brown paper envelopes and oven dried at 72 °C for 48 hours and weighed to calculate the total dry matter accumulation.

Yield and yield attributes:

Five hills from each plot were selected at random and were labeled with tags for recording morphological and yield attributes. The following data were recorded:

- i. Number of effective tillers hill⁻¹
- ii. Panicle length (cm)
- iii. Number of grains panicle⁻¹
- iv. Weight of 1000-grains (g)
- v. Grain yield (t ha⁻¹)
- vi. Straw yield (t ha⁻¹)
- vii. Harvest index (%)



Procedure of recording data

Number of effective tillers hill⁻¹: The panicles which had at least one grain were considered as effective tillers.

Panicle length (cm): Panicle length was recorded from the basal node of the rachis to apex of each panicle.

Weight of 1000-grains (g): Thousand grains were randomly selected from each plot and then it was dried in an oven. Weight was taken in an electric balance and the weight was adjusted to 14% moisture content (MC) by using the formula.

$$\text{1000-grain weight at 14\% MC} = \frac{(100 - \text{Sample MC}) \times \text{1000-grain weight at sample MC}}{(100 - 14)}$$

Grain yield (t ha⁻¹): The crop was harvested from 2 m² area on the center of each plot. The grain was threshed from the plants, cleaned, dried and then weighed. The yield of grain in kg plot⁻¹ was adjusted 14% moisture content of grain and then it was converted into t ha⁻¹.

$$\text{Grain Yield (t ha}^{-1}\text{) at 14\% MC} = \frac{10 (100 - \text{Sample MC}) \times \text{Plot yield (gm) at sample MC}}{(100 - 14) \times \text{plot area (m}^2\text{)} \times 1000}$$

Straw yield (t ha⁻¹): The rice straw from the 2m² sample area from which grain yield recorded was sun dried to constant weight. Then the straw was weighed and the straw yield per plot on the dry weight basis was determined. The yield of straw in kg plot⁻¹ was converted into t ha⁻¹.

Harvest index (%): Harvest index was calculated on the basis of adjusted grain and straw weight using the following formula.

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

Statistical analysis

The data were analyzed by partitioning the total variance through ANOVA using MSTAT-C program. The treatment means were compared using Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984). Standard regressions were developed using different growth and yield parameters.

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the study on the effect of nitrogen levels and spacing on the yield of transplant *aman* rice (cv.BR 23) have been presented and discussed in this chapter.

Effect of levels of nitrogen and spacing on growth characters of transplant *aman* rice. (cv BR 23)

Plant height

It was observed that application of nitrogen had significant effect on plant height. The highest plant height was found with 150 kg N ha⁻¹ at 60 DAT (Fig. 1). The lowest plant height was obtained from control (0 kg N ha⁻¹) at all stages of crop growth. The results indicated that the use of increasing levels of nitrogen was found to produce a positive effect on plant height. This might be due to higher amount of N uptake from the soil which ultimately increased plant height positively. Similar results were also obtained by Reddy and coworkers (1988) and Oh and coworkers (1990).

Plant height was significantly influenced by spacing at all stages. The highest plant height was found with (25 × 20) cm spacing at 60 DAT and the lowest was obtained from (15× 10) cm spacing (Fig. 2). The tallest plants were recorded possibly due to availability of more light, air and higher absorption of nutrients from at spacing.

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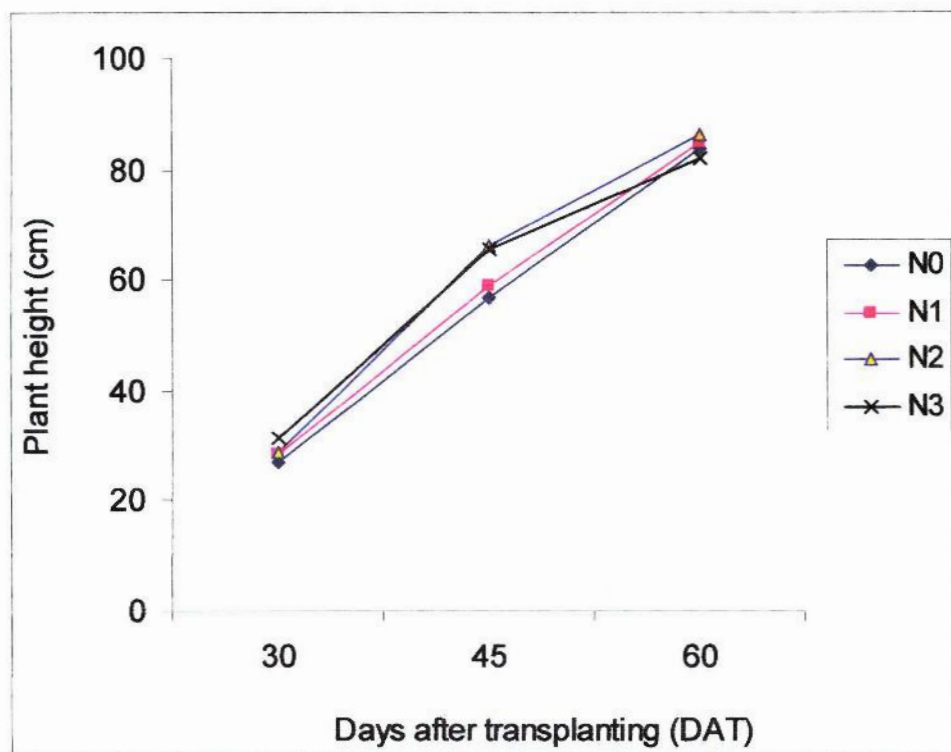


Fig. 1. Effect of nitrogen on plant height of BR 23 rice at different days after transplanting

