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Effect of Split Application of Nitrogen on Physiological Maturity of Rice (*Oryza sativa*)

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ABSTRACT
Rice is the main crop for India, in eastern part comprising mainly of West Bengal, Bihar, Assam and parts of Uttar Pradesh rice cultivation is feasible both during Kharif and summer seasons in the irrigated tracts. Of the total 38.9 million hectares under rice in India, about 20 million ha or 50% of the area are under lowland where there is standing water of varying depths depending on the topography of the land for varying periods. Nitrogen plays on important role in regulating life span of a crop. Evidences are there to show that nitrogen application in rice at later stages of growth enhances maturity time. However, rice varieties having early maturity time. An experiment was conducted on split application of nitrogen on physiological maturity in rice at Dighwadubauli, Baikunthpur, Gopalganj, Bihar during two consecutive seasons of year 2009 and 2010 respectively. The results shown that plant height and leaf area index was significant at 20th day of transplanting when the amount of nitrogen applied as basal dressing. Plots getting higher doses at transplanting had better expression of these characters. After application of second instalment of nitrogen at active tillering stage, when the treatments completed 75 to 100 percent quota of the full dose of nitrogen, there was no significant difference in plant height and leaf area index in the subsequent observations. Plots getting nitrogen in two equal splits either in 50:50 or 25:75 ratio at transplanting and active tillering stage produced highest grain yields. Very high basal dressing (75%) was associated with production of lowest grain yields.

Key words: *Nitrogen, Split application, physiological maturity, Oryza sativa*

INTRODUCTION

Rice in tropical and sub-tropical Asia has been primarily a monsoonal crop grown from June to December, with the evolution of high yielding dwarf varieties insensitive to photoperiod, the seasonal barrier was overcome and it is possible to grow rice all-round the year, provided temperature is in favourable range (20°C to 38°C mean temperature) and irrigation facility exists. Abiding the nature of thermo sensitivity, while rice is grown throughout the year in peninsular India, its cultivation is limited to only one season in northern and most of the western parts of the country. In eastern part comprising mainly of West Bengal, Bihar, Assam and parts of Uttar Pradesh rice cultivation is feasible both during Kharif and summer seasons in the irrigated tracts.

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Nitrogen fertilization is one management tool that affects rice yield and milling quality. Applying N fertilizer close to booting can enhance photosynthetic capacity during the grain filling period, leading to an increase in head rice yield. Wopereis-Pura *et al.*[17] showed that grain yield increased with the addition of 30 kg N ha^{-1} at booting by about 5 and 25% during the wet and dry seasons, respectively. Among the three seasons (Monsoon, winter and summer) in which rice is grown in India, the yield per unit area is maximum during summer in the states taking two or more than two crops of rice a year. Chatterjee and Maiti[2] have reported that the average rice yield in the country harvested during autumn, winter and summer seasons are 951, 1073 and 1876 kg per hectare respectively keeping in view essentiality or varietal earliness for rice the production in space and time during summer will be still higher than those obtained during Kharif and Rabi Seasons. The reasons for higher yield during summer are associated with higher intensity of incoming solar radiation, clear sunny days, longer sunshine duration in reproductive phase, better fertilizer use efficiency and least plant protection problems. The rice grain ripens much before the senescence occurring on plants, but the farmers are adapting to harvest the crop after complete senescence. To safeguard against the loss, the rice should be harvested, when Spikelet attains their maximum dry weight and quality of a seed. Thus, if harvesting is done at physiological maturity, it will save crop from heavy monsoon downpour and also release the field for timely cultivation of the rice crop. Nitrogen also plays on important role in regulating life span of a crop. Evidences are there to show that nitrogen application in rice at later stages of growth enhances maturity time. However, rice varieties are early maturity time. Thus, if nitrogen application is restricted only up to active tillering stage, the crop can be harvested earlier, which will facilitate in early threshing and processing of rice and timely cultivation of rice. Rice is must be of high milling quality to command a premium price, and to obtain this high quality and maximum yields; rice must be cut at the proper stage of maturity (moisture content). It is due to this reason that this investigation was taken up during 2009 and 2010.

