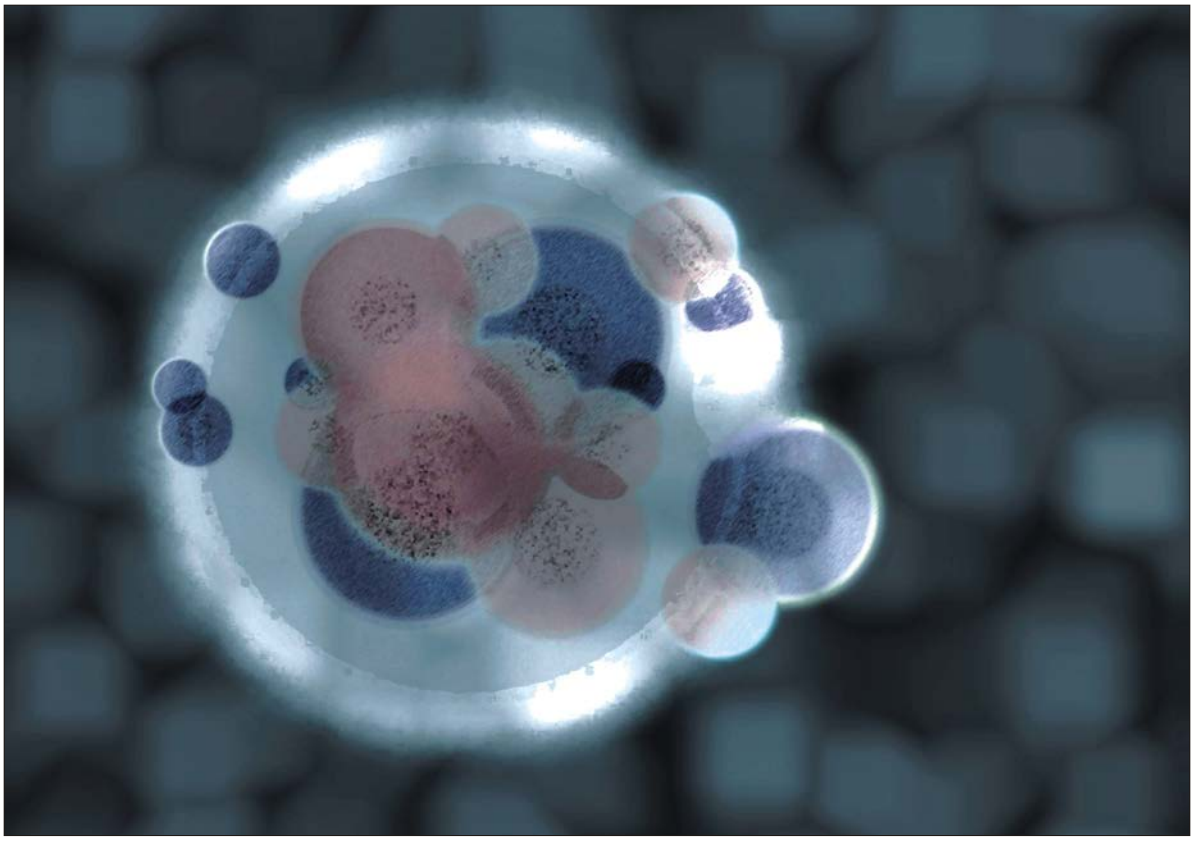

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Effect of Number of Seedling per Hill and Urea Supergranules on Growth and Yield of the Rice cv. BINA Dhan4

