Original Research Article

Effect of planting time and nitrogen doses on growth, phenology and yield of Basmati rice (*Oryza sativa* L.) under agro-climatic conditions of Haryana

Abstract

A field experiment on rice was conducted at RRS, Kaul (Kaithal) of Chaudhary Charan Singh Haryana Agricultural University, Hisar during *Kharif* season of 2022 to find out optimum dose of nitrogen in rice under late planted condition for getting higher yield. Soil of experimental field was sandy clay loam texture, alkaline in reaction (7.81), low in organic carbon (0.39%), available nitrogen (130 kg ha^{-1}) and medium in available phosphorous (24 kg ha^{-1}) and high in available potash (480 kg ha^{-1}). The experiment included two transplanting dates (P_1: First week of July and P_2: Fourth week of July), five levels of N application (N_1:0, N_2:30, N_3:60, N_4:90, N_5:120 kg N ha^{-1}) laid out in factorial randomised block design. The growth parameters *viz.* plant height (cm), number of tillers m^{-2} and dry matter accumulation (g) were reduced significantly under late planting (P_2). The yield (grain and straw) of the rice crop increased with each successive increase in N level, although the response was only significant up to 90 kg ha^{-1}. The interaction between planting time and N levels was found to be significant in terms of grain yield, revealing that dose of 90 kg ha^{-1} was sufficient in timely transplanted rice crops (1st week of July), whereas late transplanted crops (4th week of July) may require a higher dose of N (120 kg ha^{-1}) to get higher yield. However, the highest yield was obtained when the crop was timely transplanted (1st week of July) and supplied 90 kg of N ha^{-1}.

Key words: Rice, basmati, planting time, nitrogen levels, growth, phenology, grain yield

INTRODUCTION

Rice (*Oryza sativa* L.), is the most important cereal crop of the world and a principal food grain crop. It is staple food of more than half of world population and more than 2 billion people depend on rice in Asia for livelihood. Due to its extensive physiological flexibility, rice can be effectively produced not only in tropical or subtropical regions but also in many temperate regions up to 2000 meters above mean sea level (Okon *et al*., 1998). India is the second-largest producer of rice after China and occupies largest area under rice. In India, rice is grown over an area of about 46 million hectares with a production of 111.8 million tons (Anonymous, 2022).

In addition to genetic characteristics, environmental factors including fertilization and planting timing are of particular importance which also has a significant role in determining the rice production and quality (Hiroyuki *et al*., 2002). However, occasionally the transplantation get delayed because of shortage of labour and water during the brief transplanting period, which may affect the crop yield adversely under late planting. The length of the varietal life cycle, sensitivity to photoperiod, temperature, rainfall and other climatic factors play a significant role in determining the best time to transplant rice. The ideal time to plant rice guarantees that the vegetative, reproductive or grain-filling phases receive the ideal temperature and photoperiod, which is necessary for high yield harvest.

Rice crop is a heavy feeder of nutrients and is very responsive to application of nutrients particularly nitrogen. Because of the higher nutrient needs of the rice crop and the adoption of extensive cropping systems such as rice-wheat in rice growing regions of the Indo-Gangetic Plains, including Haryana, additional nutrient input is required for the crop as the topsoil are poor in nutrients. Among nutrients, nitrogen is the most crucial macronutrient for rice and is one of the factors that restricts irrigated rice output worldwide (Samonte *et al*., 2006). Plant growth, phenology and yield of rice crop vary due to planting time and hence N application rate may differ accordingly. It has been observed that rice yield decreases with late planting, primarily due to a reduction in the number of effective tillersm^{-2}and number of grains panicle^{-1} (Mukesh *et al.*, 2013; Wani *et al.*, 2016) which can be significantly increased by supplying N in optimum levels, as N is one of the most crucial components impacting the crop's growth and yield.