This investigation is a venture to find out solution to these burning problems, which have restricted the expansion of rice cultivation. The ways and means, expected to avoidance and tolerance capacity to rice cultivation and which formed the base for the present investigation, to find out the stages of physiological maturity in rice, when spikelet attain full character of seed.

MATERIAL AND METHODS

The experiment was conducted at Dighwadubauli, Baikunthpur, Dist.- Gopalganj during two consecutive seasons of year 2009 and 2010 respectively. The experimental plots had uniform topography and soil characteristics typical to suit rice cultivation. Dighwaduauli is situated at latitude of 26°25'40" N and longitude 84°05'45" E in Gopalganj district of Bihar State under Gangetic plain of India. The experiment was conducted in split plot design replicated thrice. Treatments comprising of different ways of nitrogen splitting were put in the main plot and combinations of time of harvest and desiccants in the sub-plots. There were four treatments in the main plot and 12 treatments combination in the sub-plot making a total of 48 sub plots in each replication. Induction of sub-plot treatment took place only two days before harvesting. Thus, throughout the vegetative and reproductive phase of the crop, the plots received only main plot treatment virtually making it a randomized block design. The split plot design was operation after the application of sub-plot before harvest of the crop. The test variety selected for this investigation was MTU-7029. It is popularly known as Swarna and derivatives of Mansuri, is the most popular improved rice variety that is grown in a large number of states. Major Pre-harvest observations are as follows-

Plant Height

Progressive increase in plant height were recorded. Measurement was taken from ground level to the top most growing part of the plant.

Tiller count

The number of tiller per sampling unit (60 cm x 60 cm) was counted at all the growth stages. At harvest, total tillers as well as number of ear bearing tillers were counted separately.

Dry- matter production

Plants from the boarder rows were selected randomly and taken out for studying dry matter production pattern. The plants were dried in an oven at 60°C till constant weight reached.

Leaf Area Index (LAI)

The leaf area was computed from the same plants taken for dry matter production studies. The leaves of all the four hills were counted and separated from sheath. Ten leaves were selected randomly from the bulk and the prints of these leaves were taken on graph paper. From the graph paper, the leaf area of these ten leaves was calculated. Then these leaves were dried in oven at 60°C till constant weight reached. The ratio of leaf dry matter and leaf area thus obtained was utilized to calculated leaf area of reaming leaves in the hill. Finally, the dry matter of detached leaves was added to the dry matter of culm to give total dry matter production. The leaf area index was then calculated by dividing the leaf area with the land area occupied.

Days to 50 percent flowering

Five randomly selected and tagged plants in the two sampling units of each plot were used as criterion to ascertain the time of heading. When half of the fully developed tillers of these plants came to heading, the time was recorded as 50 percent flowering.

RESULTS AND DISCUSSION

The observation recorded during the course of investigation and results obtained from growth studies are presented as follows-

Plant height

Mean observational data in respect of progressive development of plant in height, recorded at 20, 40, 60 and 80 days after transplanting have been presented in Table -1.

Table 1: Plant height (cm) at different stages of growth as affected by split application of nitrogen (pooled)

Treatments	Days after transplanting			
Symbol	20	40	60	80
N_1 (75%B+25%AT)	41.22	55.22	74.72	83.80
N_2 (25%B+75%AT)	34.88	53.38	75.88	85.13
N_3 (50% B+50%AT)	37.72	56.72	77.88	85.63
N_4 (50%B+25%AT+25%PI)	37.72	54.05	77.88	85.01
S. E.	2.60	1.46	1.56	0.95
S. E. m±	1.29	0.73	0.78	0.47

B- Basal, AT- Active tillering, PI - Panicle initiation

The difference in plant height under the influence of split application of nitrogen, were significant only upto 20th day of transplanting. Plants getting 75 percent nitrogen at transplanting (N_1) had significantly taller plants (41.22cm) than those gained through basal application of 25 or 50 percent nitrogen (N_2, N_3 and N_4). After the application of nitrogen at active tillering stage, plants did not show significant variation in height in the subsequent observations. Data for the individual years, however, did not record significant difference in plant height even at 20th day of transplanting as in table -2.