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Abstract: A field experimental was conducted at the farm of Bangladesh Institute of Nuclear Agriculture (BINA) during July to November 1999. The objective was to see the effect of four levels of seedling hill^{-1} viz., 1, 2, 3 and 4 and two forms of nitrogen fertilizer-urea and USG on growth, yield and yield components of transplant *aman* rice cv. BINA Dhan4. The experiment was laid out in a split-plot design with three replications. The plots were fertilized @ 15, 40, 10, 1 kg ha^{-1} of PKSZn, respectively one day before transplanting. Urea was top dressed @ 80 kg ha^{-1} in three equal splits at 10, 30 and 50 DAT. The USG was placed at 5-8 cm depth at 10 DAT @ 2 granules in the center of four hills in alternate rows to supply 80 kg N ha^{-1}. Thirty-five day-old seedlings were transplanted on 19 August 1999. Results of mean effect of number of seedling hill^{-1} on growth parameters showed that plant length (141.31 cm) at 91 DAT and total tillers (13.06 hill^{-1}) at 30 DAT were maximum with 1 and 4 seedlings hill^{-1}, respectively. The LAI of 4 seedlings hill^{-1} treatment had the highest value (5.22) at 63 DAT. Total dry matter (46.82 g hill^{-1}) was the maximum at 91 DAT when the crop was transplanted at 4 seedlings hill^{-1}. The mean effects of forms of nitrogen fertilizer showed that USG had significant effect on all growth parameters at all samplings except LAI and number of total tillers hill^{-1} at 30 DAT. The interaction effects on growth parameters did not varied significantly. Most of the growth parameters at all levels of seedling hill^{-1} gave higher values with USG than those with urea. The yield contributing characters like effective tillers hill^{-1}, number of spikelets panicle^{-1} and number of filled grains panicle^{-1} were maximum with single seedling hill^{-1} and the values were 8.3, 140.1 and 109.6, respectively. The highest grain yield was 5.71 t ha^{-1} with single seedling hill^{-1} which was statistically similar to 2 seedlings hill^{-1} (5.56 t ha^{-1}) but differed from 4 seedlings hill^{-1}. The lowest yield was with 3 or 4 seedlings hill^{-1} but number of total tillers hill^{-1} (12.6) and straw yield (8.20 t ha^{-1}) were significantly higher with 4 seedlings hill^{-1} than 1 or 2 seedlings hill^{-1}.

Key words: Rice, seedling, ureasupergranules, growth, yield

INTRODUCTION

Horizontal expansion of rice area is not possible in Bangladesh due to limited land resources and high population density. So the only avenue left is to increase production of rice by vertical means i.e, management practices. Planting density as a management practice in transplanted rice culture constitutes the number of seedling per hill or hills per unit area. Number of productive tillers and their proper growth both quantitative and qualitative are greatly influenced by number of seedling per hill. Optimum seedlings per hill enable the rice plant to grow properly both in its aerial and underground parts by proper utilizing maximum radiant energy, nutrients, space and water[1]. Excess or less number of seedlings per hill may badly affect the normal physiological activities. Excess number of seedling per hill may produce more tillers resulting in mutual shading, lodging and lead to production of more straw instead of grain. While the least number of seedlings per hill may produce insufficient tiller, thus keeping space and nutrients unutilized resulting in less number of panicles per unit area leading to poor yield. On the other hand, among the plant nutrients, nitrogen is the most limiting nutrient for growing rice[2]. Its use efficiency lies between 25 and 35% when it is applied as urea and seldom exceeds 50%[3]. Broadcast application of urea on the surface soil causes losses up to 50%. But point placement of urea supergranules in 5-10 cm depth of soil root zone of rice plant is the most effective method which results negligible

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loss and increases its use efficiency and rice yield[4-6]. The soil and climate of Bangladesh are favorable for growing rice throughout the year. But her per hectare yield is very low compared to potential yield. So far a number of high yielding varieties (HYV) have been developed. These high yielding varieties involved high cost for inputs like chemical fertilizers, irrigation and pesticides but poor farmers of Bangladesh are not always able to afford them. In the present experiment the management practices such as number of seedling per hill and urea supergranules compared to prilled urea was evaluated to see its effects on growth and yield of the newly developed HY rice cultivar BINA Dhan4.

MATERIALS AND METHODS

The experiment was conducted at the field of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during the period from July to November 1999. The field soil was silty loam, pH 6.2 and located in the agro-ecological zone, AEZ-9. The rice cultivar BINA Dhan4 a high yielding transplanted *aman* cultivar developed by BINA was used as plant material. The treatments comprised of two factors viz., (A) number of seedling per hill, four levels- one seedling (S1), two seedlings (S2), three seedlings (S3) and four seedlings (S4) per hill and (B) forms of nitrogen fertilizer, two levels prilled urea (PU) and urea supergranules (USG). The experiment was laid out in a split plot design with three replications, placing factor A in the main plot and B in sub-plot. The unit plot size was 3.75x3.30 m. The main and sub-plots were separated from one another by 1 and 0.5 m, respectively. The plots were fertilized @ 80, 15, 40, 10 and 1 kg ha^{-1} of N, P, K, S and Zn from the sources of prilled urea/ USG, triple super phosphate, muriate of potash, gypsum and zinc oxide, respectively and all fertilizers except N were applied one day before transplanting. The nitrogen fertilizer urea was top dressed in three equal splits at 10 days after transplanting (DAT), 30 DAT and 50 DAT. The USG weighing 1 g each were placed at 5-10 cm soil depth at 10 DAT in the center of four hills in alternate rows @ 2 granules in one spot to supply 80 kg N ha^{-1}. Thirty five day-old seedlings were transplanted giving 1, 2, 3 and 4 seedlings $hill^{-1}$ according to treatments on August 10,1999 with a planting spacing of 20x15 cm. A herbicide named Goltir 5G, product of Relige India and marketed by Auto-equipment Ltd., Bangladesh, was applied @35 kg ha^{-1} at 3 DAT for controlling weed. In addition, one hand weeding was also done at 35 DAT. Irrigation was provided to keep the standing water about 2-3 cm depth in the field except for a dry period of one week from 40 DAT. The field water also drained out when about 80% of the panicles became golden yellow.