Both tall and semi dwarf varieties of Basmati rice are grown in Haryana but the semi dwarf varieties with higher yield potential are more responsive to N application than the tall ones. But the information on N requirement of Basmati rice as affected by date of planting is limited. Therefore, there is need to find out optimum dose of N application in Basmati rice, particularly in high yielding semi dwarf varieties, under late planting.

MATERIAL AND METHODS

The experiment was carried out at the Research Farm of Rice Research Station, Kaul (Kaithal) which is a sub-campus of CCS Haryana Agricultural University, Hisar. The soil was sandy clay loam texture, having pH 7.81, medium levels of organic carbon (0.39), low levels of readily available nitrogen (130 kg ha^{-1}), medium levels of phosphorus (24 kg ha^{-1}) and high levels of potash (480 kg ha^{-1}) as per the limits. The treatments comprised 2 transplanting times (1st week of July and 4th week of July) and 5 nitrogen levels (0, 30, 60, 90 and 120 kg N ha^{-1}).

This experiment was laid out in Factorial RBD with 3 replications. Seedlings of 30 days of 'PUSA Basmati 1121' scented rice were transplanted on 7th July (timely) and 27th July (late) in *kharif* season of 2022 under puddled conditions. The nitrogen treatments were applied in 3 equal splits: 1/3rd at the time of transplanting, 1/3rd at 21 DAT and 1/3rd at 42 DAT. All plots were given 30 kg P_2O_5 ha^{-1} through SSP and 25 kg $ZnSO_4$ ha^{-1} at the time of transplanting.

All growth parameters *viz.* plant height, number of tillers and dry matter accumulation were recorded at 60, 90 DAT and at maturity. The height of longest tiller was measured by selecting three hills plot^{-1}. The plant height was calculated from its base to tip of its last fully opened leaf till panicle emergence and after panicle emergence from base to the tip of panicle. The number of tillers was recorded from three randomly selected hills in each plot and was expressed as tillers m^{-2}. The selected hills were averaged to determine the mean number of tillers hill^{-1}. The average number of tillers per hill^{-1} was multiplied by the respective number of hills per m^{-2} area for each plot to get the average number of tillers per m^{2} area. Dry matter accumulation was recorded in g m^{-2}. Three randomly selected hills were cut from the ground level in each treatment plot. The plants were first dried in the sun and later they were dried in an oven at 65 ± 5°C until constant weight was achieved. The dry weight of the plant samples was measured and averaged to calculate the mean dry matter accumulation hill^{-1} for each treatment plot.

Anthesis was determined when 50% of the panicles were visible in the plot. When 95% of the spikelet turned yellow, the crop had reached physiological maturity. The data were analysed using RBD with two factor for ANOVA and differences among treatments were compared at $P \leq 0.05$ level of significance using the OPSTAT.

RESULTS

Growth parameters: The plant growth parameters showed significant variation due to the time of transplanting. Time of planting had significant effect on plant height at 90 DAT and maturity but it did not affect the plant height at 60 DAT. At 90 DAT (122.4 cm) and maturity (126.5 cm) plant height was higher under timely planting (1st week of July) and decreased significantly under late planting (4th week of July) (Table 1). Number of tillers m^{-2} declined with the crop age beyond 60 DAT with the maximum decline occurring during the period from 60 to 90 DAT. The number of tillers at 60 DAT (385), 90 DAT (342) and at maturity (335) were significantly higher under timely transplanting than that under late transplanting (Table 2). Dry weight increased with crop age with comparatively more increase occurring during the period from 60 DAT to 90 DAT (80%) than the period from 90 DAT to maturity (47%). The highest dry weight was obtained at maturity. At all the stages; 60 DAT (665 g m^{-2}), 90 DAT (1200 g m^{-2}) and maturity (1774 g m^{-2}), timely transplanted crop had significantly higher dry weight m^{-2} as compared to late transplanted (Table 3).

