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Effect of varying sowing dates and nitrogen levels on growth and physiology of scented rice

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ABSTRACT

A field experiment was carried out to determine the influence of sowing dates and nitrogen (N) levels on different growth and physiological parameters of scented rice cv. Pusa Sugandh-3. Significant variation in terms of phenological stages and growing degree days (GDDs) accumulation on rice crop was recorded due to different sowing dates and nitrogen levels. The earlier sown crop took more number of days and GDDs to reach various phenological stages as compared to late sown crop. Among the nitrogen levels, 80 and 60 kg N ha^{-1} took significantly more number of days and GDDs to reach different phenological stages. The 15th standard meteorological week (SMW) and 16th SMW sown crop recorded significantly higher number of primary and secondary tillers while tertiary tillers were significantly higher for 18th SMW crop. Pertaining to dry matter partitioning among different levels of nitrogen, significantly more photosynthates were translocated to leaves as well as stem from 45 DAT to harvest at the nitrogen level of 80 kg ha^{-1} and least in control. Also, more photosynthates were translocated to panicle for 80 kg N ha^{-1} and least for the control. At harvest significantly higher nitrogen uptake was recorded for the 15th SMW (106.86 kg N ha^{-1}) and 16th SMW (103.64 kg N ha^{-1}) sowing. Nitrogen uptake was significantly higher for 80 and 60 kg N ha^{-1}.

Key words: *Dry matter partitioning, nitrogen uptake, phenology, Pusa Sugandh-3, sowing date, tiller count*

Rice (*Oryza sativa* L.), the single most important crop, is the primary food source for more than one third of the global population (Hasamuzzaman *et al*. 2009) and grown in 11 per cent of the world's cultivated area (Islam *et al*. 2009). The crop has wide physiological adaptation and is grown successfully in tropics, subtropics and temperate regions up to 2000 m above mean sea level (Okon *et al*. 1998). It has the capacity to grow under continuous flooded condition as well as mild to moderate water deficit stress (Kumar *et al*. 2016, 2017). It is endowed with amazing genetic diversity including more than one hundred thousand landraces and improved cultivars maintained in the germplasm collections spread world over. A unique sub-group that has distinguished itself as a result of natural and human selection, which found wider acceptance all over the world as a speciality rice is called "scented rice".

For utilization of solar radiation effectively and storage of ensuing photosynthate (assimilate), plants need a transport system to transfer assimilate from areas of synthesis to areas of consumption. Assimilate produced by green tissue is transferred all over the plant for growth, development, storage and cell maintenance. This division of assimilate among these processes, termed as partitioning, not only affects productivity but also survival of plant (Gardener *et al*. 2010). The duration of plant growth has two conspicuously different features, *i.e.*, phasic and morphological development. Phasic development comprises alteration in stages of growth and is almost invariably coupled with major changes in biomass partitioning patterns. Morphological development refers to the commencement and ending of development of various plant organs within the plant life cycle (Ritchie *et al*. 1998). The productiveness of rice depends not only on accrual of dry matter but also on its efficient partitioning to leaf, stem and grain as this is key to yield stability (Kumar *et al*. 2006). Numerical estimation of the impact of meteorological parameters on crop growth and development can help to realize the stabilization of crop production to great extent. The dry matter production and its partitioning into different plant parts provides a lucid insight of plant efficiency (Palit *et al*. 1976; Jand *et al*. 1994).

The sowing date of the rice crop is important for three major reasons. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperature and high levels of solar radiation. Secondly, the optimum sowing date for each cultivar ensures that the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, sowing on time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved (Farrell *et al*. 2003). Owing to the short rice crop growing period under Kashmir conditions, synchronising of critical stages of the crop with optimal temperature regime is of utmost importance. Under field conditions the impact of temperature on phenology and yield of crop plants can be examined via accumulated heat unit system since plants require a definite temperature before they attain certain phenological stage (Rajput *et al*. 1987; Bishnoi *et al*.1995; Brar *et al*. 2011).