Table 2: Plant height (Cm) at different stages of growth as affected by split application of nitrogen

2009

Treatments Symbol	Days after transplanting 20	40	60	80
N_1 (75% B+25% AT)	34.88	52.72	72.38	82.30
N_2 (25% B+75% AT)	32.72	50.38	73.38	83.55
N_3 (50% B+50% AT)	35.05	53.72	75.72	83.72
N_4(50% B+25% AT+ 25% PI)	35.38	51.38	76.05	85.30
S. E.	1.21	1.47	1.79	1.23
S. E. M±	0.60	0.73	0.89	0.75

2010

Treatments Symbol	Days after transplanting 20	40	60	80
N_1 (75% B+25% AT)	43.05	57.72	77.05	85.30
N_2 (25% B+75% AT)	37.05	56.38	78.38	86.72
N_3 (50% B+50% AT)	40.38	59.72	80.05	87.55
N_4(50% B+25% AT+ 25% PI)	40.05	56.72	79.72	84.72
S. E.	2.46	1.50	1.37	1.29
S. E. M±	1.22	0.75	0.68	0.79

Number of tillers

The number of tillers per meter square recorded at 20, 40, 60 and 80 days after transplanting has been presented in table –3 and table-4.

Table 3: Number of total tillers and effective tillers per meter square as affected by different treatment at harvest

Treatments	No. of total tillers			No. of effective tillers		
Symbol	2009	2010	Pooled	2009	2010	Pooled
Main plot :						
N_1(75%B+25%AT)	312.08	324.03	317.61	283.80	297.66	290.73
N_2(25%B+33%AT)	357.24	373.74	365.49	312.27	325.91	319.09
N_3(50%B+50%AT)	351.72	370.93	361.33	316.61	333.49	326.05
N_4(50%B+25%AT+25%PI)	309.36	316.69	313.02	276.30	290.11	283.20
S.E.	25.39	30.18	27.88	20.17	21.13	20.98
S.E. m±	12.69	15.08	13.94	30.08	10.56	10.48

B= Basal, AT- Active Tillering, PI:- Panicle Initiation and DAF-Days After 50 percent Flowering.

Table 4: Number of total tillers per meter square at different Stages of growth as affected by split application of nitrogen

Treatments	Days after transplanting			
Symbol	**20**	**40**	**60**	**80**
Pooled				
N_1 (75% B+25% AT)	215.65	309.05	334.38	320.72
N_2 (25% B+75% AT)	187.72	368.22	385.38	370.22
N_3 (50% B+50% AT)	208.38	352.55	367.38	362.22
N_4(50%B+25%AT+25%PI)	208.88	299.38	315.55	314.55
S. E.	12.09	33.29	31.53	28.35
S. E. M±	6.04	16.64	15.76	17.36
2009				
N_1 (75% B+25% AT)	212.75	315.35	317.35	326.75
N_2 (25% B+75% AT)	181.75	382.38	379.35	378.05
N_3 (50% B+50% AT)	205.05	363.35	357.05	370.35
N_4(50% B+25% AT+ 25% PI)	208.35	302.35	310.05	318.35
S. E.	13.85	38.14	32.89	30.18
S. E. M±	6.92	19.06	16.44	18.48
2010				
N_1 (75% B+25% AT)	217.35	302.75	331.35	314.75
N_2 (25% B+75% AT)	198.75	354.05	391.35	362.35
N_3 (50% B+50% AT)	211.75	341.75	377.75	354.05
N_4(50% B+25% AT+ 25% PI)	209.35	296.35	321.05	310.75
S. E.	7.79	28.48	34.40	26.51
S. E. M±	3.89	14.24	17.20	16.23