Growth parameters were also affected significantly due to levels of N supply. At all the growth stages (*viz.* 60, 90 DAT and at maturity), plant height (Table 1), number of tillers m^{-2} (Table 2) and drymatter accumulation (Table 3) increased significantly with each successive increase in N dose from 0 to 120 kg ha^{-1}. But the increase was significant up to 90 kg ha^{-1} as the plant height, number of tillers m^{-2} and dry matter with 120 kg N ha^{-1} was not significantly higher than that with 90 kg N ha^{-1}.

Table 1: Plant height (cm) at different growth stages of the crop as influenced by transplanting time and nitrogen dose

Treatment	Plant height at		
	60 DAT	90 DAT	Maturity
Time of planting			
P_1 – 1st week of July	86.0	122.4	126.5
P_2 – 4th week of July	84.9	108.9	112.5
SEm±	0.8	1.1	1.1
CD (p= 0.05)	NS	3.1	3.2
Levels of N (kg ha^{-1})			
N_1- 0	71.2	95.9	96.1
N_2- 30	81.7	111.1	116.1
N_3- 60	88.6	120.8	124.7
N_4- 90	92.5	125.2	129.9
N_5- 120	93.3	125.3	130.7
SEm±	1.3	1.7	1.7
CD (p= 0.05)	3.9	5.0	5.1

NS= Not significant

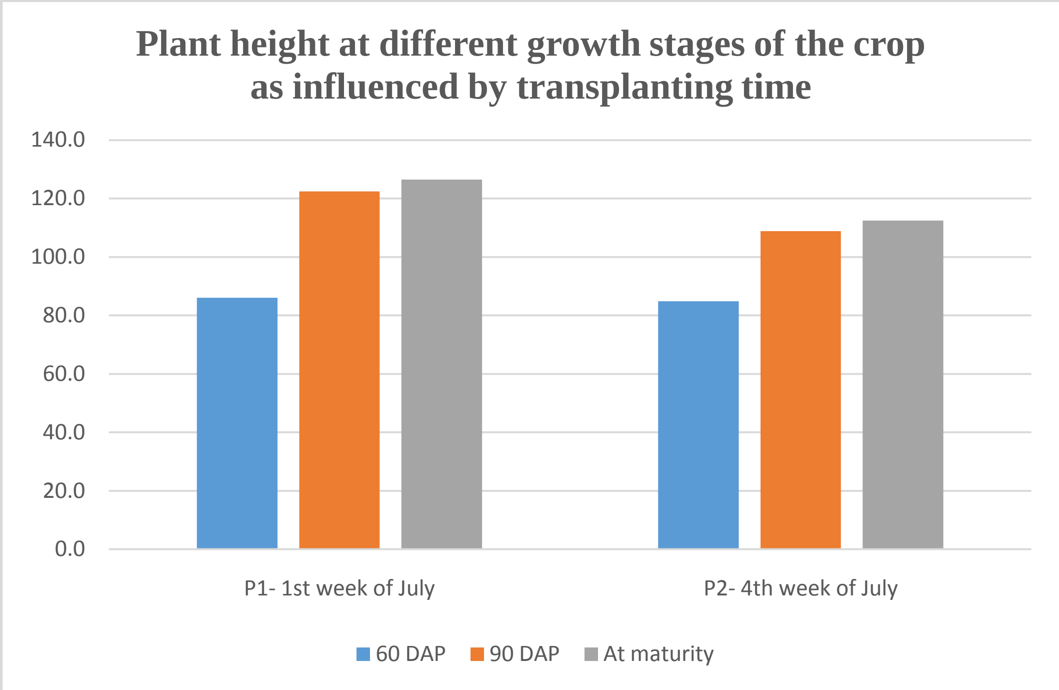

Fig. 1: Plant height at different growth stages of the crop as influenced by transplanting time

