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Effect of Seedling Age and Nitrogen Fertilizer on Growth, Chlorophyll Content, Yield and Economics of Hybrid Rice (*Oryza sativa* L.)

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Abstract

A field experiment was conducted during kharif season of 2010 and 2011 to investigate the optimization of nitrogen levels under different age of seedlings transplanted on growth, chlorophyll content, yield and economics of hybrid rice. Fifteen treatment combinations consisted of three levels of seedlings age (10, 20 and 30 days) and five levels of nitrogen viz. N_0, N_{50}, N_{100}, N_{150} and N_{200} kg ha^{-1}. Seedlings age had marked effect on all the growth, chlorophyll content and yield attributing traits. Transplanting of 10 days seedlings showed significantly highest grain yield of 5575 and 5946 kg ha^{-1} in 2010 and 2011, respectively. The percentage of grain yields an increase of 10.7 and 21.3 per cent in first year and 10.6 and 21 per cent in second year over 20 and 30 days seedlings respectively. Among of the nitrogen levels N_{200} kg ha^{-1} gave significant higher Plant height, panicle initiation, Number of tillers hill^{-1}, total chlorophyll content, panicle length and straw yield and nitrogen levels N_{150} kg ha^{-1} gave significant higher Number of effective tillers^{-1}, effective tiller index, panicle weight, filled grain panicle^{-1}, 1000 grain weight, grain yield, and harvest index as compared to N_0, N_{50}, N_{100} during both years. N_{150} kg ha^{-1} produced significantly highest grain yield of 6286 and 6652 kg ha^{-1} in 2010 and 2011, respectively. The percentage of grain yields an increase of 72.5, 44.4, 23.8 and 5.1 per cent in first year and 69.9, 44.1, 22.1 and 3.5 per cent in second year over N_0, N_{50}, N_{100} and N_{200} kg ha^{-1} respectively.

Keywords: Hybrid rice, Age of seedlings,Nitrogen, Grain yield.

Introduction

Without having any scope to bring more area under rice, the only option left is higher productivity per unit area to meet the demand of increased rate of population. Increase production of rice is an important requirement to meet the needs of over increasing population in World. With limited cultivated area it is necessary to increase the productivity per unit area. Growing of hybrid rice is an appropriate strategy to increase the yield potentiality of rice to help the world to meet the future projected demand. Rice hybrids have a mean yield advantage of 10-15% over inbred varieties (Li, 1981 and Yang and Sun, 1988). Growth and development processes associated with higher grain yields of rice hybrids include a more vigorous and extensive root system (Li, 1981 and Yang and Sun 1988), increased growth rate during vegetative growth (Yamauchi 1994), more efficient sink formation and greater sink size (Kabaki, 1993), greater carbohydrate translocation from vegetative plant parts to the spikelets (Song *et al*., 1990), and larger leaf area index (LAI) during the grain-filling period, but the physiological basis for heterosis remains unknown (Peng, 1998). The age of seedling had a significant effect on number of grains per panicle (Hariomrk and Singh, 1989). Kim *et al*. (1999) observed that 10-day old seedlings had more vigorous stem elongation and higher tillering ability compared with 15- and 40-day old seedlings. It was observed that the tiller production was higher among 30-day old seedlings transplanted in *kharif* season than others (Khatun 1995). Modern production agriculture requires efficient, sustainable, and environmentally sound management practices. Nitrogen is normally a key factor in achieving optimum lowland rice grain yields (Fageria *et al*. 1997). It is also a prime nutrient for protein and carbohydrate synthesis, growth and development of plant body. Hybrid rice responds in variably to nitrogen nutrition. The effect of nitrogen on rice growth and grain productivity are derived from several bio-chemical, physiological and morphological processes in the plant system. It is, however, one of the most expensive inputs and if used improperly, can pollute the ground water. Increasing rice yield per unit area through use of appropriate N management practices has become an essential component of modern rice production technology (Fageria and Baligar 2001). Traditionally, the optimum rate of N-fertilization has been the rate that results in maximum economic yield. Required optimum N rate varies with soil type, yield potential of cultivar, levels of phosphorus (P) and K in the soil, water management practices, and intensity of diseases, insects, and weeds. However, rate of fertilizer application is also governed by socio-economic factors. Such factors are production cost, economic situation of the farmers, efficiency of extension service, and availability of credit to the growers. Use of adequate N rate is important not only for obtaining maximum economic return, but also to reduce environmental pollution (Fageria and Baligar 2003).