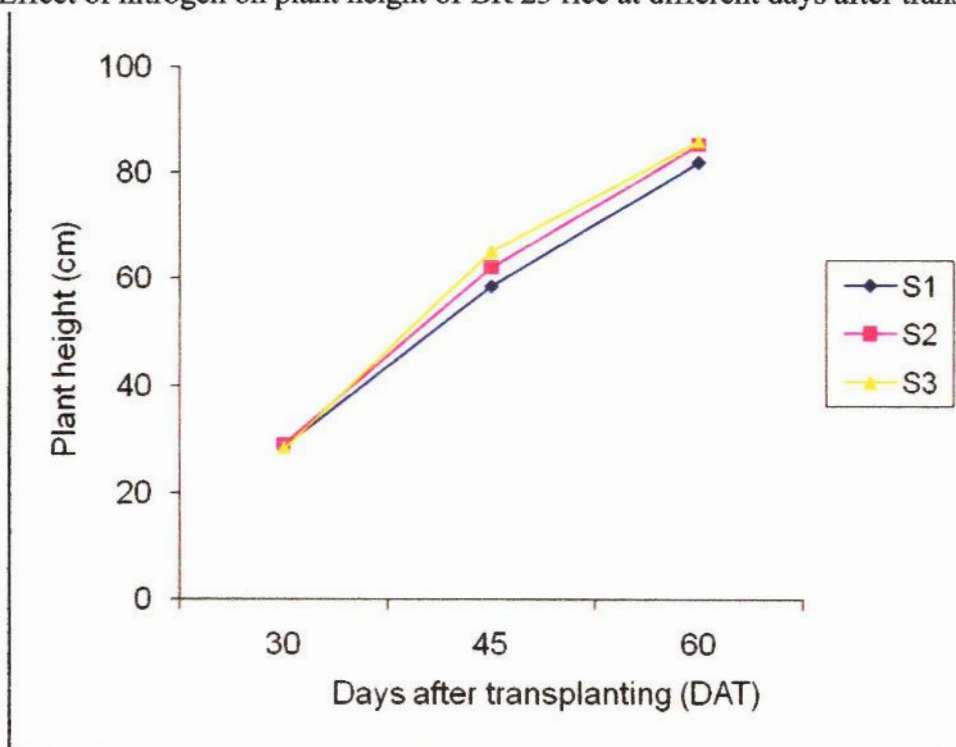


Fig. 2. Effect of spacing on plant height of BR 23 rice at different days after transplanting

Table 1. Interaction effect of nitrogen level and spacing on the plant height of transplant *aman* rice (cv. BR 23)

Treatments	Plant height over time (cm) at		
	30DAT	45DAT	60DAT
T ₀ S ₁	25.67 e	51.07e	79.40 c
T ₀ S ₂	27.06 cde	53.09de	86.43ab
T ₀ S ₃	28.15bcde	66.77a	85.23ab
T ₁ S ₁	28.13bcde	55.49d	86.87a
T ₁ S ₂	29.23abcd	62.67bc	83.83ab
T ₁ S ₃	27.40cde	59.30c	84.20ab
T ₂ S ₁	29.55abcd	65.60ab	84.70ab
T ₂ S ₂	30.67ab	66.63a	87.33a
T ₂ S ₃	26.33de	66.50a	87.00a
T ₃ S ₁	31.97a	61.97c	76.60c
T ₃ S ₂	30.13abc	66.27a	82.93b
T ₃ S ₃	31.99a	67.83a	86.87a
Level of significance	*	**	**
CV (%)	5.86	3.01	2.29

The interaction effect of nitrogen level and spacing on plant height differed significantly. However, the tallest plant (87.33 cm) was obtained from 100 kg N ha⁻¹ with 20 cm × 15 cm and the shortest plant (79.40 cm) was obtained from control with 15 cm × 10 cm spacing with 0 kg N ha⁻¹ at 60 DAT (Table 1). It was also observed that wider spacing produced higher plant height at all levels of N application and plant height increased with the advancement of crop growth.

Number of total tillers hill⁻¹

Number of total tillers hill⁻¹ significantly influenced by nitrogen levels at all sampling dates. The maximum number of total tillers hill⁻¹(11.13) was produced with 100 kg N ha⁻¹ which

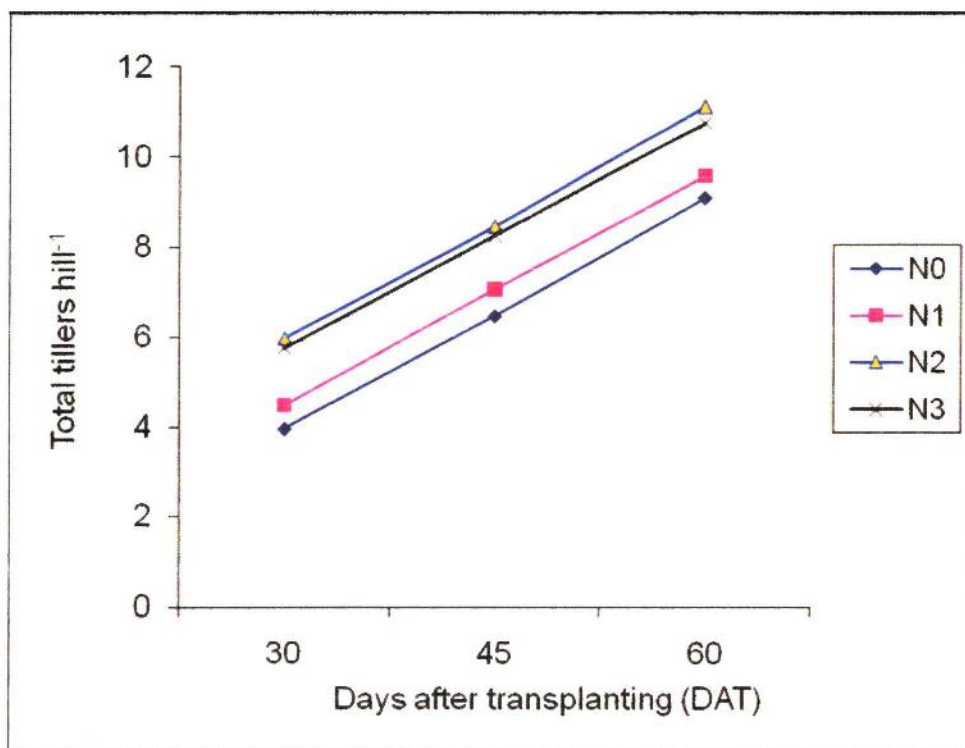


Fig. 3. Effect of nitrogen level on number of total tillers hill⁻¹ of BR 23 rice at different days after transplanting

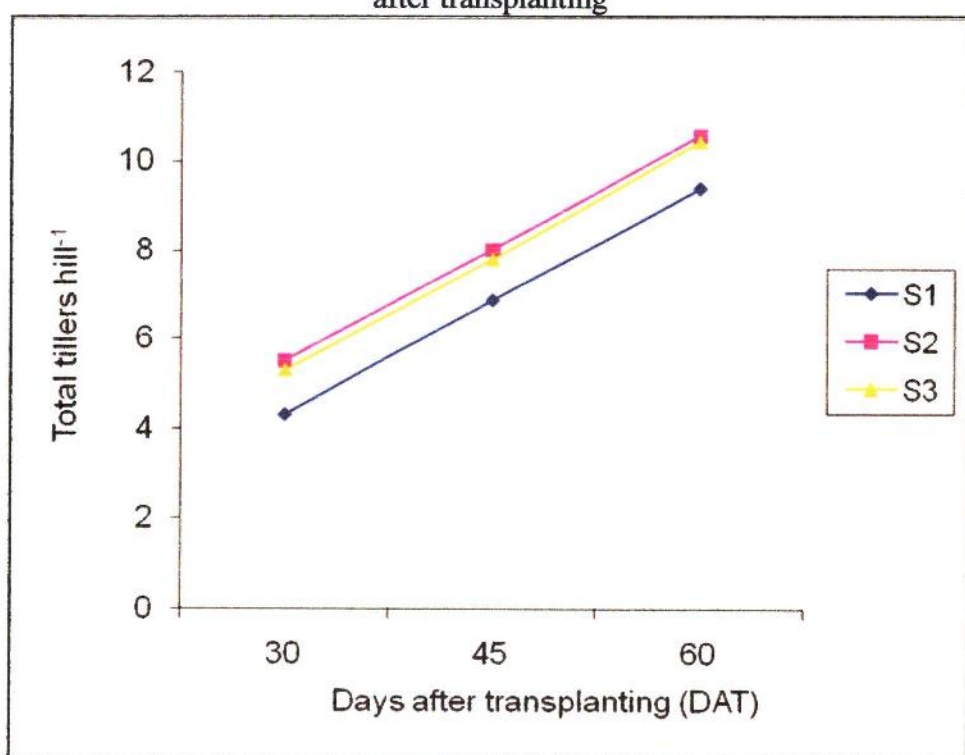


Fig. 4. Effect of spacing on total tillers hill⁻¹ of BR 23 rice at different days after transplanting