Application of nitrogen at right dose, right time and right source (Mohanty *et al*. 2017) is an important aspect of overall nitrogen management in aromatic rice for its efficient utilization, higher productivity and better quality. Excess application of nitrogen fertilizer can cause delay in crop maturity as well as high incidence of insect pest attack and lodging (Sidhu *et al*. 2004). Owing to translocation, nitrogen absorption by rice throughout vegetative growth stages promotes growth during reproduction and grain-filling stages (Norman *et al*. 1992; Bufogle *et al*. 1997; Wani *et al*. 2016). Information on the seasonal N uptake patterns and partitioning within the crop is valuable in assessing the amount, timing and method of N fertilization to prevent the occurrence of N deficiencies or over fertilization (Saito 1991; Islam *et al*. 1996; Mohanty *et al*. 2017). Keeping in view the aforementioned facts, the study, effect of varying sowing dates and nitrogen levels on growth and physiology of scented rice was undertaken.

The study was conducted at the Agronomy Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during summer season 2013. The study area is situated at 34^o 05' N latitude and 74^o 89' East longitude having an altitude of 1587 m above mean sea level. The mean temperatures ranged from 13.11 ^{0}C and 26.90 ^{0}C, respectively. Twelve treatment combinations (D_1N_0, D_1N_1, D_1N_2, D_1N_3, D_2N_0, D_2N_1, D_2N_2, D_2N_3, D_3N_0, D_3N_1, D_3N_2, D_3N_3) of 3 sowing dates, *viz*., 15th, 16th and 18th standard meteorological week (SMW) at an interval of 10 days and 4 nitrogen levels ('0', '40', '60' and '80' kg N ha^{-1}), respectively were tested and randomized in split plot design with three replications. The soil of the experimental field was silty clay loam in texture with neutral pH, normal electrical conductivity (0.23dSm^{-1}), medium available nitrogen (407.68 kg ha^{-1}), low available potassium (178.08 kg ha^{-1}), high available phosphorus (26.57 kg ha^{-1}) and organic carbon (0.95%).

The nursery was raised in low polythene tunnels during a period of low temperature (<10^{o}C). Forty days old seedlings were transplanted at a spacing of 15 cm × 15 cm. A uniform dose of phosphorous (P), potassium (K) and zinc (Zn) at the rate of 60 kg P_2O_5, 40 kg K_2O and 15 kg $ZnSO_4$ ha^{-1} was applied in all plots. The nitrogen was applied as per treatments in three splits. Entire quantity of P, K and Zn and 50% N was applied before transplanting and the remaining nitrogen was applied in two equal splits at mid tillering, *i.e.*, 30 days after tillering (DAT) and panicle initiation (60 DAT) stages as per treatments. Anthesis was determined when 50 % of panicles were visible in the centre of the plot. The crop reached physiological maturity when 95 % of spikelets had turned yellow. Number of days taken by the crop from each plot to reach mid tillering, panicle initiation, anthesis, milking, dough and maturity stage from the days after transplanting were keenly observed and recorded. Panicle initiation was determined by dissecting five main stems of plants from penultimate rows of each plot every other day after mid tillering to check for primordial growth. When 90 per cent of the main stems showed primordial growth, it was considered as the panicle initiation stage. Growing degree days (GDD) was calculated for different phenophases according to the equation developed by Summerfield *et al*. (1992). The plants used for dry weight from each plot were separated into leaves, culm (stem) and panicle to study the amount of translocates partitioned to different parts after taking the dry weight. The dry weight of each plant part (leaf, stem and panicle) from its respective treatment was measured in kg ha^{-1} and then converted to q ha^{-1}. Plant samples were collected at maximum tillering, panicle initiation, and harvesting stages of the crop at all the three sowing dates (Kumar *et al*. 2017). Nitrogen content in plant samples was estimated by modified Kjeldahl method (Jackson 1973). Nitrogen uptake was determined by multiplying dry matter accumulation at that particular stage by respective percentage of nitrogen content in plant samples and recorded in kg ha^{-1}.