Growth and dry matter production data were recorded by sampling three average hills of 10 randomly counted hills excluding the border hills from each plot at active tillering, around panicle initiation, full heading and maturity stages on 30, 42, 63 and 91 DAT. Data on growth parameters like plant height, number of tillers $hill^{-1}$ and leaf area were recorded immediate after sampling. The dry matter weights of leaves, leaf sheath+stems and or panicles were taken after drying in oven at 80±5°C for 48 h. These data were then summarized in tabular form and statistical analyses were performed. For recording yield data, 30 random hills from undisturbed area of each plot were harvested at maturity cutting by sickle at base. Five random hills among them were used to record plant height, yield and yield components like total tillers $hill^{-1}$, productive tillers $hill^{-1}$, panicle length, total spikelets $panicle^{-1}$, grains i.e, filled grains $panicle^{-1}$, percentage of filled grain etc. The rest 25 hills were threshed, dried and winnowed and finally by weighing plot yields of grain and straw were found out. The weight of 1000 grains was recorded from the composite grain yield of 25 hills. These data were then converted to per unit basis and finally statistical analyses were done by the computer program M-STAT. The mean differences among the treatments were adjudged by Duncan`s multiple range test[7].

RESULTS AND DISCUSSION

Results obtained from the experiment were presented and discussed mainly on the mean effects of both number of seedlings per hill and forms of N fertilizer. As interactions showed almost no statistical significant differences, interaction results were discussed very shortly without showing Tables or graphs.

Effects on vegetative characters during growth phases

Plant length: The plant length data observed on different days after transplanting showed that the length were higher with lower number of seedling $hill^{-1}$. The highest plant length at maturity on 91 DAT was 141.7 cm with one seedling $hill^{-1}$ (Fig. 1A) while the least was with four seedlings $hill^{-1}$ irrespective of forms of nitrogen fertilizer on the same day. These results are in corroborate with those of Shah *et al.*[8] who obtained higher plant length with lower number of seedling $hill^{-1}$ in rice. The results also revealed that the plants those received N in the form of USG had always maintained higher plant length compared to urea (Fig. 1B). It might be due to continuous availability of N from the deep placed USG that released N slowly and it enhanced growth more than urea. The

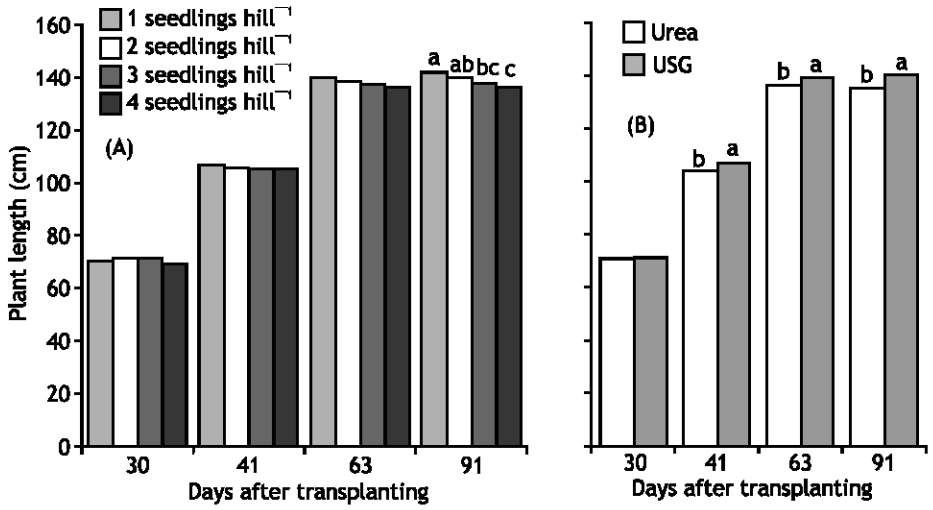

Fig. 1: Effects of number of seedling hill^{-1} (A) and form of nitrogen fertilizer (B) on plant length of the rice cv. BINA Dhan4 at different days after transplanting. The columns within same date with no or same letters do not differ significantly while with dissimilar letters differed significantly according to DMRT (P>0.05)