Table 2. Interaction effect of nitrogen level and spacing on total tillers of rice of transplant aman rice (cv. BR 23)

Treatments	No of total tillers hill ⁻¹ over time at		
	30DAT	45DAT	60DAT
T ₀ S ₁	3.60f	6.10f	8.70f
T ₀ S ₂	4.36de	6.86de	9.46cde
T ₀ S ₃	3.96ef	6.46ef	9.10ef
T ₁ S ₁	4.00ef	6.66def	9.26def
T ₁ S ₂	4.76cd	7.33cd	9.60cde
T ₁ S ₃	4.73cd	7.23cd	9.83cd
T ₂ S ₁	4.43de	6.93de	9.53cde
T ₂ S ₂	6.63a	9.13a	11.80a
T ₂ S ₃	6.86bc	9.36a	12.07a
T ₃ S ₁	5.33bc	7.83bc	10.10c
T ₃ S ₂	6.30a	8.80a	11.40ab
T ₃ S ₃	5.60b	8.16b	10.77b
Level of significance	**	**	**
CV (%)	7.36	4.78	3.77

The interaction effect of nitrogen level and spacing on tiller production was found significant at all sampling dates. The highest number of total tillers hill⁻¹(12.02) was recorded from 100 kg N ha⁻¹ with 25 cm × 20 cm spacing and the lowest (8.70) was observed from 0 kg N ha⁻¹ with 15 cm × 10 cm spacing at 60 DAT (Table 2).

Total dry matter hill⁻¹

Total dry matter production was significantly influenced by nitrogen level at 30, 45, 60 DAT. The highest total dry matter hill⁻¹(43.82 g) was produced at 150 kg N ha⁻¹ and the lowest total dry matter hill⁻¹ (30.72 g) was obtained with control (Fig. 5). There are several reports on the increase in total dry matter due to increased nitrogen fertilizer application (Prasad, 1981; Park, 1987).

Spacing had significant effect on total dry matter hill⁻¹ at all sampling dates. The highest total dry matter hill⁻¹ was found with 20 cm × 15 cm spacing and the lowest total dry matter hill⁻¹ was found with 15 cm × 10 cm (Fig. 6). The results showed that wider spacing had a tendency to produce more total dry matter yield unit⁻¹ area at all sampling dates compared to closer spacing.

The interaction effect of nitrogen level and spacing on dry matter was found significant yield all sampling dates. It is found that 150 kg N ha⁻¹ with 25 cm × 20 cm spacing produced the highest total dry matter hill (44.70 g) and 0 kg N ha⁻¹ with 15 cm × 10 cm spacing produced the lowest total dry matter hill⁻¹ (28.40 g) (Table 3).



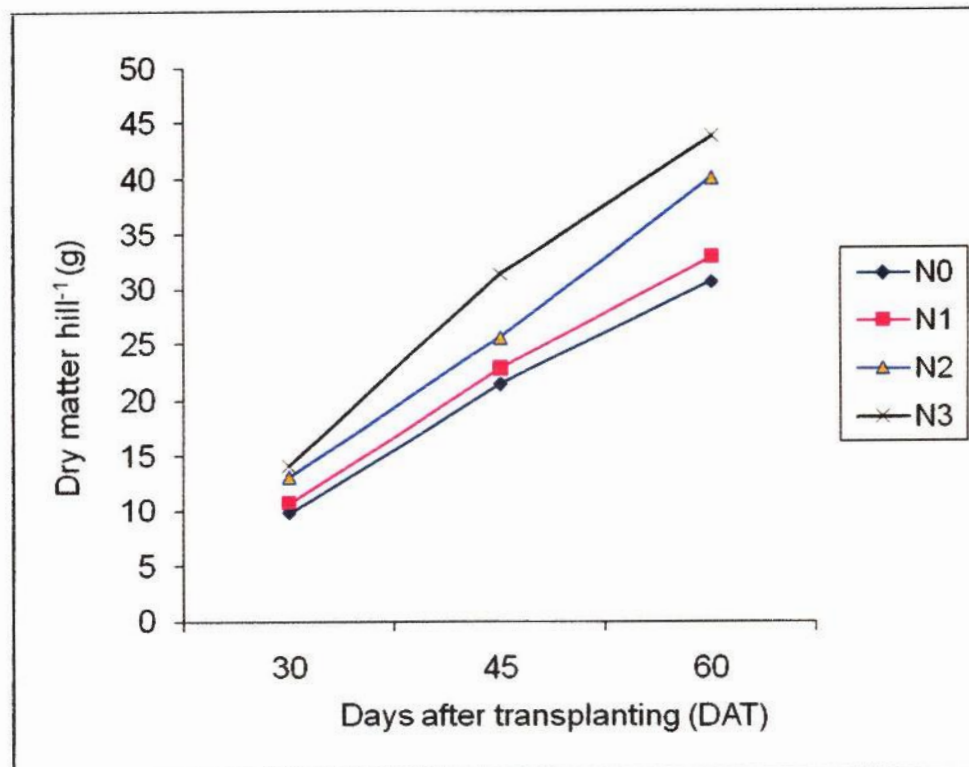


Fig. 5. Effect of nitrogen levels on dry matter hill⁻¹ of BR 23 rice at different days after transplanting