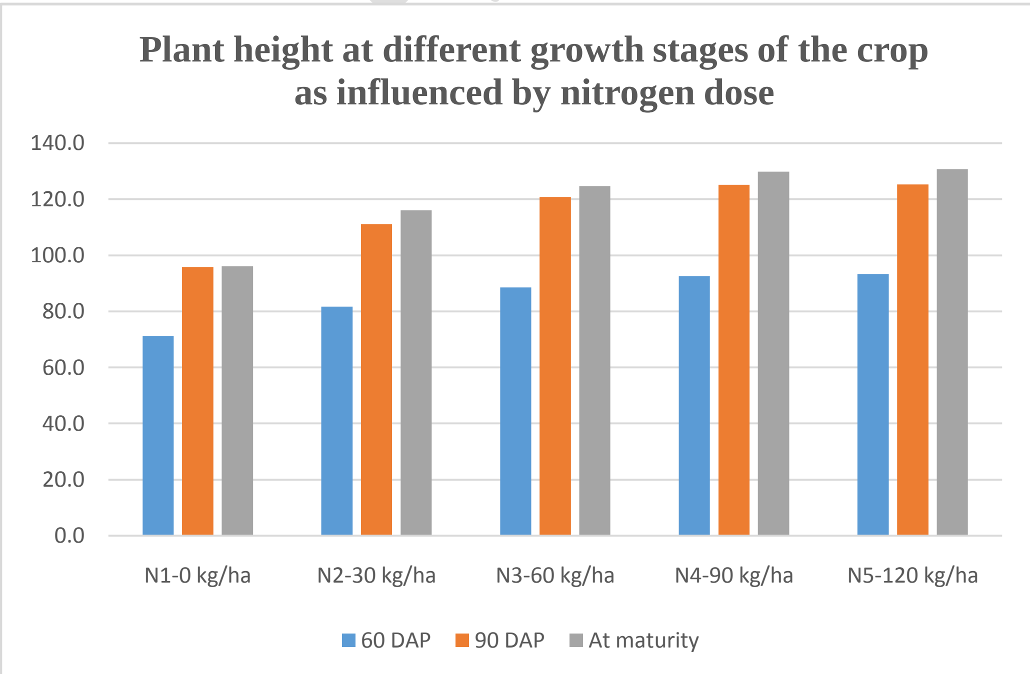

Fig. 2: Plant height at different growth stages of the crop as influenced by N dose

Table 2: **Number of tillers m^{-2} at different growth stages of the crop as influenced by transplanting time and nitrogen dose**

Treatment	No. of tillers m^{-2}		
	60 DAT	90 DAT	Maturity
Time of planting			
P_1 – 1st week of July	385	342	335
P_2 – 4th week of July	354	286	281
SEm±	7	6	5
CD (p= 0.05)	22	18	16
Levels of N (kg ha^{-1})			
N_1- 0	223	211	206
N_2- 30	326	286	281
N_3- 60	399	332	328
N_4- 90	443	364	358
N_5- 120	457	377	367
SEm±	12	10	8
CD (p= 0.05)	35	29	25