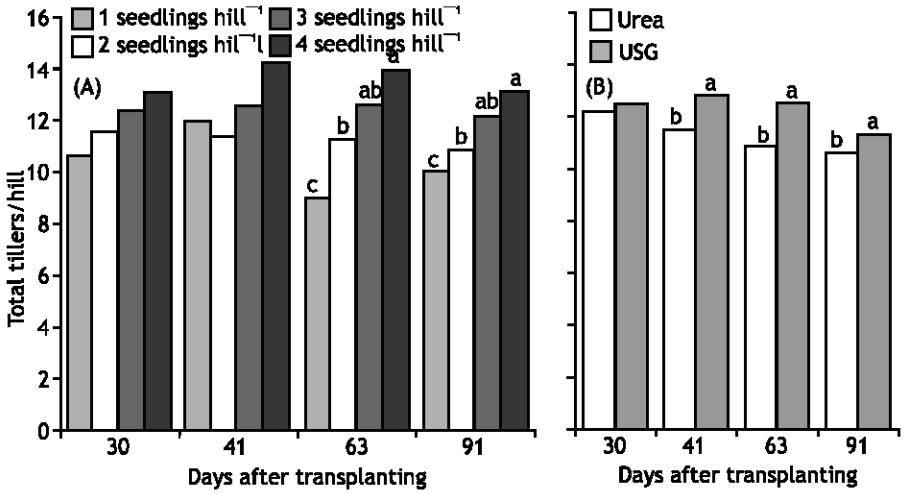

Fig. 2: Effects of number of seedlings hill^{-1} (A) and form of nitrogen fertilizer (B) on total tillers/hill of the rice cv. BINA Dhan4 at different days after transplanting. The columns within same date with no or same letters do not differ significantly while with dissimilar letters differed significantly according to DMRT (P>0.05)

results are in agreement with those of Singh and Singh[10] who reported that USG produced taller plants than prilled urea when applied @ 27 to 87 kg N ha^{-1}. Although interaction data showed no statistical significant variation among treatment combination but single seedling hill^{-1} with USG produced longer plant than higher number of seedlings hill^{+} .

Total tiller: Total tillers hill^{-1} recorded during the period 30-91 DAT showed significant variation only at full heading on 63 DAT and at maturity on 91 DAT due to number of seedling per hill. The four seedlings hill^{-1} treatment produced 13.87 and 13.08 tillers hill^{-1} at 63 and 91 DAT, respectively while on the same days the least number of tillers were observed with single seedling hill^{-1}. Maximum number of total tillers hill^{-1} in all the seedling per hill treatments were observed at 30 DAT and then with advancement to age it declined up to 91 DAT (Fig. 2A). These results are in agreement with the findings of Pataniswamy and Gomez[9] who found that number total tillers hill^{-1} increased with increasing number of seedling hill^{-1}. Forms of N fertilizer affected tiller production significantly at all observations of growth period except at 30 DAT. The USG applied plots always produced higher number of total tiller hill^{-1} irrespective of number of seedling hill^{-1} (Fig. 2B). Singh and Singh[10],