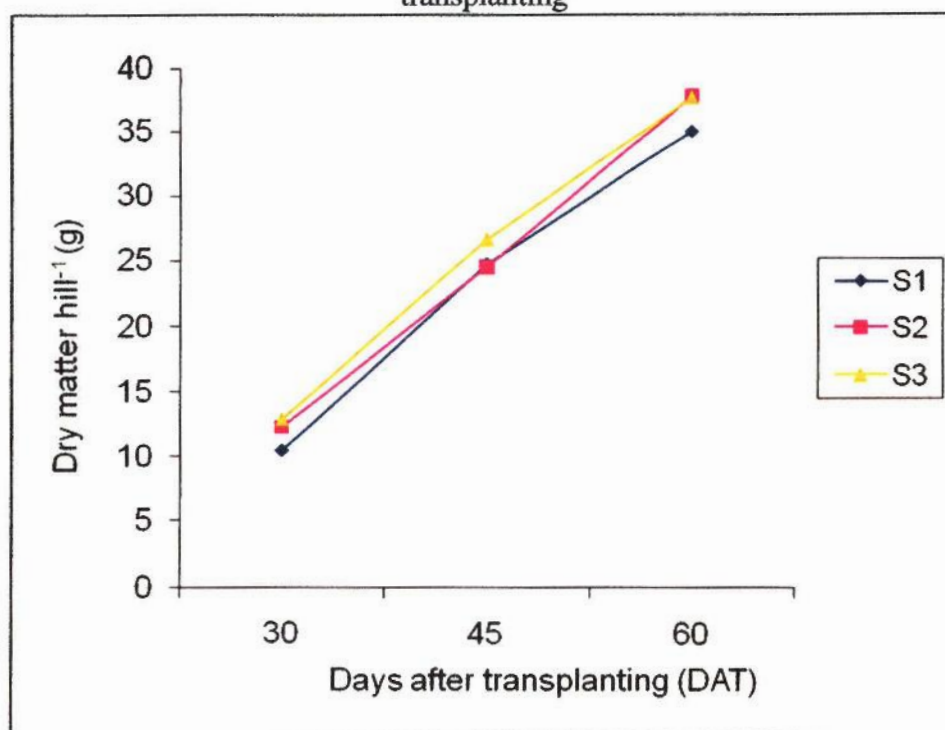


Fig. 6. Effect of spacing on dry matter hill⁻¹ of BR 23 rice at different days after transplanting

Table 3. Interaction effect of nitrogen level and spacing on dry matter of rice of transplant *aman* rice (cv. BR 23)

Treatments	Dry matter over time (g)		
	30DAT	45DAT	60DAT
T ₀ S ₁	8.26h	19.47f	28.40i
T ₀ S ₂	11.43ef	22.37def	32.30g
T ₀ S ₃	9.80g	22.33def	31.47gh
T ₁ S ₁	10.73f	22.47def	32.27g
T ₁ S ₂	8.93h	20.63ef	31.27h
T ₁ S ₃	12.63d	25.33cd	35.33f
T ₂ S ₁	11.07f	24.97cd	37.53e
T ₂ S ₂	14.77b	23.63de	43.20b
T ₂ S ₃	13.53c	28.27bc	39.40d
T ₃ S ₁	12.10de	32.10a	42.20c
T ₃ S ₂	14.40b	31.40ab	44.53a
T ₃ S ₃	15.93a	30.77ab	44.70a
Level of significance	**	*	**
CV (%)	3.92	7.41	1.33

Table 4. Yield and yield contributing characters of rice cv. BR 23 as influenced by different levels of nitrogen

Treatments	Effective tiller hill ⁻¹	Panicle length (cm)	Filled grains panicle ⁻¹	Unfilled grains panicle ⁻¹	Weight of 1000-grain (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Harvest index (%)
N ₀	9.622c	24.24c	86.42c	18.39c	21.18c	2.569c	2.552c	50.22
N ₁	10.84b	25.00b	101.0b	19.24c	22.09b	4.258b	4.230b	50.11
N ₂	12.31a	25.67a	106.6a	21.09b	22.84a	4.574a	4.619a	49.80
N ₃	12.02a	26.02a	103.7b	22.84a	22.09b	4.192b	4.190b	50.04
Level of significant	**	**	**	**	**	**	**	NS
CV (%)	3.24	1.08	2.55	4.28	1.29	1.95	2.98	1.32

** Indicate significance at 1% level level probability

* Indicate significance at 5% level level probability

NS =Not significant

Table 5. Yield and yield contributing characters of rice cv. BR 23 as influenced by spacing

Treatments	Effective tiller hill ⁻¹	Panicle length (cm)	Filled grains panicle ⁻¹	Unfilled grains panicle ⁻¹	Weight of 1000-grain (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Harvest index (%)
S ₁	9.05b	23.85b	83.11b	18.59b	21.27b	3.02c	3.04b	49.81
S ₂	12.47a	25.77a	109.8a	21.14a	22.60a	4.40a	4.34a	50.53
S ₃	12.08a	26.08a	106.8a	21.44a	22.28a	4.26b	4.30a	49.78
Level of significance	**	**	**	**	**	**	**	NS
CV (%)	3.24	1.08	2.55	4.28	1.29	1.95	2.98	1.32

Table 6. Interaction effect yield and yield contributing characters of rice of transplant *aman* rice (cv. BR 23) as influenced by nitrogen levels and spacing

Treatments	Effective tillers hill ⁻¹	Panicle length (cm)	Filled grains panicle ⁻¹	Unfilled grains panicle ⁻¹	Weight of 1000-grains (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Harvest index (%)
N ₀ S ₁	8.13e	23.27h	76.33h	17.93e	20.73	2.32g	2.38f	49.38c
N ₀ S ₂	10.73c	24.60ef	93.07c	19.00de	21.60	2.73f	2.62e	51.33a
N ₀ S ₃	10.00d	24.87e	89.87ef	18.23e	21.200	2.64f	2.65e	49.94bc
N ₁ S ₁	8.26e	23.80g	83.30g	18.53de	21.33	3.25e	3.29d	49.64c
N ₁ S ₂	12.33b	25.40d	111.0cd	20.13cd	22.60	4.84c	4.66c	50.96ab
N ₁ S ₃	11.93b	25.80d	108.7d	19.07de	22.33	4.67d	4.72c	49.73bc
N ₂ S ₁	10.00d	24.27fg	87.13fg	18.73de	21.80	3.31e	3.29d	50.13abc
N ₂ S ₂	13.60a	26.27c	121.3a	21.17c	23.53	5.29a	5.38a	49.60c
N ₂ S ₃	13.33a	26.47bc	117.3ab	23.37b	23.20	5.11b	5.18b	49.67c
N ₃ S ₁	9.80d	24.07g	85.67fg	19.17de	21.20	3.22e	3.22d	50.08bc
N ₃ S ₂	13.20a	26.80ab	113.8bc	24.27ab	22.67	4.73cd	4.69c	50.23abc
N ₃ S ₃	13.07a	27.20a	111.6cd	25.10a	22.40	4.62d	4.65c	49.80bc
Level of significance	*	*	**	**	NS	**	**	*
CV (%)	3.24	1.08	2.55	4.28	1.29	1.95	2.98	1.32

Effect of nitrogen level and spacing on yield and yield contributing characters of transplant aman rice (cv. BR 23)