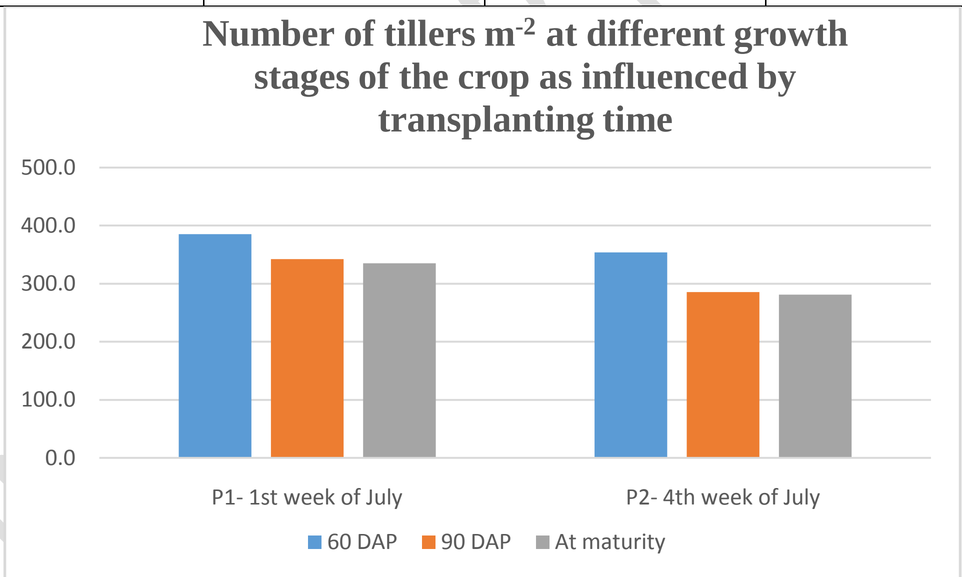

Fig. 3: Number of tillers m^{-2} at different growth stages of the crop as influenced by transplanting time

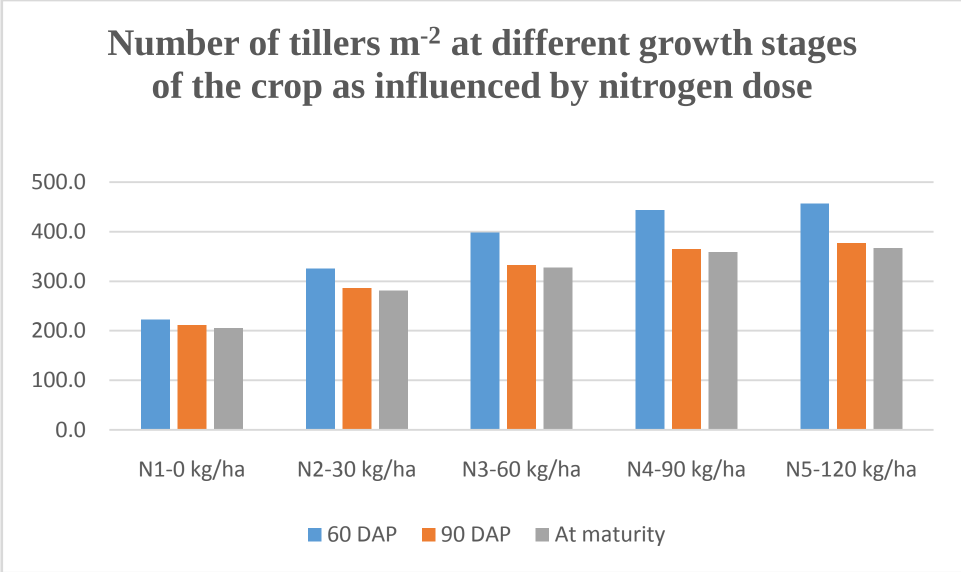

Fig. 4: Number of tillers m^{-2} at different growth stages of the crop as influenced by N dose

Table 3: Dry matter accumulation (g m^{-2})at different growth stages of the crop as influenced by transplanting time and nitrogen dose

Treatment	Dry matter (g m^{-2}) at		
	60 DAT	90 DAT	Maturity
Time of planting			
P_1 – 1st week of July	665	1200	1774
P_2 – 4th week of July	607	1076	1622
SEm±	`10.4	16.9	26.3
CD (p= 0.05)	31	51	79
Levels of N (kg ha^{-1})			
N_1- 0	362	646	926
N_2- 30	578	1039	1552
N_3- 60	692	1227	1860
N_4- 90	762	1367	2020
N_5- 120	786	1412	2134
SEm±	16.4	26.7	41.5
CD (p= 0.05)	49	80	124