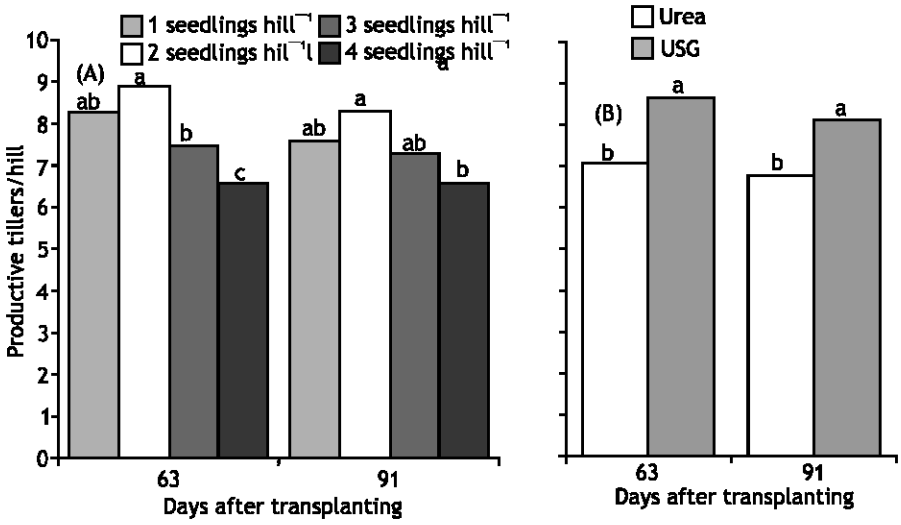

Fig. 3: Effect of number of seedlings hill^{-1} (A) and form of nitrogen fertilizer (B) on productive tillers/hill of the rice cv.BINA Dhan4 at 63 DAT (heading) and 91 DAT (maturity). The columns within same date with no or same letters do not differ significantly while with dissimilar letters differed significantly according to DMRT (P>0.05)

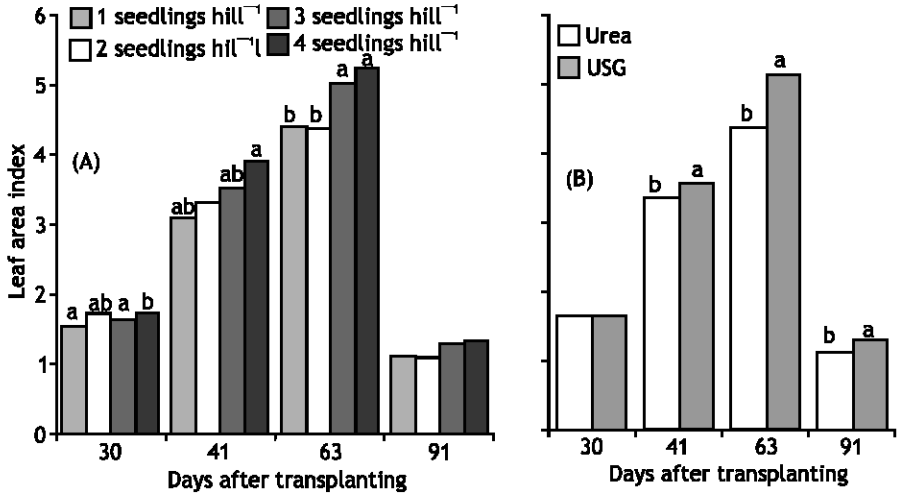

Fig. 4: Effects of number of seedlings hill^{-1} (A) and form of nitrogen fertilizer (B) on leaf area index of the rice cv. BINA Dhan4 at different days after transplanting. The columns within same date with no or same letters do not differ significantly while with dissimilar letters differed significantly according to DMRT (P>0.05)

Mirzeo and Reddy[11] also reported similar results. In all samplings, it was observed that total tillers hill^{-1} with USG were higher than those of urea and at the same time number of tillers hill^{-1} increased with increasing number of seedlings hill^{-1}. It could also be noticed from the Fig. 1A and B that number of tillers attained its maximum value at 42 DAT and thereafter it gradually declined till 91 DAT.

Productive tiller: Total tillers determine the amount of dry matter production per unit area while productive tillers per unit area determine the final yield of rice. This is why it is said that the higher the effective tillers, the higher the yield. Both number of seedling hill^{-1} and forms of N fertilizer significantly affected productive tiller production. Single or two seedlings hill^{-1} produced the highest productive tillers (8.30 or 8.91) at full heading on 63 DAT and at maturity (7.56 or 8.30) on 91 DAT compared to three or four seedlings hill^{-1} (Fig. 3A and B). It might be due to less competition for vital resources like nutrients, water, light and air that enhanced better growth for the plots of single or two seedlings hill^{-1}. On the other hand, the plots transplanted with three or four seedlings hill^{-1} produced more total tillers (Fig. 2A and B) but lower