Number of effective tillers hill⁻¹

Nitrogen level had significant effect on the production of effective tillers hill⁻¹. The highest number of effective tillers hill⁻¹ (12.31) was produced with 100 kg N ha⁻¹ which was statistically similar to those produced with 150 kg N ha⁻¹. The lowest number of effective tillers hill⁻¹ (9.622) was obtained from the control treatment (Table 4). Adequacy of nitrogen at 100 kg N ha⁻¹ probably favoured the proper cellular activities during panicle formation and development which led to increase the number of effective tillers hill⁻¹. Spacing had

significant influence on effective tillers hill⁻¹. It is observed that medium spacing (20 cm×15 cm) produced the highest number of effective tillers hill⁻¹ (12.47) and closest spacing (15 cm×10 cm) produced the lowest number of effective tillers hill⁻¹(9.05). This difference might be due to the fact that wider spacing allowed more light, space and nutrients for producing higher number of effective tillers hill⁻¹. These results are supported by the findings of Muhammad and coworkers (1987) and Srinivasan and Purushothaman (1990). Interaction effect of nitrogen level and spacing on the number of effective tillers hill⁻¹ was significant. The highest number of effective tillers hill⁻¹(13.60) was produced by kg 100 N ha⁻¹ with 20 cm × 15 cm spacing. The lowest number of effective tillers hill⁻¹ (8.133) was obtained from the control treatment with 15 cm×10 cm spacing and it was statistically similar to all other nitrogen rates under same plant spacing. Regression analysis between grain yield (t ha⁻¹) and effective tillers hill⁻¹ revealed that and linear positive relation existed between these two parameters (Fig. 7). The higher value of R² (R²=0.81) indicates that over 80% of the variation in grain yield of BR 23 rice during aman season would be explained by the variation in the number by effective tillers hill⁻¹.

Panicle length

Nitrogen levels had significant effect on panicle length. The plant receiving no nitrogen fertilizer produced the shortest panicle. The longest panicle (26.02 cm) was found from 150 kg N ha⁻¹ which was statistically similar to 100 kg N ha⁻¹ (25.67 cm) and 50 kg N ha⁻¹ (Table 4). These results are supported by the findings of Sharma and Mittra (1984) and Sadaphal and coworkers (1981). It was observed that different plant spacing had significant effect on the panicle length. The highest panicle length (26.08 cm) was produced by 25 cm × 20 cm spacing and the shortest one (23.85 cm) with 25 cm × 10 cm spacing (Table 5). Similar

results were also reported by Liou (1987). The results showed that the interaction effect of the nitrogen level and spacing had significant effect on panicle length. The longer panicles (27.20 cm) were obtained from 150 kg N ha⁻¹ with 25 cm × 20 cm spacing and the shortest (23.27 cm) were obtained from control treatment with 15 cm × 10 cm spacing.

Number of filled grains panicle⁻¹

Nitrogen levels had influenced on the production number of filled grains panicle⁻¹. The highest number of filled grains panicle⁻¹ (108.6) was obtained from 100 kg N ha⁻¹ and the lowest number of filled grains panicle⁻¹ (86.42) was obtained from the control treatment (Table 6). The highest nitrogen level 150 kg ha⁻¹ produced a lower number of grains panicle⁻¹ than that of 100 kg N ha⁻¹. Adequate supply of nitrogen contributed to grain formation which probably increased number of filled grains panicle⁻¹ with increasing nitrogen levels. These results are in full compliance with those of Hossain and Sharma (1991) and Andrade Amorim Neto (1996) who reported the positive influence of nitrogen level on number of grains panicle⁻¹. Like nitrogen levels spacing had significant effect on filled grains panicle⁻¹. The highest number of filled grains panicle⁻¹ was obtained from medium spacing (20 cm × 15 cm) which differed significantly from other spacing treatments. The lowest number of filled grain panicle⁻¹ (83.11) was obtained at closer spacing (15 cm × 10 cm). The effect interaction between nitrogen level and spacing on the number of filled grains panicle⁻¹ was found significant. The highest number of filled grain panicle⁻¹ (121.3) was obtained from 100 kg N ha⁻¹ with 20 cm × 15 cm and the lowest (76.33) was obtained from control treatment with 15 cm × 10 cm (Table 6). Plotting grain yield (t ha⁻¹) against number of filled grains panicle⁻¹ yielded a straight line (Fig. 8) and about 90% ($R^2 = 0.898$) of the variation in grain yield could be satisfied by the variation in filled grains panicle⁻¹.

Number of unfilled grain panicle⁻¹

Nitrogen levels had significant effect on the production number of unfilled grains panicle⁻¹ (Table 4). The maximum number of unfilled grain panicle⁻¹ (22.84) was recorded with 150 kg N ha⁻¹ and the minimum (18.39) was produced at control treatment. The results showed that number of unfilled grains panicle⁻¹ gradually increased with increased level of nitrogen. Higher levels of nitrogen were probably a case of over dose production of more unfilled grains panicle⁻¹ which might lead to loss. (Rafey and coworkers 1989) reported a similar trend of results in the case of unfilled grains panicle⁻¹. Spacing had significant influence on unfilled grains panicle⁻¹. The maximum number of unfilled grains panicle⁻¹ (21.44) was recorded with 25 cm × 20 cm spacing which was statistically superior to all of the treatments and lower (18.59) was recorded with 15 cm × 10 cm spacing (Table 6).

The effect of interaction between nitrogen level and spacing on the number of unfilled grains panicle⁻¹ was significant. However, the highest number of unfilled grains panicle⁻¹ (25.10) was obtained from 150 kg N ha⁻¹ with 25 cm × 20 cm and the (17.93) was found with control treatment under (15 × 10) cm plant spacing (Table 6).

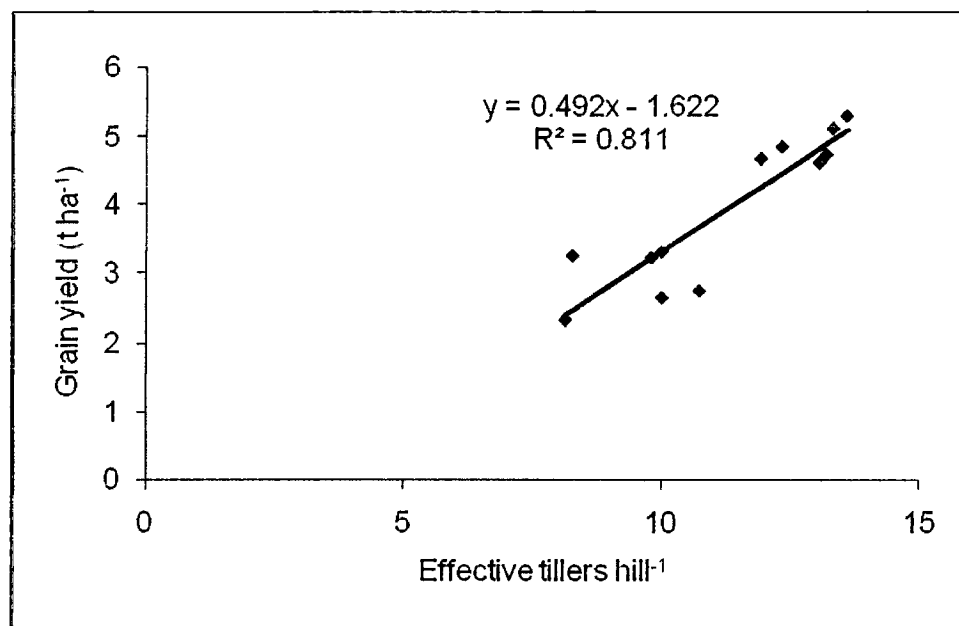


Fig. 7. Functional relationship between grain yield (t ha⁻¹) and effective tillers hill⁻¹ of rice cv. BR 23