Data were analysed using split plot design for analysis of variance (ANOVA). Significant ($P \leq 0.05$) differences between treatments were determined using critical difference. The software program used for the analysis was IRRISTAT data analysis package (IRRI 2000).

Days taken to different phenological stages

The phenological stages of rice crop *viz*., mid tillering, panicle initiation, flowering, milking, dough and maturity varied significantly due to effect of various treatments (Table 1). As far as sowing dates are concerned, earlier sown crop took more number of days to reach various phenological stages as compared to late sown crop. The 15th SMW sowing date took significantly highest number of days to reach mid tillering (39.97), panicle initiation (64.81), flowering (95.06), milking (105.04), dough (126.06) and harvest (135.06), whereas the 18th SMW sowing date took significantly least number of days to reach different phenological stages (Table 1). It might have been due to the higher temperature experienced by the 18th SMW sowing date during the vegetative stage which shortened its basic vegetative phase while the prolonging of the vegetative phase of the 15th SMW sowing might be due to lower temperature during initial growth stages. Sowing date primarily influences the length of vegetative period of rice with early sown rice requiring a greater number of days to accumulate the same number of degree days units compared with later sown rice was also reported by Norman *et al*. (1999). Lee *et al*. (2001) reported that days from sowing to flowering were shortened as sowing dates were delayed from 25th April to 5th June in the field and phytotron experiments. Linscombe *et al*. (2004) found that days from seedling emergence to 50 per cent panicle emergence decreased as planting was delayed. Dixit *et al*. (2004) ascertained that panicle initiation stage started late in early sown crop (5th and 10th June) and 50 per cent flowering was earlier in late crop (25th June). Chopra *et al*. (2006) reported that days to 50 and 100 per cent flowering were significantly affected due to delay in transplanting.

Among the nitrogen levels, 80 & 60 kg N ha^{-1} took significantly more number of days to reach different phenological stages while significantly lower number of days were taken by 40 and 0 kg N ha^{-1} to reach different phenological stages, indicating that higher doses of nitrogen increase the crop growth period. Delayed flowering with higher nitrogen dose may be due to more vegetative growth, as reflected by increased plant height (data not shown), which delayed maturity. Abou-Khalifa *et al*. (2007) found that maximum tillering, panicle initiation, heading date, crop growth rates, leaf area index, and grain yield increased with increased levels of nitrogen up to 165 kg N ha^{-1}. Mahajan *et al*. (2010) reported that the high level of N fertilizer (60 kg N ha^{-1}) delayed flowering by 2-3 days in 'Pusa 1121' and 'Punjab Basmati 2'; while in unfertilized plots, flowering was early by 2 days, irrespective of the cultivar used. However, the interaction was non significant.

Growing degree days (GDD) accumulated by crop to reach different phenological stages

With change in sowing dates and nitrogen levels, GDD accumulation also varied for the crop. Sowing dates behaved differently to the number of growing degree days required to reach various phenological stages (Table 2). No significant difference was noticed among all sowing dates as regards GDD accumulation to reach mid tillering and panicle initiation. However, treatments sown earlier *i.e.*, 15th and 16th SMW required significantly higher number of GDDs to reach to different phonological stages *viz*., flowering, milking, dough and harvest stages whereas late sown