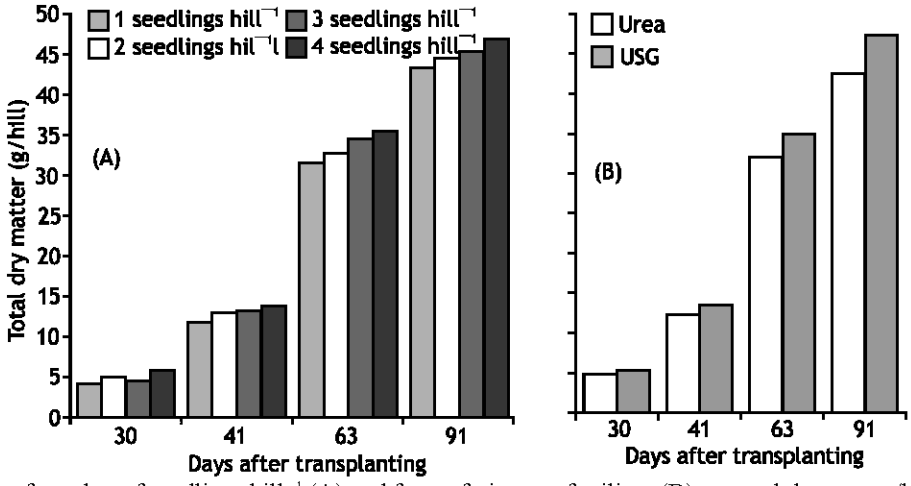

Fig. 5: Effects of number of seedlings hill^{-1} (A) and form of nitrogen fertilizer (B) on total dry matter/hill of the rice cv. BINA Dhan4 at different days after transplanting. The columns within same date with no or same letters do not differ significantly while with dissimilar letters differed significantly according to DMRT (P>0.05)

productive tillers (Fig. 3A and B). It might be due to unavailability of sufficient nutrients, light and also mutual shading by large number of total tillers, caused decaying of weak tillers and finally reduced the productive tillers. In the present study productive tillers in 1-3 seedlings hill^{-1} did not vary statistically while it differed significantly from 4 seedlings hill^{-1}. Nitrogen in the form of USG resulted in higher productive tillers hill^{-1} (8.63 at full heading and 8.10 at maturity) compared to urea split application (Fig. 3B). It was in agreement with Rama *et al.*[16] who reported that USG produced higher number of panicles m^{-2} than split application of urea.

Leaf area: Number of seedling hill^{-1} had remarkable influence on leaf area index (LAI). The LAI as a normal phenomenon increased with the advancement of plant age but it attained its peak (5.22) with 4 seedlings hill^{-1} at full heading stage on 63 DAT (Fig. 4A). There were significant variations among different seedling per hill treatments observed at each sampling irrespective of forms N fertilizer. Although there was no statistically difference of LAI observed at 30 DAT due to forms of N fertilizer but LAI was significantly higher in USG receiving plots than urea at heading. However, after heading LAI declined due to senescence of leaves with the progress to maturity in both the forms of N fertilizer. Yoshida[12] reported that LAI gradually reached at its peak at around flowering and then started to decline with the advancement of maturity. In the present experiment it showed similar pattern but LAI of USG plots remained always higher than urea at all stages of sampling (Fig. 4A and B). The higher LAI due to USG obviously caused by higher number of tillers as well as growth enhancement of leaves by a steady supply of N from USG. Numerically the highest LAI was recorded with the treatment combination of 4 seedlings hill^{-1} x USG while the least was from 1 seedling hill^{-1} x urea at maturity.

Total dry matter production: Total dry matter (TDM) excluding root i.e, leaves, leaf sheath+stem and or panicles data taken at different growth phases indicated that it increased with increasing number of seedling transplanted hill^{-1}. The maximum TDM was 46.82 g hill^{-1} recorded at maturity on 91 DAT with 4 seedlings hill^{-1} (Fig. 5A). Total dry matter produced at different dates showed the trend of 1 seedling<2 seedlings<3 seedlings<4 seedlings hill^{-1}. This higher TDM with 4 seedlings hill^{-1} might be the out come of higher number of total tillers produced by this treatment. The TDM production was affected significantly by the forms of N fertilizer. It could be observed from the Fig. 3B that at each sampling, USG applied plots gave higher TDM compared to urea irrespective of number of seedling transplanted hill^{-1}. At the same time it could also be noticed that the difference between treatments for TDM was narrower at early growth stages but became larger in later stages. This might be due to the fact that USG receiving plants got continuous supply of N and plants could better utilize it and growth parameters were positively responded to it. Rao *et al.*[13] and Rambabu *et al.*[14] from their study concluded that USG was the most effective in increasing TDM than split application of urea.