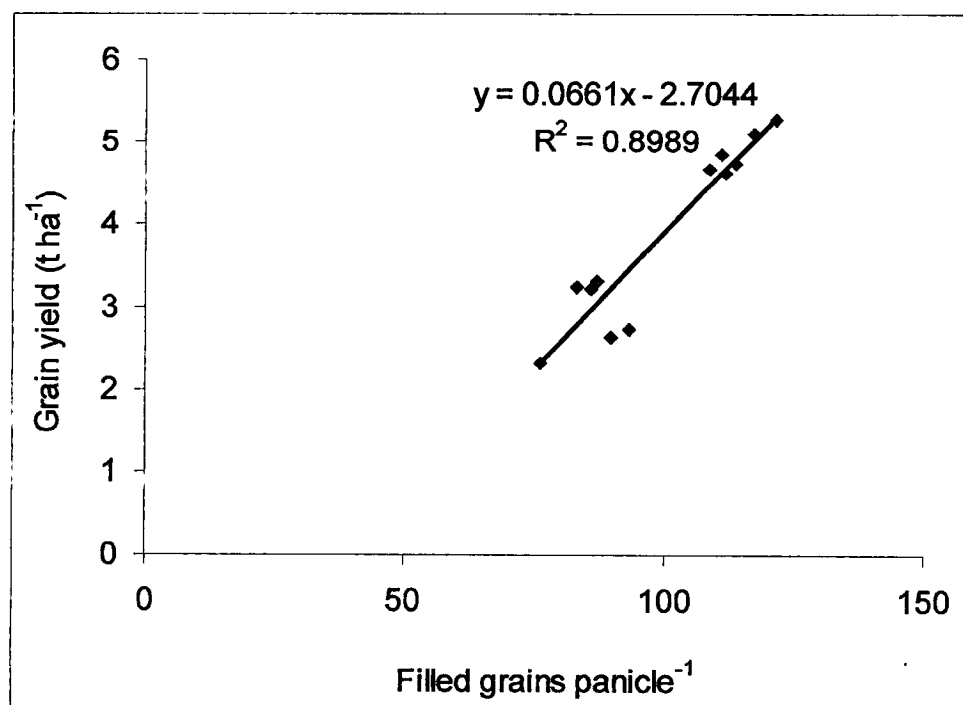


Fig. 8. Functional relationship between grain yield (t ha⁻¹) and filled grains panicle⁻¹ of rice cv. BR 23

Weight of 1000-grains

Nitrogen levels had significant effect on 1000-grain weight. Weight of 1000-grains was higher (22.84) at the rate of 100 kg N ha⁻¹ and lower (22.18) at the rate of 0 kg N ha⁻¹. The results showed a tendency to increase 1000-grain weight with the increased rates of nitrogen application (Table 4). The results are consistent with the report of Lawal and Lawal (2002), Chandrasekharan and Salam (1995) and Awan and coworkers (1984). Spacing also showed significant effect on 1000-grains weight. It was observed that spacing (20 cm × 15 cm) produced the highest 1000-grains weight (22.60 g) which was statistically similar to 25 cm × 20 cm spacing where the weight of 1000-grains was (22.28 g). However, the closest spacing 15 cm × 10 cm produced the lowest (21.27 g) in grain weight. Such variation might be due to the variations of supply of food materials and light for proper development of grains comparing closest to wider spacing.

The effect of interaction of nitrogen level and spacing on 1000-grains weight was not significant. The maximum 1000-grains weight (23.53 g) was obtained from 100 kg N ha⁻¹ with 20 cm × 15 cm spacing and the minimum (20.73 g) was obtained from 0 kg N ha⁻¹ and 15 cm × 10 cm spacing (Table 6). Regression analysis taking grain yield (t ha⁻¹) as depended variable and 1000-grain weight (g) as independent variable showed a positive and linear relationship (Fig. 9). This result suggests that grain yield increased with the increased of 1000-grain weight and more than 90% of the variation in yield would be justified by the variation in 1000-grain weight.

Grain yield

Grain yield of rice significantly influenced by Nitrogen application. The highest grain yield (4.57 t ha⁻¹) was obtained from 100 kg N ha⁻¹ which was statistically similar to 50 kg N ha⁻¹



and the lowest (2.56 t ha^{-1}) was obtained from control (Table 4). The application of nitrogen up to 100 kg N ha^{-1} registered an increased grain yield. Further increment of nitrogen level had no positive influence on grain yield. Increase in grain yield due to application of nitrogen in a certain level was mainly by the improvement of yield contributing characters like number of effective tillers hill^{-1} , panicle length, 1000-grain weight and number of filled grains panicle^{-1} . These results are in agreement with those obtained by Islam and co workers (1990). Spacing had significant effect on the grain yield (Table 5). The highest grain yield (4.40 t ha^{-1}) was obtained with $20 \text{ cm} \times 15 \text{ cm}$ spacing and the lowest grain yield (3.02 t ha^{-1}) was obtained with $15 \text{ cm} \times 10 \text{ cm}$ spacing (Table 5). The result therefore, indicated that wider or much closer spacing was not favorable for higher yield of rice. Grain yield decreased as spacing ($15 \text{ cm} \times 10 \text{ cm}$) become due to lower performance of yield attributes. Yield was also found to be decreased at wider spacing due to decreased number of hills unit^{-1} area as a result nutrients and place were not used properly. The moderate spacing $20 \text{ cm} \times 15 \text{ cm}$ was found to be the most suitable for good harvest of this crop. The results are in agreement with the results of Wei and coworkers (1986), Rao and coworkers (1990), and Azad and coworkers (1995).

The interaction effect of nitrogen level and plant spacing on grain yield was found significant. Apparently the highest grain yield (5.29 t ha^{-1}) was obtained from 100 kg N ha^{-1} with $20 \text{ cm} \times 15 \text{ cm}$ spacing. The lowest grain yield (2.32 t ha^{-1}) was obtained from control treatment with $15 \text{ cm} \times 10 \text{ cm}$ spacing (Table 6). Plotting grain yield against nitrogen levels expressed a non- linear (parabolic) relationship (Fig. 10). Results indicate that the yield response of the rice variety BR 23 to nitrogen fertilizers mean be adequately described by the quadratic equation ($y = -0.0002x^2 + 0.0414x + 2.6028$). The computed value ($R^2 = 0.990$)

indicates that 99% of the total variation in the mean yield was explained by the quadratic regression equation estimated.