Table 1. Effect of sowing dates and nitrogen levels on phenology of rice

Treatment	Mid tillering	Panicle initiation	Flowering	Milking	Dough	Harvesting
Sowing dates						
15th Standard Meteorological week	39.97	64.81	95.06	105.04	126.06	135.06
16th Standard Meteorological week	35.99	60.06	92.05	102.31	124.06	132.06
18th Standard Meteorological Week	35.08	59.03	90.06	101.22	118.85	127.23
SEm±	0.23	0.35	0.59	0.35	1.09	1.29
CD ($p \leq 0.05$)	0.77	0.95	1.86	1.03	3.42	3.96
Nitrogen levels (kg ha^{-1})						
Control (N_0)	36.95	58.74	90.17	100.13	120.02	128.81
40 kg N ha^{-1} (N_{40})	36.97	59.78	91.23	101.36	121.15	130.12
60 kg N ha^{-1} (N_{60})	37.06	62.82	94.16	104.18	125.02	132.92
80 kg N ha^{-1} (N_{80})	37.06	63.85	95.20	105.23	126.15	133.95
SEm±	0.19	0.27	0.29	0.33	0.35	0.53
CD ($p \leq 0.05$)	NS	0.87	1.03	1.09	1.12	1.55
Sowing dates ×Nitrogen levels			NS			

treatments ie during 18th SMW required significantly the lower number of GDDs to reach different phenological stages. Since the duration to reach different phenological stages was more in case of 15th SMW sowing and least for the 18th SMW sowing date, hence 15th SMW sowing date required more GDDs to complete its growing cycle and least was required for the 18th SMW sowing date (Table 2). Chopra and Chopra (2004) reported that growing degree days from transplanting to maturity (total phenophases) got reduced almost linearly with delay in transplanting. Similar results were also reported Reddy *et al*. (2004). Accordingly, early sown crop accumulated more GDDs to reach different phenological stages compared to late sown crop. Brar *et al*. (2011) reported that 10 to 20 days delay in transplanting led to 13 and 24 days reduction in total growing cycle of the crop under June 25 and July 5 transplanted crops as compared to June 15 transplanted crop, respectively. Consequently, this led to reduction in accumulated GDDs to the tune of 86 and 20 heat units to attain the maturity under June 25 and July 5 transplanted crop as compared to June 15 transplanted crop, respectively.

Regarding the nitrogen levels, significantly more number of GDDs were required for higher nitrogen levels of 80 and 60 kg N ha^{-1} while significantly lower number of GDDs were accumulated by treatments receiving lower nitrogen levels *i.e*., 40 and 0 kg N ha^{-1}, to complete the various phenological stages. This may be attributed to the fact that treatments (60 and 80 kg N ha^{-1}) received higher application of nitrogen took more days to complete different phenological stages and hence more growing degree days. Similar results were reported by Mahla *et al*. (2011). However, the interaction was non significant.

Dry matter partitioning (q ha^{-1})

The dry matter partitioning to leaf and stem were recorded at 15, 30, 45 and 60 DAT while from 75 DAT

Table 2. Effect of sowing dates and nitrogen levels on GDD's taken by rice to reach different phenological stages

Treatment	Mid tillering	Panicle initiation	Flowering	Milking	Dough	Harvesting
Sowing dates						
15th Standard Meteorological week	484.59	861.84	1292.05	1400.55	1598.96	1757.98
16th Standard Meteorological week	482.72	847.11	1271.52	1408.45	1558.47	1751.49
18th Standard Meteorological Week	480.38	834.08	1230.05	1389.50	1507.48	1660.49
SEm±	1.92	4.31	8.68	4.76	11.07	14.19
CD ($p \leq 0.05$)	NS	NS	26.81	14.55	33.21	43.14
Nitrogen levels (kg ha^{-1})						
Control (N_0)	482.31	823.18	1236.55	1393.16	1530.50	1701.16
40 kg N ha^{-1} (N_{40})	482.33	831.28	1248.78	1383.37	1540.67	1712.36
60 kg N ha^{-1} (N_{60})	482.80	864.06	1281.61	1405.58	1569.22	1734.25
80 kg N ha^{-1} (N_{80})	482.80	874.18	1292.88	1415.88	1579.50	1745.50
SEm±	1.3	1.18	6.23	3.67	9.35	12.11
CD ($p \leq 0.05$)	NS	3.66	18.84	11.19	28.43	36.71
Sowing dates ×Nitrogen levels			NS			