Materials and Methods

Experimental Site

A field experiment was conducted during the *kharif* season of 2010 and 2011 to investigate the optimization of nitrogen levels under different age of seedlings transplanted on growth, chlorophyll content, yield and economics of hybrid rice at the adjacent area of the farm of the Institute of Agriculture (Palli Siksha Bhavana), Visva-Bharati, Sriniketan, West Bengal. The place is situated at $23^0 39'$ N latitude, $87^0 42'$ E longitude and an elevation of 58.9 m above mean sea level. Normally the area received about 1000 mm rainfall during the *kharif* season (July to October). But there was low rainfall during the crop season of both the years (672 mm in 2010 and 720 mm in 2011). The deficiency in rainfall was 32.2% in 2010 and 27.4% in 2011 (Figure 1). Temperature ranging from 16.60 to 34.09 and 19.12 to 34.70 ^{0}C, relative humidity ranging from 66.49 to 91.74% and 75.03 to 89.65 % and total bright sunshine of 111.07 hours and 113.79 hours prevailed during the crop periods of 2010 and 2011 respectively. The soil of the experimental plot was sandy loam in texture (60.0% sand, 23.2% silt and 16.8% clay), slightly acidic (pH 5.9), low in soil organic carbon (0.51%), available nitrogen (191.40 kg ha^{-1}), low in available phosphorus (13.40 kg ha^{-1}) and medium in potassium (176.90 kg ha^{-1}).

Experimental details

The field experiment was carried out in Factorial RBD design with three replications in 5 m x 4 m plots with three levels of seedlings age (10, 20 and 30 days) and five levels of nitrogen (N_0, N_{50}, $N_{100,}$ N_{150} and N_{200}). In the study, “25-P-25” commercial hybrid of rice was used. It is most suitable for cultivation in both *kharif* and dry seasons under alluvial and lateritic tracts of West Bengal. It takes 115-120 days to mature during *kharif* season. The grains are off white in colour and are of superior quality with 24.0 g of its test weight. It can produce 6500-7000 kg grains $ha-^1$ in *kharif* season under good management practices. The nitrogen fertilizer was weighted separately as per need of the treatment for individual plots. Required quantity of fertilizer as per treatment was applied uniformly in the plots through broadcast method of application. A uniform dose of 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} were applied in the form of Single Super Phosphate (16% P_2O_5**)** and Murate of Potash (60% K_2O). All plots received full dose of P and K and $1/4^{th}$ N fertilizer at basal and remaining N fertilizer in three equal splits - at mid-tillering, panicle initiation and flowering as per treatments. The crop irrigated as and when required. Insects were controlled by chemicals to avoid biomass and yield loss. No fungicide was applied under the study. The weeds were removed manually at 20 and 40 days after transplanting (DAT). Harvesting was done on November 10, 2010 and November 6, 2011.

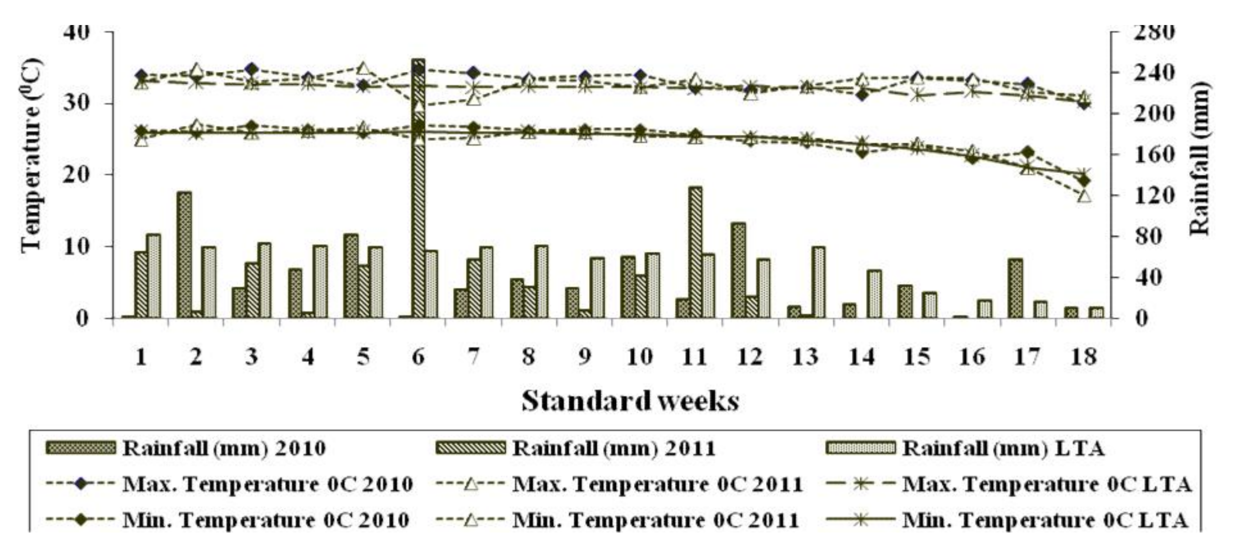

Figure 1. Climatic condition of the experimental station

Observations recorded

The observation on plant height was recorded from 10 hills randomly selected in each plot at different stages and their average was worked out. Tiller number from the same hills was also recorded at 45 DAT.