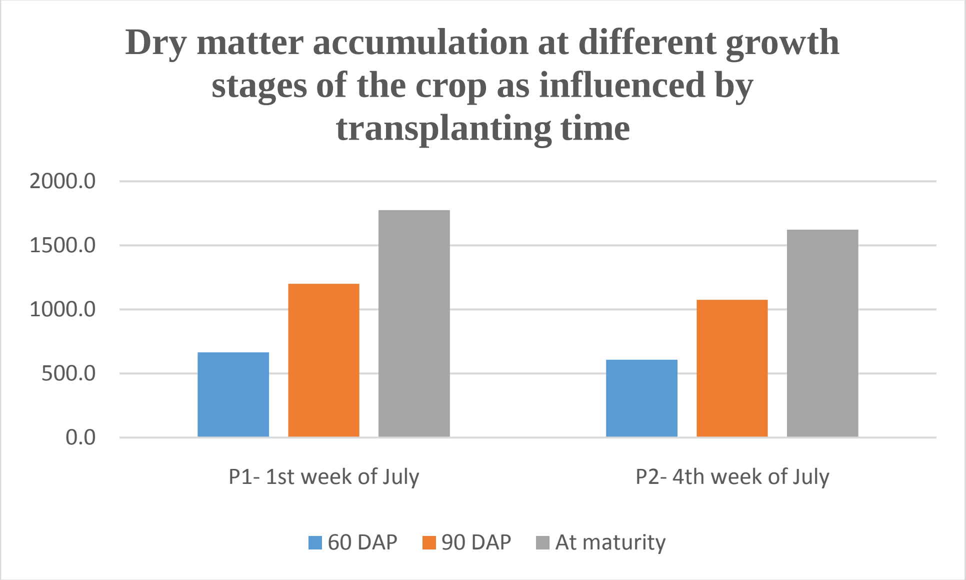

Fig 5: Dry matter accumulation at different crop growth stages as influenced by transplanting time

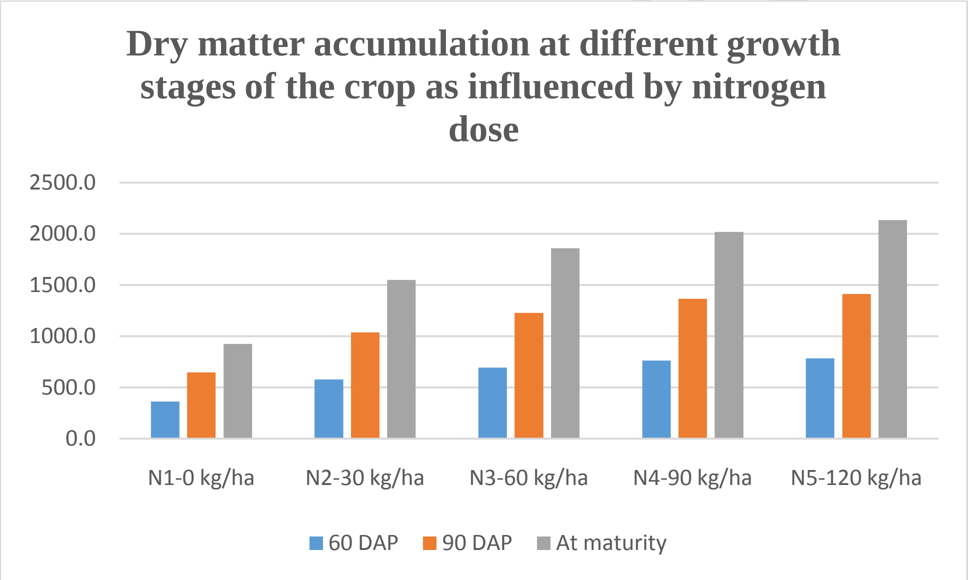

Fig 6: Dry matter accumulation at different crop growth stages as influenced by nitrogen dose

Phenological parameters: Number of days taken to panicle initiation, 50% flowering and maturity varied significantly among the transplanting dates (Table 4). The phenological growth stages of rice crop *viz.* days to panicle initiation, days to 50% flowering and days to maturity were highly influenced by the transplanting time. The crop transplanted during 1st week of July took more days (10 days) to attain panicle initiation, 50% flowering (8 days) and maturity (8 days) than the crop transplanted during 4th week July. But there was little variation in the time of occurrence of all these phenological stages due to change in N supply.