i.e., during reproductive phase, partitioning to leaf, stem and panicle was recorded (Table 3). Most of the dry matter (photosynthates) was partitioned to stem up to 60 DAT but the magnitude of difference of dry matter partitioned to stem and leaf decreased during later stages up to 90 DAT. Gardner *et al*. (2010) reported that during vegetative growth roots, stem and leaves are competitive sinks for assimilate. However, from 75 DAT to harvest a constant increase in dry matter partitioning towards panicle took place and was much higher as compared to the dry matter partitioned to leaf and almost comparable to the dry matter partitioned to stem. The manner in which the dry matter is distributed among different parts of the plants, determines the magnitude of economic yield (Kumar *et al*. 2017). This might be due to the fact that leaves which produce photosynthates get stored in stem of the plant due to which stem constitutes more portion of the plant weight, and the subsequent increase in leaf weight is due to the increase in the leaf number. Moreover, the increase in the weight of panicle from 75 DAT to harvest is attributed to the fact that apart from accumulation of photosynthates in panicle (sink) resulting from flag leaf photosynthesis, mobile carbohydrates, proteins and mineral nutrients from different sources are also moved to panicle during the grain filling stage. Jain (2016) reported that the amount of assimilates transported to harvest organ is much more in comparison to other organs of the plant.

Regarding the dry matter partitioning to stem among all the sowing dates, no significant difference was recorded up to 90 DAT but significantly higher dry matter partitioning was recorded for the 15th SMW and 16th SMW sowing dates as compared to the 18th SMW. While the dry matter partitioning to leaf was not found statistically different among all the sowing dates at all crop growth stages. Moreover, no significant difference was noticed in dry matter partitioning to panicle among all the sowing dates. Brar *et al*. (2011) ascertained that total dry matter accumulation and its partitioning was influenced significantly under three (15 and 25 June and 5 July) days of transplanting at various stages of the crop.

Pertaining to levels of nitrogen application, the partitioning of dry matter to stem was not significantly different up to 30 DAT, while highest dry matter partitioning to stem was found to occur from 45 DAT to harvest in the nitrogen level of 80 kg N ha^{-1} and least in control (Table 3). This might be due to the fact that more photosynthates were formed in the leaf of the plants receiving higher fertilization levels (N_1 and N_2) which were translocated to stem resulting in significantly higher dry matter partitioning of stem. The dry matter partitioning to leaf was not significantly different up to 30 DAT and at 105 and 120 DAT, but the dry matter partitioning to leaf from tillering to flowering stage *i.e.*, at 45, 60, 75 and 90 DAT was significantly different among various nitrogen levels. The highest dry matter partitioning to leaf was found in the nitrogen level of 80 kg N ha^{-1} and least in control. However, 60 kg N ha^{-1} was at par with 80 kg N ha^{-1} at all growth stages. The differences in the dry matter partitioning to leaf at 45,

Table 3. Effect of sowing dates and nitrogen levels on dry matter partitioning (q ha $^{-1}$) of rice

Treatment	Days after transplanting							
	15		30		45		60	
	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf
Sowing dates								
15th Standard Meteorological week	0.82	0.21	4.88	1.50	21.75	9.24	38.79	21.74
16th Standard Meteorological week	0.82	0.22	5.36	1.51	21.97	9.27	38.71	21.77
18th Standard Meteorological Week	0.83	0.22	5.20	1.50	21.94	9.33	38.01	21.37
SEm±	0.01	0.03	0.08	0.05	0.63	0.41	0.64	0.69
CD ($p \leq 0.05$)	NS	NS	NS	N.S	NS	NS	NS	NS
Nitrogen levels (kg ha^{-1})								
Control (N_0)	0.81	0.22	4.63	1.45	18.92	8.09	34.59	19.46
40 kg N ha^{-1} (N_{40})	0.82	0.22	5.25	1.49	20.96	8.84	37.21	20.82
60 kg N ha^{-1} (N_{60})	0.83	0.22	5.32	1.52	23.03	9.71	39.93	22.46
80 kg N ha^{-1} (N_{80})	0.83	0.22	5.43	1.55	24.64	10.48	42.26	23.77
SEm±	0.01	0.02	0.17	0.06	0.65	0.51	0.69	0.80
CD ($p \leq 0.05$)	NS	NS	NS	NS	1.95	1.52	2.08	2.38
Sowing dates ×Nitrogen levels	NS							