Observation on yield parameters like panicle length, panicle weight, filled grain panicle^{-1}, 1000 grain weight, grain yield, straw yield, biological yield, harvest index were recorded at maturity. The economics of hybrid rice was worked out considering the prevailing market price of the inputs and outputs.

Chlorophyll estimation

Total chlorophyll content was measured adopting the method of Hiscox and Israelstam (1979), using Dimethyl sulfoxide (DMSO) and the following procedure. Leaf material of 50 mg was taken from fully emerged leaf and placed in a test tube, and 10 ml of DMSO was added. This was kept in an oven at 65^{0}C for about 4 hours. After 4 hours the chlorophyll was expressed in the liquid form without any grinding. The extract was taken in a measuring cylinder and final volume was made up to 10ml by using DMSO. The absorbance of the solution was read at 663nm and 645nm using spectrophotometer against the DMSO blank. The chlorophyll content was determine by using the formula given by Arnon (1949) and expressed as mg g^{-1} of fresh leaf. Arnon's formula estimate total chlorophyll as follows.

$$\text{Total Chlorophyll} = [20.2\ (D_{645}) + 8.02\ (D_{663})] \times \frac{V}{1000XW}$$

where, D = Absorbance
V = Final volume of DMSO (ml)
W = Weight of fresh leaf (g)

Statistical Analysis

The data were statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05 (Cochran and Cox, 1977).

Results and Discussion

Plant height

Plant height was significantly increased due to age of seedlings during both the years under study (Table 1). The tallest plant (103.81 and 107.67 cm) was produced with 10 days age seedlings. The second best treatment was 20 day's age seedlings in respect of plant height. The dwarf plant height (91.38 and 95.34 cm) was recorded with 30 days age seedlings. The highest plant height from younger seedlings might be due to more vigor, root growth and lesser transplant shock because of lesser leaf area during initial growth stages which stimulate increased cell division causing more stem elongation. Similar types of results were also reported by Sangsu *et al*., (1999) and Rahman, (2001).

Nitrogen level played an important role on increasing plant height of hybrid rice (Table 1). The plant height increased gradually due to successive increasing level of nitrogen fertilizer application during both years.The tallest plant height (112.83 and 116.40 cm) was recorded in crop receiving N_{200} kg ha^{-1} as compared to N_0 N_{50}, N_{100} and N_{150}kg ha^{-1}. The dwarf plant height (81.63 and 86.53 cm) was recorded in crop receiving without nitrogen fertilizer. The increase in plant height was due to various physiological processes including cell division and cell elongation of the plant. Zhilin *et al.* (1997) stated that plant height is increased significantly due to nitrogen application.

Number of tillers hill^{-1}

The number of tillers hill^{-1} recorded at 45 DAT was statistically analyzed and has been presented in the table 1.

Age of seedling density showed significant effect on influencing the tiller production in hybrid rice. The highest number of tillers hill^{-1}(21.5 and 23.3) was produced in crop at the young age of seedlings (10 days) and it was significantly greater than what obtained at other age of seedlings (20 and 30days) at 45 DAT. The lowest number of tillers hill^{-1} (13.8 and 15.3) was produced in crop receiving the oldest seedlings (30 days) and was markedly lower as compared to those recorded at other age of seedlings at 45 DAT. The young seedlings recorded better root growth and facilitated increased cell division and cell enlargement due to increased photosynthetic rate subsequently increasing the plant height and number of tiller hill^{-1} (Shrirame *et al*., 2000). Similar results were reported by Vijayakumar *et al*., (2005) and Salem *et al*., (2011).

Nitrogen level played an important role in increasing number of tillers hill^{-1} of hybrid rice (Table 1). The results showed that the number of tillers hill^{-1} increased gradually due to increasing level of nitrogen application at 45 DAT under study. The maximum number of tillers hill^{-1} (24.4 and 26.7) was recorded in crop receiving N_{200} kg ha^{-1} during both the years of experimentation. The crop receiving no nitrogen (N_0) produced the lowest number of tillers hill^{-1} (10.8 and 11.9) that was greatly lower than all other nitrogen treatments at 45 DAT under the study. The results showed the importance of plant nutrition on increasing the tillering capacity of hybrid rice. The results are in conformity with the findings of Jiang *et al.* (1993).