Table 4: **Phenological stages of the crop as influenced by transplanting time and nitrogen dose**

Treatment	Phenological stages		
	Days to panicle initiation	Days to 50% flowering	Days to maturity
Time of planting			
P_1 – 1st week of July	96	106	136
P_2 – 4th week of July	86	98	128
Levels of N (kg ha^{-1})			
N_1- 0	90	101	131
N_2- 30	91	102	132
N_3- 60	91	102	132
N_4- 90	91	102	132
N_5- 120	91	102	132

Yield parameters: Timely transplanted rice crop gave significantly higher mean grain yield (4036 kg ha^{-1}) than late transplanted (3366 kg ha^{-1}) (Table 5). The reduction in grain yield of rice crop due to late transplanting was about 17%. Mean grain yield increased significantly with each successive increase in N application rate from 0 to 90 kg N ha^{-1}. Further, increase in the yield obtained with 120 N kg ha^{-1} was not significant over that obtained with 90 kg N ha^{-1}.

Table 5: **Yield of rice influenced by transplanting time and nitrogen dose**

Treatment	Yield parameters		
	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Time of planting			
P_1 – 1st week of July	4036	4889	45.4
P_2 – 4th week of July	3366	4001	45.9
SEm±	50	65	0.2
CD (p= 0.05)	151	195	NS
Levels of N (kg ha^{-1})			
N_1- 0	2244	2536	46.8
N_2- 30	3289	3883	46.1
N_3- 60	3998	4860	45.3
N_4- 90	4415	5338	45.0
N_5- 120	4560	5608	45.0
SEm±	80	103	0.4
CD (p= 0.05)	239	308	NS

The interaction between transplanting time and N levels was found to be significant in terms of grain yield (Table 6). The highest yield was obtained with 90 or 120 kg N ha^{-1} under timely planted conditions which was statistically at par with the yield obtained with 120 kg N ha^{-1} in late planted conditions. The increase in the yield was 40%, 15%, 7% and 0.1% when

N dose was increased from 0 to 30, 30 to 60, 60 to 90 and 90 to 120 kg ha^{-1}, respectively under timely planted condition. The corresponding increase in the yield was 57%, 30%, 14% and 6.8% under late planted conditions which showed that the response was better and up to higher N levels under late planting than in timely planting. Therefore, the crop responded up to higher N application levels (120 kg ha^{-1}) under late planted conditions whereas the timely planted crop responded significantly only up to 90 kg N ha^{-1} showing that late planted crop may be supplied with higher dose of nitrogen to prevent yield reduction due to late planting.

Table 6: Interaction between effect of planting time and levels of nitrogen application on grain yield (kg ha^{-1}) of rice crop

Time of planting	Level of N (kg ha^{-1})					
	N_1	N_2	N_3	N_4	N_5	Mean
P_1	2703	3780	4358	4667	4673	4036
P_2	1785	2798	3638	4163	4447	3366
Mean	2244	3289	3998	4415	4560	
SEm±	113					
CD (p= 0.05)	338					

Higher straw yield was obtained from timely transplanting (4889 kg ha^{-1}) and it reduced significantly under late transplanting (4001 kg ha^{-1}) (Table 5). There was significant increase in the straw yield with each successive increase in N supply up to 90 kg N ha^{-1}. Further increase in the straw yield obtained with 120 kg N ha^{-1} over the yield obtained with 90 kg N ha^{-1} was not significant.

The harvest index did not vary significantly due to difference in the transplanting time. Similarly, the N application dose had no significant influence on the harvest index (Table 5).

DISCUSSION

Growth parameters: Late transplanting of the crop reduced the plant height (cm), number of tillers m^{-2} and dry matter accumulation (g) at 60 DAT, 90 DAT and at maturity as compared to timely transplanting. This might be due to the reduction in the vegetative phase of rice crop under late planting. Furthermore, the availability of more time for crop growth with appropriate photoperiod and temperature for timely transplanted crops may have contributed in greater N absorption for protoplasm synthesiswhich leads to rapid cell division that increases thesize and shape of plant. These results are similar to that of Wani *et al.* (2016) and Prabhakar and Reddy (2010) who found that timely transplanting of rice leds to better growth as compared to late.