Effects on yield and yield components

Number of panicles: Number of seedling hill^{-1} affected significantly the number of panicles per hill. The highest

Table 1: Effect of number of seedlings hill^{-1} and forms of nitrogen fertilizer on yield and yield contributing characters of transplant *aman* rice (cv. BINA Dhan4)

Treatment	Panicles hill^{-1} (No.)	Panicle length (cm)	Number of spikelets panicle^{-1} (No.)	Number of grains panicle^{-1} (No.)	Percentage of filled grain	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Number of seedlings hill^{-1}									
1	7.60ab	27.40	140.07a	109.59a	78.87	5.71a	7.28c	12.99ab	43.96a
2	8.31a	26.84	138.77a	108.14ab	79.15	5.56a	7.57bc	13.13a	42.35a
3	7.36ab	26.47	133.92b	105.10c	76.95	4.57b	7.98ab	12.55b	36.42b
4	6.71b	26.61	133.16b	105.54bc	78.57	4.37b	8.19a	12.56b	34.80b
Level of significance	0.05	NS	0.01	0.05	NS	0.01	0.05	0.05	0.01
Forms of N-fertilizer									
Urea	6.83b	26.83	135.63	105.61b	78.38	4.90b	7.37b	12.27b	39.94
USG	8.16a	26.84	137.33	108.59a	78.39	5.20a	8.14a	13.34a	39.01
Level of significance	0.01	NS	NS	0.05	NS	0.05	0.01	0.01	NS

In a column, figures with no or common letter (s) do not differ significantly while with dissimilar letters differ significantly at 5 or 1% level of significance according to DMRT, NS = Non significant, DAT = Days after transplanting, USG = Urea supergranules

number of panicles (8.31 hill^{-1}) was recorded with one seedling hill^{-1} and the least was (6.71 hill^{-1}) with four seedlings. On the other hand, urea super granules form of N produced the maximum number of panicles (8.16 hill^{-1}) while urea applied plot had 6.83 panicles hill^{-1} irrespective of seedlings hill^{-1} (Table 1). These results are similar to Jee and Mahapatra[15], Singh and Singh[10] who mentioned that panicles m^{-2} was significantly higher with 90 kg N ha^{-1} in the form of USG over the same quantity of urea applied in splits. Rama *et al.*[16] also reported that USG when applied @40-120 kg as N ha^{-1} produced more panicles than the same amount of urea split application.

Panicle length: Neither the number of seedling hill^{-1} nor the form of N fertilizer exerted statistically significant influence on panicle length (Table 1). It might be due to inherent characters of the variety that might not be much changed by cultural treatment although there were numerical variations. Sen and Pandey[17] found similar panicle length by applying 38.32 kg N ha^{-1} either in the form of USG or prilled urea. However, in the present experiment numerically the longest panicle (27.46 cm) was obtained in the treatment combination of 1 seedling hill^{-1} x USG and the shortest in 3 seedlings hill^{+} x urea.

Number of spikelets panicle^{-1}: The highest and the lowest number of spikelets panicle^{-1} were 140.07 and 133.16, respectively observed with 1 seedling and 4 seedlings transplanted hill^{-1}. There was no statistical variation observed on number of spikelets panicle^{-1} due to form of N fertilizer (Table 1). However, numerical variation was noticed. Apparently the treatment combination of 1 seedling hill^{-1} x USG had the maximum number of spikelets panicle^{-1} while 4 seedlings hill^{-1} x urea produced the least.

Number of grains panicle^{-1} and percentage of filled grains: Number of seedling transplanted hill^{-1} significantly affected number of filled grains i.e. grains panicle^{-1}. It showed a decreasing trend with increasing number of seedling transplanted hill^{-1} and vice versa. The maximum number of grains panicle^{-1} was 109.6 with 1 seedling hill^{-1} and the minimum was 105.1 with 3 seedlings hill^{-1} (Table 1). The results are consistent with those of Shah *et al.*[8] who reported that grains panicle^{-1} increased with decreasing number of seedlings transplanted hill^{-1}. Forms of N fertilizer had also significantly affected grains panicle^{-1}. Results presented in Table 1 showed that higher number of grains panicle^{-1} was obtained with USG than urea. Rama *et al.*[18] found significantly higher filled grains panicle^{-1} with 40, 80 or 120 kg N ha^{-1} applied as USG over split application of urea. The present results support those results. Percentage of filled grain did not show statistically significant variation due to seedlings transplanted hill^{-1} or by the forms of N fertilizer (Table 1). However, it ranged 76.81% in 3 seedlings hill^{-1} with USG to 79.35% in 2 seedlings hill^{-1} with USG.