Number of effective tillers hill^{-1}

Grain yield of cereals is highly dependent upon the number of effective tillers per produced by each plant (Power and Alessi, 1978 and Nerson, 1980). In general, the number of effective tillers hill $^{-1}$ (Table 1) was significantly influenced by age of seedlings and nitrogen levels.

Age of seedlings was a significant influenced on the number of effective tillers hill $^{-1}$. The maximum number of effective tillers hill $^{-1}$ (17.07 and 18.90) was obtained from the transplanting of 10 days age seedlings during the both years, respectively. This might be due to quick establishment of plant and more effective use of light, nutrient, space etc. which increased plants hill^{-1}, consequently increased effective tillers hill^{-1}. The minimum number of effective tillers hill^{-1} (10.08 and 11.28) was recorded in crop transplanted at 30 days old seedlings during the both years, respectively..

Table 1. Plant height, number of tillers hill^{-1}, number of effective tillers hill^{-1} and effective tiller index of hybrid rice as affected by different seedlings age and nitrogen levels

Treatment	Plant height at harvest (cm)		No. of tillers hill^{-1}		No. of effective tillers hill^{-1}		Effective tiller index	
	2010	2011	2010	2011	2010	2011	2010	2011
Seedlings age (day)								
10	103.81	107.68	21.50	23.32	17.07	18.90	78.15	79.72
20	96.32	99.99	17.96	19.83	13.71	15.42	73.71	75.18
30	91.38	95.34	13.79	15.33	10.08	11.28	68.88	71.57
SEm(±)	1.34	1.44	0.30	0.28	0.30	0.30	0.81	0.53
CD(p=0.05)	3.89	4.17	0.87	0.81	0.87	0.87	2.35	1.53
Nitrogen levels (kg ha^{-1})								
N_0	81.63	86.53	10.84	11.93	7.14	8.23	65.19	68.47
N_{50}	89.07	92.30	12.77	14.12	9.00	10.06	70.14	70.77
N_{100}	97.16	100.83	18.55	20.41	13.77	15.04	73.53	73.17
N_{150}	105.16	108.95	22.16	24.27	20.03	22.14	85.13	88.23
N_{200}	112.84	116.40	24.43	26.73	18.16	20.53	73.85	76.83
SEm(±)	1.73	1.86	0.39	0.36	0.39	0.39	1.05	0.68
CD(P=0.05)	5.02	5.38	1.13	1.04	1.13	1.13	3.04	1.97

Nitrogen level played an important role in increasing number of effective tillers hill^{-1} of hybrid rice. The results showed that the number of effective tillers hill^{-1} increased gradually due to increasing level of nitrogen application up to N_{150}. The maximum number of effective tillers hill^{-1} (20.03 and 22.14) was recorded in crop receiving nitrogen 150 kg ha^{-1} as compared to 0, 50, 100 and 200 kg ha^{-1} respectively during the both years. The increased in effective tillers hill^{-1} observed for this treatments were due to favorable root growth and higher mobility of nitrogen in soil solution and its absorption by plant root. The results are in conformity with those of Tripathi and Jaishwal (2006); Bera and Pramanik (2010).

Effective tiller index

Effective tiller index was influenced by age of seedlings and levels of nitrogen application (Table 1). The maximum effective tiller index (78.1 and 79.7) was obtained from the treatment with transplanting of 10 days age seedlings whereas the minimum effective tiller index (68.8 and 71.5) was recorded in crop receiving 30 days age seedlings during both the year of experiment. Similar results were reported by Vijayakumar *et al*., (2005) and Salem *et al*., (2011).

The effective tiller index significantly increased by increasing nitrogen levels from zero up to 150 kg ha^{-1}.The maximum effective tiller index (85.1 and 88.2) was recorded in crop receiving N_{150} kg ha^{-1} during both the years of experimentation. The crop receiving no nitrogen (N_0) produced the lowest effective tiller index (65.1 and 79.7). The results are in conformity with those of and Bera and Pramanik (2010).

Total chlorophyll content

The total chlorophyll content of different growth stages was significantly increased for the transplanting of 10-days seedlings (Table 2). This can be associated to prolific root growth resulting from none destruction of the root system during uprooting and transplanting. 30-day old seedlings gave the lowest value for total chlorophyll content. These results are in agreement with those obtained by Ebaid and Ghanem (2001). Total chlorophyll content was gradually increased with increasing nitrogen levels from zero to 200 kg ha^{-1}.