All the growth parameters viz. plant height (cm), number of tillers m^{-2} and dry matter accumulation (g) of rice crop at 60 DAT, 90 DAT and at maturity increased with each successive increase in N level. The increase in growth parameter with higher nitrogen dose may be related to the fact that nitrogen promotes plant vegetative growth. Furthermore, greater nitrogen absorption by plants under higher N supply contribute more to crop's growth through translocation (Bufoglee*t al.*, 1997). The favourable effect of increased N supply on growth parameters such as plant height (cm) and tillers might be responsible for higher dry matter accumulation (g) of the crop. The results of the present study are in agreement with the findings of Chopra and Chopra (2000), Mannan *et al.* (2010), Salem *et al.* (2011) and Pramanik and Bera (2013).

Phenological parameters: The vegetative period of crop was shortened as a consequence of the delayed planting. Planting time has a major impact on duration of crop growth period as early planted rice need more days to accumulate the same number of degree day units than late transplanted rice (Norman *et al.*, 1999). Similarly, Peng-fei*et al.* (2013) observed a linear negative association between sowing time and growth period. The findings of the present study were also similar to those reported by Lalitha *et al.* (2000), Dixit *et al.* (2004), Chopra *et al.* (2006), Linscombe*et al.* (2004), and Lee *et al.* (2001).

Level of applied N had little or no effect on the time of occurrence of various phenological growth stages of the crop. Wani *et al.* (2018) observed that temperature is the key driving force for development in photoperiod insensitive rice varieties, therefore the lack of influence of N dose on rice crop phenology in the present study could be related to the fact that just one type of variety (photo-insensitive) was used. Gebremaraiam and Baraki (2016) also made similar observations.

Yield parameters: Crop yield in any given environment is the result of yield components developed at different stages of development. Early transplanting gave significantly higher yield (grain + straw) than late planting. The higher yield of early planted crop may be due to longer duration for growth period, more favourable temperature and better photoperiod during plant growth which resulted in increased accumulation of dry matter (g), more tillers or panicles m^{-2}. Similar results were also reported by Mahajan *et al.* (2009), Mukesh *et al.* (2013), Singh *et al.* (2017) and Hussain *et al.* (2021). The yield increased significantly with each successive increase in N level. The increase in yield (grain and straw) might be attributed mainly to an increase in yield attributes such as no. of panicle m^{-2} and grain $panicle^{-1}$ which is attributed to increased growth as a result of increased N supply or availability. The response of late planted crop to higher N dose might be due to poor growth of late planted crop under normal N levels. Similar findings with respect to yield parameters were given by Pramanik and Bera (2013), Iqbal *et al.* (2019) and Adhikari *et al.* (2018).

There was no significant difference in harvest index due to different transplanting dates. Similarly, the harvest index did not alter significantly due to N application levels. The results were in accordance with the findings of Rao *et al.* (2013) and Singh *et al.* (2017a).

The interaction between transplanting time and N levels was found to be significant in terms of grain yield which revealed that the crop responded up to 90 kg ha^{-1} under timely planting but the response to N was significant up to 120 kg ha^{-1} under late planting. According to Singh *et al.* (2017a), late transplanted rice responded to higher levels of N than timely planted rice.

CONCLUSION:

It can be concluded from the results of the present field experiment that timely planted (1^{st} week of July) semi dwarf Basmati rice gave higher yield than late planted (4^{th} week of July) when supplied with 90 kg N ha^{-1} under the agro-climatic condition of Haryana. However, if planting gets delayed, a higher dose of N application (120 kg N ha^{-1}) may be applied to prevent the yield reduction due to late planting.

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