60, 75 and 90 DAT might be due to the presence of higher leaf number per plant in the plots receiving higher doses of nitrogen, which consequently contributes to higher leaf dry weight. The dry matter partitioning to panicle was not found significantly different at 75 DAT but from 90 DAT to harvest, the higher dry matter partitioning to panicle was found in the nitrogen level of 80 kg N ha^{-1} and was significantly different from other nitrogen levels 40 and 0 kg ha^{-1}. The higher dry matter partitioning to panicle from 90 DAT to harvest might be due to the greater reserves of photosynthates present in the stem of the plants receiving higher nitrogen levels which were translocated to the panicle resulted in significant difference in the dry weight of panicle from the plants received lower nitrogen applications. Qinglin *et al*. (2000) reported that higher nitrogen application significantly enhanced dry matter partitioning at the vegetative stage. Moreover, leaf partitioning of absorbed nitrogen compared to dry matter was higher and varied little during early vegetative growth, but varied greatly from panicle initiation onwards probably due to competition for nitrogen among leaves, stem and the developing panicle. Azarpour *et al*. (2014) reported that the dry matter partitioning to various parts of the plant is influenced by the amount of nitrogen. However, the interaction was non significant.

Nitrogen content and uptake

The data on nitrogen content recorded at various phenological stages of the rice crop revealed that nitrogen content did not show any significant variation by altering the sowing dates and nitrogen levels (Table 4). Regarding nitrogen uptake there was no significant difference among the sowing dates at maximum tillering and panicle initiation stage (Table 5). However, at harvest significantly higher nitrogen uptake was recorded for the 15th SMW (106.86 kg N ha^{-1}) and 16th SMW (103.64 kg N ha^{-1}) sowing. The lowest nitrogen uptake was recorded for the 18th SMW sowing date (87.76 kg N ha^{-1}). Pandey *et al*. (2008) reported that nitrogen uptake in hybrid rice planted on July 5 or 20 was significantly higher compared to 5 or 20 August planting dates. Among levels of nitrogen significant difference for nitrogen uptake was recorded. The application of 80 kg N ha^{-1} recorded significantly highest nitrogen uptake at all the stages of crop growth while the level of 60 kg N ha^{-1} recorded significantly higher nitrogen uptake than 40 kg N ha^{-1}. The lowest nitrogen uptake was recorded in the control. The nitrogen uptake was significantly different among the nitrogen levels and increased with increase in nitrogen levels (Table 5). Increased nitrogen uptake with application of nitrogen levels from 0 to 80 kg N ha^{-1} might be due to increased root growth that absorbs more N from the soil at higher N level resulting in higher nitrogen concentration in dry matter. Also this might be attributed to the fact that high nitrogen uptake of the crop is favoured by additional supply of nitrogen during maximum growth phase. Tayefe *et al*. (2011) observed that total N uptake varied significantly with the increment of the amount of nitrogen applied. Rao et al. (2013) reported that at all growth stages nitrogen uptake was maximum at 240 kg ha^{-1} which was significantly superior over low level (120 kg N ha^{-1}). Moreover, nitrogen uptake increased with increase in the levels of nitrogen up to 240 kg ha^{-1}. The beneficial effect of increasing nitrogen levels on the nitrogen uptake was also reported by Ebaid and Ghanem (2000). The results were also in accordance with those of Srivastava *et al*. (2006), Zaidi *et al*. (2007), Prudente *et al*. (2008). Pandey *et al*. (2008) reported that nitrogen uptake increased significantly with increasing levels of nitrogen from 50-150 kg N ha^{-1}. However, the interaction was non significant.