Application of nitrogen directly increased the chlorophyll content and leaf surface area resulting in increased photosynthesis process leading to more sugar formation (Dikshit and Paliwal, 1989). Nitrogen nutrition influences the content of photosynthetic pigments, the synthesis of the enzymes taking part in the carbon reduction, the formation of the membrane system of chloroplasts, etc. Thus the increase in growth and yield owing to the application of N-fertilizers may be attributed to the fact that these nutrients being important constituents of nucleotides, proteins, chlorophyll and enzymes, involve in various metabolic processes which have direct impact on vegetative and reproductive phases of plants (Mengel and Kirkby, 1996). Verma *et al*., (2004) recorded that the N content in the third leaf, chlorophyll a content increased with increasing nitrogen rate. Nitrogen at 100 and 150 kg ha^{-1} resulted in the highest yield. These results are in agreement with those obtained by Abd El-Wahab (1998) and Kumar *et al*. (1995).

Table 2. Total chlorophyll content (mg g^{-1} of fresh leaf) at different growth stages of hybrid rice as affected by different seedlings age and nitrogen levels

Treatments	Total chlorophyll content (mg g^{-1} of fresh leaf) at different growth stages							
	20 DAT		40 DAT		60 DAT		Flag leaf at milking stage	
	2010	2011	2010	2011	2010	2011	2010	2011
Seedlings age (day)								
10	3.18	3.25	3.56	3.63	3.24	3.43	2.34	2.55
20	2.75	2.85	3.13	3.24	2.82	2.94	1.90	2.16
30	2.34	2.45	2.72	2.83	2.42	2.53	1.59	1.78
SEm(±)	0.02	0.03	0.02	0.03	0.02	0.02	0.03	0.03
CD(p=0.05)	0.06	0.09	0.06	0.09	0.06	0.06	0.09	0.09
Nitrogen levels (kg ha^{-1})								
N_0	2.02	2.06	2.36	2.42	2.05	2.13	1.24	1.40
N_{50}	2.29	2.39	2.66	2.76	2.35	2.47	1.50	1.69
N_{100}	2.69	2.80	3.05	3.17	2.73	2.87	1.82	2.09
N_{150}	3.21	3.32	3.63	3.71	3.31	3.42	2.40	2.63
N_{200}	3.59	3.73	4.00	4.11	3.68	3.81	2.78	3.02
SEm(±)	0.03	0.04	0.03	0.04	0.03	0.04	0.04	0.05
CD(P=0.05)	0.09	0.12	0.09	0.12	0.09	0.12	0.12	0.14

Panicle length

Age of seedlings showed significant effect on length of panicle of hybrid rice in Table 3. The longer panicles (25.79 and 26.28 cm) were form in crop transplanted at 10 days age seedlings during both the years of experiment, respectively. The second best result was obtained from treatment of 20 days old seedlings. The shorter panicles (23.32 and 23.94 cm) were recorded in aged seedlings (30 days) during both years, respectively. Gasparillo *et al*. (2001) also noted significant variation of panicle length due to age of seedlings.

The nitrogen level exerted significant effect of on panicle length in hybrid rice in Table 3. The panicle length increased steadily up to the application of 200 kg N ha^{-1}. It produced the highest panicle length (26.4 and 26.94 cm) and was significantly greater than what obtained (22.78 and 23.33 cm) at the lowest nitrogen level (N_0). Longer panicle length due to nitrogen because nitrogen takes part in panicle formation as well as panicle elongation and for this reason, panicle length increased with the increase of N-fertilization.

Table 3. Panicle length, panicle weight, filled grains panicle^{-1} and 1000 grain weight of hybrid rice as affected by different seedlings age and nitrogen levels

Treatments	Panicle length (cm)		Filled grain panicle^{-1}		Panicle weight (g)		1000 grain weight (g)	
	2010	2011	2010	2011	2010	2011	2010	2011
Seedlings age (day)								
10	25.79	26.28	139.60	146.20	3.04	3.30	23.62	23.80
20	24.18	24.76	127.33	133.86	2.78	3.06	23.11	23.32
30	23.32	23.94	118.46	124.20	2.66	2.94	22.67	22.86
SEm(±)	0.19	0.16	0.73	0.94	0.01	0.02	0.06	0.05
CD(p=0.05)	0.55	0.46	2.11	2.72	0.03	0.06	0.17	0.14
Nitrogen levels (kg ha^{-1})								
N_0	22.78	23.33	101.44	106.55	2.44	2.69	22.39	22.51
N_{50}	23.37	23.95	113.00	120.00	2.55	2.81	22.70	22.84
N_{100}	24.13	24.76	128.55	134.89	2.78	3.06	23.13	23.30
N_{150}	25.45	25.97	156.56	163.00	3.26	3.55	23.88	24.11
N_{200}	26.40	26.94	142.78	149.33	3.09	3.37	23.57	23.87
SEm(±)	0.25	0.21	0.94	1.21	0.02	0.02	0.08	0.07
CD(P=0.05)	0.72	0.61	2.72	3.50	0.06	0.06	0.23	0.20

Number of filled grains panicle^{-1}

The number of filled grains panicle^{-1} counted at maturity was analyzed statistically and presented in the Table 3.