Grain yield: The number of seedling hill^{-1} treatment affected grain yield significantly. Data revealed that the highest grain yield (5.71 t ha^{-1}) was obtained by 1 seedling hill^{-1}, which was statistically similar to the yield of 2 seedlings hill^{-1} (5.56 t ha^{-1}). More than 2 seedlings hill^{-1} produced significantly lower yields (Table 1). The results are similar to the findings of Shahi and Gill[18] who reported the highest yield in 20x20 cm spacing by planting 1 seedling hill^{-1}. However, Pillai *et al.*[19] reported that 2 or 3 seedlings hill^{-1} at 15x10 cm spacing produced the highest paddy yield. The present results also confirmed that 1-2 seedlings hill^{-1} produced the highest yield with the spacing of 20x15 cm. Ramasamy *et al.*[20] reported that yield decreased with more than 2 seedlings hill^{-1} which was similar to the findings of present study. However, report of Banik *et al.*[21] was inconsistent with the present results who reported that grain yield increased with

increasing number of seedlings. The higher yields with 1-2 seedlings hill^{-1} of the present experiment were mainly contributed by higher number of panicles hill^{-1}, spikelets panicle^{-1} and filled grains panicle^{-1} (Table 1). Grain yield varied significantly due to the forms of N-fertilizer. Higher mean grain yield (5.20 t ha^{-1}) by urea supergranules irrespective of number of seedling hill^{-1} indicated its superiority over split application of urea (4.90 t ha^{-1}). Placement of nitrogen fertilizer in the form of USG @ 80 kg N ha^{-1} in the present experiment produced the highest number of panicles hill^{-1}, spikelets panicle^{-1}, filled grains panicle^{-1} which ultimately gave higher grain yield than split application of urea. Similar results were reported by Raju *et al.*[22] who observed that among all the forms of N, urea supergranules recorded the highest grain yield and proved significantly superior to other sources. They also reported about 14.7% higher yield due to USG over split application of urea. In the present experiment we found 6.12 % higher mean yield in USG over urea irrespective of number of seedling hill^{-1}. Superiority of deep placement of USG over split application of urea in respect of yield had been reported by many other researchers[23,24,25,26,29]. The interaction between number of seedling hill^{-1} and forms of N-fertilizer could not produced significant variation on yield. However, apparently the highest grain yield (5.94 t ha^{-1}) was produced by the treatment combination of 1 seedling hill^{-1} x USG and it was followed by 2 seedlings hill^{-1} x USG (data were not shown). It was also observed that grain yield decreased when more than 2 seedlings hill^{-1} was transplanted but the yield of USG receiving plots were yet produced higher than those with urea applied plots.

Straw yield: The maximum straw yield (8.19 t ha^{-1}) was observed with 4 seedlings hill^{-1} and the minimum (7.27 t ha^{-1}) was from 1 seedling hill^{-1} (Table 1). The higher straw yield with four seedlings hill^{-1} was mainly due to higher number of total tillers hill^{-1}. The other possible reasons were that they could produce more biomass but mutual shading hampered translocation of enough food materials from body to growing panicles and thus favor the production of more straw instead of grain. On the contrary, 1 seedling hill^{-1} though produced lower number of total tillers hill^{-1} compared to 4 seedlings hill^{-1} but produced more effective tillers which bore panicles and growing panicles received more stored matter from stems and as a result straw yield was lower. These results are in agreement with the findings of Mian and Gaffer[27] who reported that straw yield increased with the increasing number of seedling hill^{-1} from 1 to 4. Karim *et al.*[28] also reported that 4 seedlings hill^{-1} produced higher straw than 1 seedling hill^{-1}. The mean straw yield due to form of N fertilizer revealed that straw yield was the highest (8.14 t ha^{-1}) in urea supergranules. Mirzeo and Reddy[11] also observed that urea supergranules in rice gave significantly higher straw yield than split application of prilled urea. Although straw yield did not differ significantly due to interaction of number of seedling hill^{-1} and forms of nitrogen fertilizer, apparently, the highest straw yield (8.55 t ha^{-1}) was obtained from the treatment combination of 4 seedlings hill^{-1} x USG and the lowest one (6.93 t ha^{-1}) was from the treatment combination of 1 seedling hill^{-1} x urea (data were not shown).

Harvest index (%): The results presented in the Table 1 showed that the maximum harvest index (43.99%) was obtained from 1 seedling hill^{-1}, which was statistically similar to 2 seedlings hill^{-1}. On the other hand, the minimum harvest index (34.83%) was obtained from 4 seedlings hill^{-1} which was statistically similar to 3 seedlings hill^{-1}. One seedling produced higher grain yield compared to straw. This resulted in higher harvest index than those of 3 or 4 seedlings hill^{-1}. Forms of nitrogen fertilizer had exerted very little variation on harvest index and it was 39.87% in urea supergranules and 38.96% in urea.

In conclusion it could be suggested that transplanting 1 or 2 seedlings hill^{-1} and N fertilizer in the form of USG was found to be a promising practice for good yield of the newly developed transplant *aman* rice cv. BINA Dhan4.

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