Primary, secondary and tertiary tillers m^{-2} at the time of harvest

The data on primary, secondary and tertiary tillers m^{-2} recorded at the time of harvest is presented in Table 6. The highest number of primary tillers was observed in early sown crop ***i.e.***, 15th SMW sowing date and lowest in late sown crop ***i.e.***, 18th SMW which might be due to longer vegetative period of earlier sown date (18th SMW), which favoured primary tiller development. However, the 16th SMW sowing date was found at par with both 15th SMW as well as 18th SMW sowing dates. Pertaining to number of secondary tillers m^{-2}, significant differences were recorded among the sowing dates wherein 15th SMW and 16th SMW sowing dates recorded significantly higher number of secondary tillers m^{-2} and were at par with each other while lowest number of secondary tillers m^{-2} were recorded for the 18th SMW sowing date. On the contrary, 18th SMW sowing date recorded significantly higher number of tertiary tillers m^{-2} than other sowing dates. This may

Table 4. Effect of sowing dates and nitrogen levels on dry matter partitioning (q ha $^{-1}$) of rice

Treatment	Days after transplanting											
	75			90			105			At harvest		
	Stem	Leaf	Panicle	Stem	Leaf	Panicle	Stem	Leaf	Panicle	Stem	Leaf	Panicle
Sowing dates												
15th Standard Meteorological week	45.59	33.97	9.83	39.48	29.94	26.96	43.10	16.46	37.76	44.56	12.59	39.71
16th Standard Meteorological week	45.54	33.93	9.91	39.18	29.62	26.76	42.24	16.32	37.44	44.18	12.48	39.38
18th Standard Meteorological Week	44.15	32.73	9.52	37.17	28.11	25.38	40.04	15.44	35.42	41.78	11.80	37.24
SEm±	0.86	0.51	0.29	0.84	0.39	0.35	0.23	0.49	0.97	0.38	0.21	1.04
CD ($p \leq 0.05$)	NS	NS	NS	NS	NS	NS	0.91	NS	NS	1.48	NS	NS
Nitrogen levels (kg ha^{-1})												
Control (N_0)	41.05	30.58	8.96	35.12	26.55	23.99	37.87	14.63	33.56	39.60	11.19	35.29
40 kg N ha^{-1} (N_{40})	44.26	32.97	9.54	37.55	28.39	25.64	40.50	15.64	35.89	42.35	11.97	37.75
60 kg N ha^{-1} (N_{60})	46.76	34.84	10.08	40.28	30.45	27.51	44.14	16.75	38.43	45.35	12.81	40.42
80 kg N ha^{-1} (N_{80})	48.33	35.78	10.42	41.50	31.49	28.34	44.68	17.26	39.60	46.72	13.20	41.64
SEm±	0.78	0.80	0.67	0.90	0.86	0.84	0.87	0.80	0.79	0.88	0.80	0.76
CD ($p \leq 0.05$)	2.32	2.39	NS	2.69	2.56	2.51	2.59	NS	2.35	2.63	NS	2.27
Sowing dates ×Nitrogen levels						NS						

Table 5. Effect of sowing dates and nitrogen levels on nitrogen content and uptake (kg ha $^{-1}$) by rice