Age of seedlings played an important role in regulating the grain development process in hybrid rice. The number of filled grains panicle^{-1} decreased greatly due to increase in age of seedlings. The highest number of filled grains panicle^{-1} (139.6, 146.2) was recorded in crop planted at young age (10 days) and it was significantly greater than those obtained at other age of seedlings (20 and 40 days) during both the years of experiment. The lowest number of filled grains panicle^{-1} recorded from the crop at the high aged seedlings (30 days).

The number of filled grains panicle $^{-1}$ varied markedly among the different nitrogen levels. The highest number of filled grains panicle^{-1}(156.5 and 163.0) was produced in crop receiving 150 kg N ha^{-1} and was followed by those (142.7 and 149.3) of the crop at the highest nitrogen level (200 kg N ha^{-1}), Both the nitrogen levels recorded significantly greater number of filled grains panicle^{-1} than those of the lower nitrogen levels. The crop at no nitrogen produced the lowest number of filled grains panicle^{-1} (101.4 and 106.5) which was significantly lower than any other nitrogen level. The results indicated that application of low dose of fertilizer did not mitigate the nutrient need of the crop particularly during the grain filling period resulting in lower number of filled grains panicle^{-1}. The results are in conformity with the finding of Hu *et al.* (2007) and Huang *et al.* (2008). On the other hand, application of 200 kg N ha^{-1} reduced the number of filled grains panicle^{-1}, which may be caused by an increase in competition for metabolic supply among tillers or possibly due to vigorous vegetative growth causing heavy drain on soluble carbohydrate resulting in its reduced availability for spikelet formation and thereby affecting the production of fertile spikelets. Hasegawa *et al*. (1994) and Wu *et al*. (1998) also reported similar results in that with increasing levels of soil fertility, the number of filled spikelets per panicle decreased with corresponding increase in unfilled spikelets.

Panicle weight

Like numbers of filled grains panicle^{-1}, the grain weight panicle^{-1} was significantly influenced by age of seedlings (Table 3). The highest grain weight panicle^{-1} (3.04 and 3.30 g) was produced by the crop which was transplanted at younger age (10 days) whereas the lowest grain weight panicle^{-1} (2.66 and 2.94 g) was recorded in 30 days ages seedlings. This might be due to higher number of filled grains panicle^{-1} in 10 days aged seedlings.

Likewise, the maximum grain weight panicle^{-1} (3.09 and 3.37 g) was obtained from crop receiving 150 kg N ha^{-1}. The minimum grain weight panicle^{-1} (2.44 and 2.69 g) was recorded in control plot (N_0). Significantly more number of filled grains panicle^{-1} might have contributed to significant increase in grain weight panicle^{-1}

Test weight

Age of seedlings and varying levels of nitrogen had a significant effect on test weight. The maximum test weight (23.62 and 23.80 g) was obtained from the transplanting of 10 days aged seedlings and the minimum test weight (22.67 and 22.86 g) was obtained from the 30 days aged seedlings during both the years of experiment (Table 3). This might be due to the proper crop growth and development and assimilate synthesis in the grains. Similar types of results were obtained by Husain *et al*. (2004).

The nitrogen levels although exerted significant effect on test weight of hybrid rice grain. The nitrogen level of N_{150} kg ha^{-1} registered the highest test weight (23.88 and 24.11 g) as compared to other nitrogen levels respectively during the both years. The minimum test weight (22.39 and 22.51 g) was obtained from the control plot (N_0). Increase in grain weight at higher nitrogen rates might be primarily due to increase in chlorophyll content of leaves which led to higher photosynthetic rate and ultimately plenty of photosynthates available during grain development. At higher nitrogen level (N_{200} kg ha^{-1}) produced lesser test weight than N_{150} kg ha^{-1}. Reduction in 1000-grain weight with increasing applied levels of N is probably the result of insufficient supply of carbohydrates to individual spikelets due to competition effect resulted by vigorous rice growth and the increased number of its spikelets. This effect further results in poor dry matter accumulation in the spikelets of rice. Similarly, Hasegawa *et al*. (1994) also indicated that increased number of spikelets and vigorous growth of rice due to high rates of N fertilizer application induce competition for carbohydrate available for grain filling and spikelet formation. This was in agreement with the findings of Channabasavanna and Setty (1994) and Raju and Reddy (1993).