Straw yield

Nitrogen levels had significant influence of straw yield (Table 4). The highest straw yield (4.61 t ha^{-1}) was obtained from 100 kg N ha^{-1} which was statistically similar to 50 kg N ha^{-1} (4.23 t ha^{-1}) and the lowest (2.55 t ha^{-1}) was produced in control (Table 4). Similar trend of straw yield was also reported by Kanda and Dixit (1996) and Chopra and Caopra (2000). It might be due to tremendous effect of N on vegetative growth specially the plant height and number of tillers hill^{-1} which contributed the highest production of straw yield ha^{-1} . The straw yield was significantly affected by different spacing. The highest straw yield (4.34 t ha^{-1}) was obtained with $20 \text{ cm} \times 15 \text{ cm}$ spacing which was statistically similar to $25 \text{ cm} \times 20 \text{ cm}$ spacing. The lowest straw yield (3.04 t ha^{-1}) was obtained from $15 \text{ cm} \times 10 \text{ cm}$ spacing (Table 5). Straw yield decreased at closer spacing $15 \text{ cm} \times 10 \text{ cm}$ due to lower plant height and decreased number of tillers hill^{-1} . Straw yield was also found to be decreased with wider spacing of $25 \text{ cm} \times 20 \text{ cm}$ due to decreased number of hills unit^{-1} area.

The interaction effect between nitrogen levels and spacing on straw yield significant. However, numerically the highest straw yield (5.38 t ha^{-1}) was obtained from 100 kg N ha^{-1} $20 \text{ cm} \times 15 \text{ cm}$ spacing and the lowest straw yield (2.38 t ha^{-1}) was obtained from control with $15 \text{ cm} \times 10 \text{ cm}$ spacing (Table 6). Grain yield (t ha^{-1}) when plotted against straw yield (t ha^{-1}) gave a straight line (Fig. 11) suggesting that grain yield was highly dependent on straw yield. When straw yield increased grain yield also increased and 99% of the variation ($R^2 = 0.99$) in yield could be explained

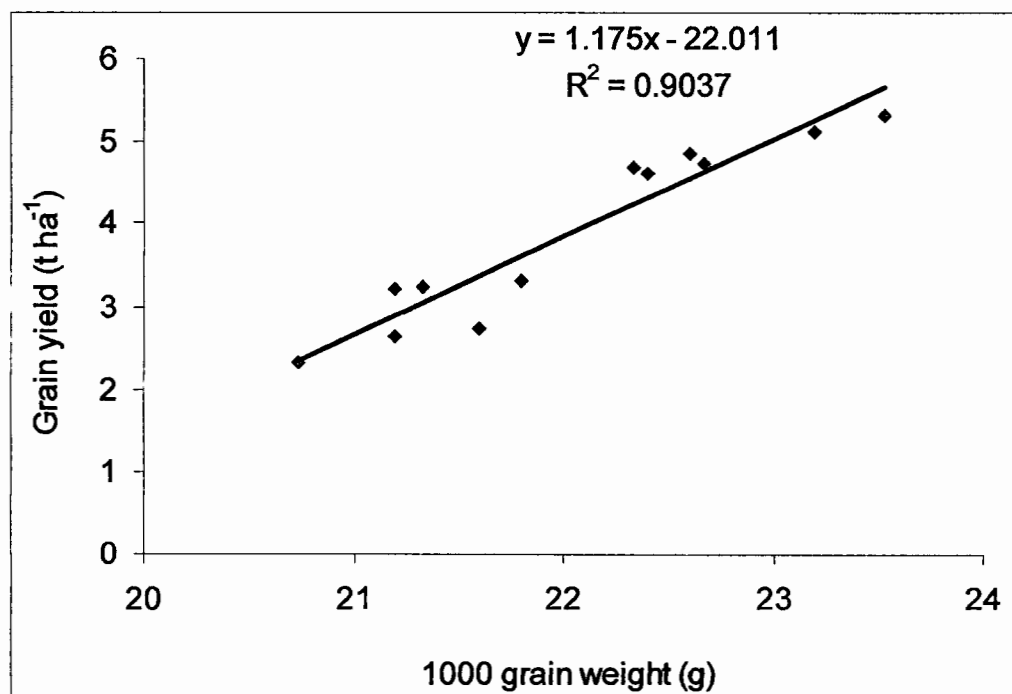


Fig. 9. Functional relationship between grain yield (t ha⁻¹) and 1000 grain weight (g) of rice cv. BR 23

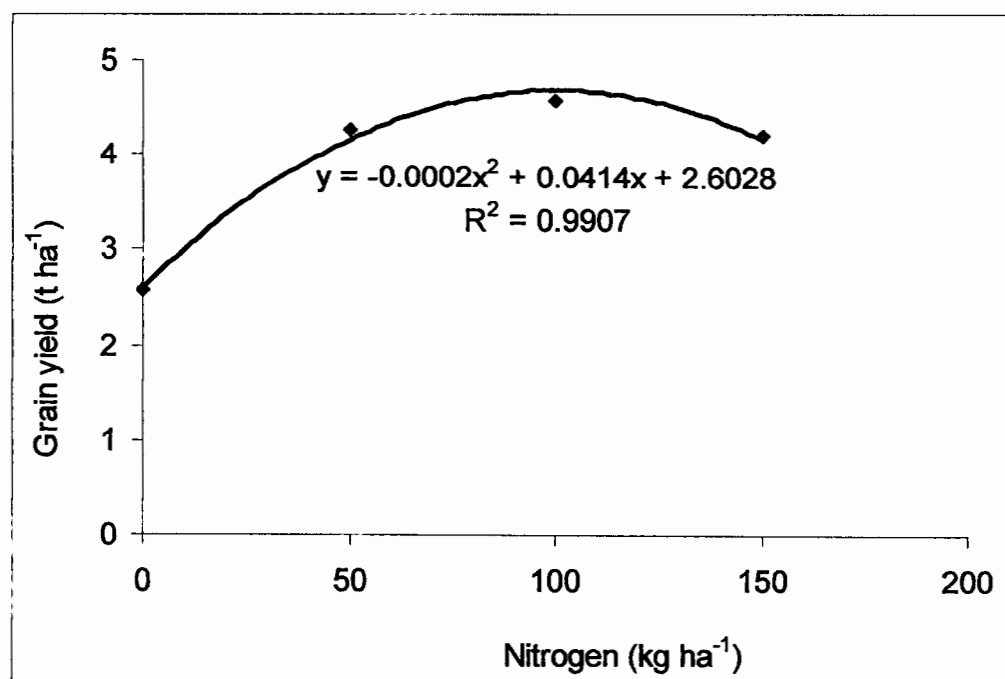


Fig. 10. Functional relationship between grain yield (t ha⁻¹) and nitrogen (kg ha⁻¹) of rice cv. BR 23

Harvest index (%)

The influence of nitrogen level on harvest index was found significant. The experimental results showed that the highest harvest index (50.22%) was obtained from (0 kg N ha⁻¹) and the lowest harvest index (49.80%) was found from 100kg N ha⁻¹ application (Table 4). The effect of spacing on harvest index was found significant. However, the results indicate that 20 cm × 15 cm produced the highest harvest index (50.53%) and the lowest (49.78%) was obtained from spacing 25 cm × 20 cm (Table 5). The effect of interaction between nitrogen levels and spacing on harvest index was also significant. The data revealed that highest harvest index (51.33%) was found with 0 kg N ha⁻¹ with 15 cm × 10 cm spacing and the lowest harvest index (49.38%) was found from control with 15 cm × 10 cm spacing (Table 6).