Treatment	N content (%)			N uptake (kg ha^{-1})		
	Maximum-tillering	Panicle initiation	Harvesting	Maximum-tillering	Panicle initiation	Harvesting
Sowing dates						
15th Standard Meteorological week	2.10	2.14	1.19	124.63	137.69	106.86
16th Standard Meteorological week	2.10	2.13	1.18	124.74	136.53	103.64
18th Standard Meteorological Week	2.11	2.13	1.18	125.12	134.08	87.76
SEm±	0.06	0.08	0.06	3.36	3.86	3.42
CD ($p \leq 0.05$)	NS	NS	NS	NS	NS	13.35
Nitrogen levels (kg ha^{-1})						
Control (N_0)	2.06	2.08	1.14	102.75	109.81	80.34
40 kg N ha^{-1} (N_{40})	2.11	2.14	1.20	118.19	130.86	93.90
60 kg N ha^{-1} (N_{60})	2.11	2.15	1.20	133.15	145.53	107.39
80 kg N ha^{-1} (N_{80})	2.12	2.15	1.21	145.24	158.20	116.04
SEm±	0.05	0.06	0.06	2.78	2.85	2.62
CD ($p \leq 0.05$)	NS	NS	NS	8.26	8.48	7.81
Sowing dates ×Nitrogen levels			NS			

be due to the fact that prevalence of lower temperature during the later stages might have favoured the tertiary tiller production. Oda and Honda (1996) also reported that the number of tertiary tillers increased with decreasing temperature.

Perusal of data with respect to different nitrogen levels indicated that primary, secondary and tertiary tillers m^{-2} recorded at the time of harvest were significantly different. The highest number of primary and secondary tillers (138.23 m^{-2}) was recorded for nitrogen level of 80 kg N ha^{-1}. However, the application of 60 kg N ha^{-1} was at par for the number of primary and secondary tillers m^{-2} with the 80 kg N ha^{-1} treatment. The lowest number of primary and secondary tillers was recorded for the control (128.51 m^{-2}). The

Table 6. Primary, secondary and tertiary tillers m^{-2} (at harvest) as influence by sowing dates and nitrogen levels

Treatment	Primary tillers (m^{-2})	Secondary tillers (m^{-2})	Tertiary tillers (m^{-2})
Sowing dates			
15th Standard Meteorological week	138.99	180.58	12.55
16th Standard Meteorological week	135.00	171.99	14.12
18th Standard Meteorological Week	127.00	154.09	24.37
SEm±	3.46	3.59	0.57
CD ($p \leq 0.05$)	10.48	14.11	2.23
Nitrogen levels (kg ha^{-1})			
Control (N_0)	128.51	147.73	14.30
40 kg N ha^{-1} (N_{40})	133.96	162.19	16.78
60 kg N ha^{-1} (N_{60})	134.62	175.84	17.93
80 kg N ha^{-1} (N_{80})	138.23	188.45	19.03
SEm±	2.88	3.75	0.72
CD ($p \leq 0.05$)	8.70	11.15	2.14
Sowing dates ×Nitrogen levels		NS	

highest number of tertiary tillers m^{-2} was also recorded for the higher doses of nitrogen used and lowest for the control treatment. The reason that could be attributed is the role of nitrogen in the growth and production of tillers. The beneficial effect of nitrogen on tillering and vegetative growth was reported by Reddy (1988). The higher tertiary tiller number recorded for the higher nitrogen levels might be due to the residual soil nitrogen present in these plots which favoured the tertiary tiller production at later stages of crop. Similar findings were also reported by Pramanik and Bera (2013). However, the interaction between sowing dates and nitrogen was non significant.

The study revealed that the days taken by the crop to reach various phenological stages and accumulation of GDDs were more in case of 15th SMW sowing and closely followed by 16th SMW while 18th SMW sowing recorded lowest values for the respective parameters. As far as nitrogen uptake is concerned, higher nitrogen uptake was recorded in the 15th and 16th SMW sowing and lowest for the 18th SMW sowing. The nitrogen content was not found significantly different among the sowing dates. Days taken to reach various phenological stages were more in case of higher nitrogen levels of 80 & 60 kg N ha^{-1} and lower in case of 40 kg N ha^{-1} and control. Nitrogen uptake was found highest in the nitrogen level of 80 kg N ha^{-1} and was closely followed by nitrogen level of 60 kg N ha^{-1}, while the lowest values were recorded for control. However, nitrogen content was not significantly different in all the nitrogen levels tested.

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