Grain yield

Age of seedlings played an important role in regulating the grain yield of hybrid rice. The grain yield decreased with increased in age of seedlings (Table 4). The highest grain yield (5575 and 5946 kg ha^{-1}) was recorded in crop planted at younger age (10 days) followed by the crop (5035 and 5374 kg ha^{-1}) planted at 20 days aged seedlings both was significantly different between each other during both the years of experiment. The lowest grain yield (4596 and 4915 kg ha^{-1}) was recorded from the crop at old age seedlings (30 days) and was significantly lower than other age of seedlings. The higher grain yield production in the younger seedlings might be attributed to the vigorous and healthy growth, development of more productive tillers and leaves ensuring greater resource utilization as compared to old age seedlings. The results also suggested that 10- days young seedlings resulted in highest increase in grain yield over 20- days and 30-days old seedlings. Similar results were reported by Vijayakumar *et al*. (2005).

The nitrogen levels exerted significant effect on grain yield of hybrid rice. The grain yield increased steadily with the increase in nitrogen level up to the 150 kg ha^{-1} and decreased with further increase of applied N fertilizer (200 kg N ha^{-1}). The highest grain yield (6286 and 6652 kg ha^{-1}) was produced in crop receiving nitrogen 150 kg ha^{-1}. This could mainly be attributed to the increase in the number of panicles hill^{-1}, total number of filled grains panicle^{-1} and test weight. Behera (1998) also reported findings indicating improvements in grain yields attributed to increments in yield components. Increases in yield components are associated with better nutrition, plant growth and increased nutrient uptake (Kumar and Rao, 1992; Thakur, 1993). The crop at no nitrogen level produced the lowest grain yield (3645 and 3916 kg ha^{-1}) which was significantly lower than all other nitrogen levels tested here. This might be due to lack of supply of nitrogen into the soil solution to meet the required nutrients for physiological processes, which in turn lower the yield. On the other hand, reduction of grain yield with further increment in applied N level at 200 kg ha^{-1} was mainly caused by successive reductions in the number of filled grains panicle^{-1} and thousand-grain weight. Singh *et al*. (1995) have also reported a decrease in grain yield of rice with application of high doses of N fertilizer. Reinke *et al*. (1994) noted that where the grain yield response is negative, yield reduction is primarily caused by a reduction in the proportion of the number of filled grains panicle^{-1}.

Straw yield

Age of seedlings had a significant effect on straw yield. The maximum straw yield of 6703 and 6958 kg ha^{-1} was obtained from the crop receiving younger seedlings (10 days) during both years of experiment (Table 4). The lowest straw yield of 5968 and 6192 kg ha^{-1} was recorded from old age seedlings (30 days). Similar results were reported by Vijayakumar *et al*. (2005).

Table 4. Grain yield, straw yield, biological yield and harvest index of hybrid rice as affected by different seedlings age and nitrogen levels

Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Harvest index (%)	
	2010	2011	2010	2011	2010	2011
Seedlings age (day)						
10	5575	5946	6703	6958	45.19	45.84
20	5035	5374	6330	6616	44.13	44.62
30	4596	4915	5968	6192	43.32	44.04
SEm(±)	42.5	47.7	86.6	93.9	0.17	0.15
CD(p=0.05)	122.9	138.0	250.8	271.8	0.49	0.43
Nitrogen levels (kg ha^{-1})						
N_0	3645	3916	4927	5213	42.48	42.86
N_{50}	4354	4616	5618	5868	43.61	43.98
N_{100}	5076	5446	6419	6669	44.13	44.92
N_{150}	6286	6652	7243	7460	46.40	47.07
N_{200}	5983	6428	7461	7734	44.45	45.35
SEm(±)	54.8	61.5	111.8	121.2	0.22	0.19
CD(P=0.05)	158.7	178.2	323.8	350.9	0.63	0.56

Nitrogen application increased the straw yield significantly with increase in levels up to 200 kg ha^{-1} (Table 4). The highest straw yield (7461 and 7739 kg ha^{-1}) was produced in crop receiving 200 kg N ha^{-1} and was closely followed by the crop (7243 and 7460 kg ha^{-1}) at the 150 kg N ha^{-1}. Both the nitrogen levels recorded significantly higher straw yield than those obtained at the lower nitrogen levels. The crop at low level (N_0) produced the lowest straw yield (4927 and 5213 kg ha^{-1}) which was significantly lower than all other nitrogen levels tested here. The results are in conformity with those of Mahajan and Tripathi (1992), Dehal and Mishra (1994).