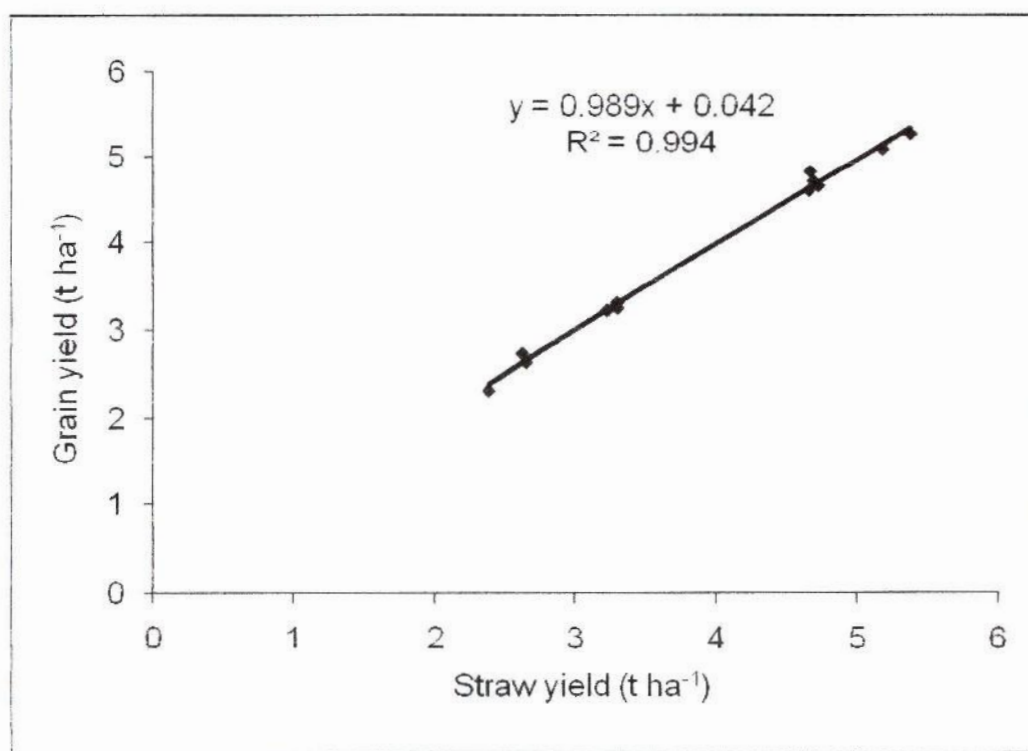


Fig. 11. Functional relationship between grain (t ha⁻¹) and straw yield (t ha⁻¹) of rice *cv.* BR 23

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the Farm of Agrotechnology Discipline of the Khulna University, during *Aman* season of 2007 to find out the effect of nitrogen levels and spacing on the yield of the transplant *aman* rice (cv. BR23). Four nitrogen levels namely 0, 50, 100, 150 kg N ha⁻¹ and three spacings, namely 15 cm×10 cm, 20 cm×15 cm, 25 cm × 20 cm were used as treatments. The experimental plot was fertilized with phosphatic, potassic, gypsum and zinc fertilizers @ 100, 70, 60 and 10 kg ha⁻¹ in the form of triple super phosphate (TSP), muriate of potash (MP) and gypsum and zinc sulphate, respectively. Urea as a source of nitrogen was applied as per experimental specification. The total amount of TSP, MP, gypsum and zinc sulphate were applied as basal dose whereas urea was applied as top dressing in three equal splits at 15, 35 and 55 DAT.

Thirty four day old seedlings were transplanted in the field. Intercultural operations such as gap filling, weeding, water management and pest management were done as and when necessary. Five hills (excluding border hills) from each plot were selected randomly for measuring plant height, counting number of total tillers hill⁻¹ and total dry matter production (TDM) at regular intervals of 30 DAT, 45 DAT, and 60 DAT. Hills (excluding border hills) were selected from area and uprooted from each unit plot prior to harvest for recording data on different crop characters. After sampling, the whole plots were harvested when 90% of the grains become golden yellow in color.

Data on different agronomic characters were recorded from the randomly selected five hills in each plot and the grain and straw yields were recorded from the whole plot. All the relevant data were analyzed using the analysis of variance (ANOVA) technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT).

Results of the experiment showed that different levels of nitrogen had significant effect on plant height, panicle length, total tillers hill⁻¹, effective tillers hill⁻¹, filled grains panicle⁻¹, unfilled grains panicle⁻¹ grain yield (t ha⁻¹) and straw yield (t ha⁻¹). Plant height, number of total tillers hill⁻¹ and total dry matter hill⁻¹ were found to be increased with increasing level of nitrogen at all sampling dates. Most of the crop characters under study were increased with the increase of nitrogen levels from 0 to 150 kg ha⁻¹. Highest effective tillers hill⁻¹ (12.31), weight of 1000- grain (22.84 g), grain yield (4.574 t ha⁻¹), and straw yield (4.61 t ha⁻¹) were obtained with 100 kg N ha⁻¹. The highest panicle length (26.02 cm) and unfilled grains panicle⁻¹(22.84) were obtained with 150 kg N ha⁻¹.

The effect of spacing was significant on plant height (cm), panicle length (cm), total tillers hill⁻¹, effective tillers hill⁻¹, filled grains panicle⁻¹, unfilled grains panicle⁻¹, grain yield (t ha⁻¹) straw yield (t ha⁻¹) and harvest index (%). The widest spacing (25 cm × 20 cm) produced the higher panicle length (26.08 cm) and unfilled grains panicle⁻¹(21.44). The highest number of grain yield (4.40 t ha⁻¹) and straw yield (4.34 t ha⁻¹) were found with the spacing 20 cm × 15 cm.

The interaction effect between nitrogen levels and spacing was found significant in respect of all the parameters studied. The highest number of effective tillers hill⁻¹ (13.60) and grains panicle⁻¹ (121.3) was found from 100 kg N ha⁻¹ with 20 cm × 15 cm spacing. The highest panicle length (27.20 cm) was found at 150 kg N ha⁻¹ with 25 cm × 20 cm spacing. The highest harvest index (50.96%) was obtained with 50 kg N ha⁻¹ with (20 cm × 15 cm) spacing.

The lowest plant height (100.8 cm), effective tillers hill⁻¹ (8.13), panicle length (23.27 cm), filled grains panicle⁻¹(76.33), unfilled grains panicle⁻¹(17.93) and 1000 grain weight (20.73 g) were obtained from the control treatment (0 kg N ha⁻¹) with closest spacing 15 cm × 10 cm.

From the results of the study, it could be concluded that the grain yield of transplanted aman rice (cv.BR 23) increased with the application of 100 kg N ha⁻¹ with 20 cm × 15 cm spacing and declined there after. Therefore, it may be concluded that rice BR 23 variety should be fertilized with 100 kg N ha⁻¹ and transplanted with 20 cm × 15 cm for higher grain yield per unit area during *aman* season.

CHAPTER VI

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