Harvest index

Age of seedlings and varying levels of nitrogen had a significant effect on harvest index. The maximum harvest index (45.19 and 45.84) was obtained from the transplanting of 10 days aged seedlings and the minimum harvest index (43.32 and 44.04) was obtained from the 30 days aged seedlings during both the years of experiment (Table 4). This might be due to the proper crop growth and development and assimilate synthesis in the grains. Similar types of results were obtained by Husain *et al*. (2004).

The nitrogen levels although exerted significant effect on harvest index of hybrid rice. The nitrogen level of N_{150} kg ha^{-1} registered the highest harvest index (46.40 and 47.07) as compared to other nitrogen levels respectively during the both years. The minimum harvest index (42.48 and 42.6) was obtained from the control plot (N_0). The results are in conformity with those of Mahajan and Tripathi (1992), Dehal and Mishra (1994).

Economics

The economics of seedlings age and application of nitrogen was calculated for gross return ha^{-1}, net return ha^{-1}, net return $rupee^{-1}$ and B:C ratio invested for hybrid rice are presented in Table 5. The result showed that age of seedlings significantly influenced the economics in kharif hybrid rice production during both the year of experimentation. In hybrid rice higher gross return (₹ 83562 and ₹ 88138) and net return ha^{-1} (₹ 52898 and ₹ 57474) was with 10-days seedling with nitrogen 150 kg ha^{-1} during the both years respectively. Transplanting of 10-days seedling and application of nitrogen fertilizer 150 kg ha^{-1} recorded higher net return $rupee^{-1}$ (₹ 2.73 and ₹ 2.87) and B:C ratio (₹ 1.73 and ₹ 1.87) invested in the hybrid rice. This might be due to better growth and higher yield of the hybrid rice grown under 10 days age seedlings and application of 150 kg N ha^{-1}**.**

Table 5. Gross return, net returns ₹ ha^{-1}, net return $rupee^{-1}$, B:C ratio of hybrid rice as affected by different seedlings age and nitrogen levels

Treatments	Gross return		Net returns Rs ha^{-1}		Net return $rupee^{-1}$		B:C ratio	
	2010	2011	2010	2011	2010	2011	2010	2011
AS_1 N_0	48070	51076	19656	22662	1.69	1.80	0.69	0.80
AS_1 N_{50}	57268	60935	28104	31771	1.96	2.09	0.96	1.09
AS_1 N_{100}	66086	70979	36172	41065	2.21	2.37	1.21	1.37
AS_1 N_{150}	83562	88138	52898	57474	2.73	2.87	1.73	1.87
AS_1 N_{200}	78445	83738	47031	52324	2.50	2.67	1.50	1.67
AS_2 N_0	44082	47663	16168	19749	1.58	1.71	0.58	0.71
AS_2 N_{50}	53155	55317	24491	26653	1.85	1.93	0.85	0.93
AS_2 N_{100}	60678	65222	31264	35808	2.06	2.22	1.06	1.22
AS_2 N_{150}	73329	77523	43165	47359	2.43	2.57	1.43	1.57
AS_2 N_{200}	71025	76295	40111	45381	2.30	2.47	1.30	1.47
AS_3 N_0	39972	43013	13058	16099	1.49	1.60	0.49	0.60
AS_3 N_{50}	46742	50149	19078	22485	1.69	1.81	0.69	0.81
AS_3 N_{100}	56149	59533	27735	31119	1.98	2.10	0.98	1.10
AS_3 N_{150}	67938	71755	38774	42591	2.33	2.46	1.33	1.46
AS_3 N_{200}	65864	70664	35950	40750	2.20	2.36	1.20	1.36

AS_1=10days seedlings, AS_2=20days seedlings and AS_3=30days seedlings,
N_0 = Nitrogen 0 kg ha^{-1}, N_{50} = Nitrogen 50 kg ha^{-1}, N_{100} = Nitrogen 100 kg ha^{-1} N_{150} = Nitrogen 150 kg ha^{-1} and N_{200} = Nitrogen 200 kg ha^{-1}

Conclusion

From the present study, it is clear that the above result and discussion following conclusion can be drawn that transplanting of 10- days seedlings and application of 150 kg N ha^{-1} significantly influence on effective tillers $hill^{-1}$, effective tillers index, panicle weight, filled grain $panicle^{-1}$ and grain yield of hybrid rice. The crop grown with 10 days age seedlings paid high net return. On the other hand, crop grown with 30 days aged seedlings without nitrogen caused very poor growth and produced low yield that ultimately paid very low return.

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