B - Basal, AT - Active Tillering, PI - Panicle initiation

At 20th day of transplanting tillering behaviours was an expression of the amount of nitrogen received as basal dressing. The plots getting 75 percent nitrogen as basal (N_1) had maximum tillering (215.65/m^2), which was at par with those getting 50 percent as basal (N_3 and N_4). The minimum tillering (187.72/m^2) was associated with minimum N-feeding at transplanting (25%) in the treatment N_2. After application of nitrogen at active tillering stage, the equation changed and the treatment N_2 getting maximum nitrogen at this stage (75%), had the highest number of tillers in all subsequent observations. However, N_2 was at par with N_3 (50% B + 50% AT) at all the growth stages. The remaining two treatments N_1 (75% B + 25% AT) and N_4 (50% B +2 5% AT + 25% PI) in turn produced significantly lower tillers and the two were at par among themselves. The data recorded at harvest revealed that tillering was mainly the function of nitrogen applied at active tillering stage. At harvest the treatment N_2 (25% B+ 75% AT) had 15.13 percent more tillers as compared to N_4 (50% B+ 25% AT + 25% PI).The treatment recording minimum tillers.

Leaf Area Index

The mean leaf area index at 20, 40, 60 and 80 days after transplanting has been given in table-5 and table-6. Split application of nitrogen was observed to have bearing on leaf area index only up to 20th day of transplanting. In subsequent observations, the treatments did not differ significantly. Leaf area index at 20th day was a reflection of the amount of nitrogen applied at transplanting. The treatment N_1 receiving 75 percent nitrogen as basal dressing had significantly highest leaf area index (1.05) and N_2 the lowest (0.83) with only 25% nitrogen as basal. The two treatments (N_3 and N_4) getting 50 percent nitrogen as basal dressing were statistically at par and placed between the treatments exhibiting highest and lowest leaf area index.

Table 5: - Leaf area index at different stages of growth as affected by split application of nitrogen (Pooled)

Treatments Symbol	Days after transplanting			
	20	40	60	80
N1 (75%B+25%AT)	1.05	2.08	4.51	4.30
N2 (25%B+75%AT)	0.83	2.29	4.89	4.66
N3 (50%B+50%AT)	0.95	2.22	4.75	4.60
N4(50%B+25%AT+ 25%PI)	0.97	2.08	4.62	4.47
S.E.	0.09	0.11	0.16	0.20
S.E. m±	0.04	0.05	0.08	0.09

B= Basal, AT - Active Tillering, PI = Panicle initiation.

Table 6: Dry matter accumulation and leaf area index at different stages of growths as affected by split application of nitrogen

2009

	Days after transplanting							
Treatments	**Dry matter in g/m^2**				**Leaf area index**			
Symbol	**20**	**40**	**60**	**80**	**20**	**40**	**60**	**80**
N_1(75%B+25%AT)	105.39	203.73	615.73	805.06	1.03	1.92	4.44	4.23
N_2(25%B+75%AT)	86.23	221.39	673.06	907.06	0.79	2.17	4.81	4.59
N_3(50%B+50%AT)	100.73	212.06	676.73	913.06	0.93	2.10	4.67	4.56
N_4(50%B+25%AT+25%PI)	98.56	196.06	663.39	895.06	0.95	2.01	4.56	4.39
S. E.	8.18	10.90	28.23	50.56	0.10	0.11	0.16	0.17
S. E. M±	4.08	5.44	14.11	30.95	0.04	0.05	0.07	0.10

2010

	Days after transplanting							
Treatments	Dry matter in g/m2				Leaf area index			
Symbol	**20**	**40**	**60**	**80**	**20**	**40**	**60**	**80**
N1(75%B+25%AT)	110.23	216.79	664.06	849.06	1.07	2.23	4.57	4.36
N2(25%B+75%AT)	86.23	228.73	728.39	968.43	0.83	2.40	4.96	4.74
N3(50%B+50%AT)	104.39	233.73	733.39	973.06	0.96	2.34	4.83	4.85
N4(50%B+25%AT+25%PI)	106.39	209.73	717.39	958.06	0.98	2.15	4.68	4.54
S. E.	10.67	10.96	31.87	59.06	0.10	0.11	0.17	0.27
S. E. M±	5.33	5.47	15.93	36.16	0.04	0.05	0.08	0.13

B - Basal, AT - Active Tillering, PI - Panicle initiation

Dry matter accumulation

Observational data on dry weight of plants per meter square recorded at 20, 40, 60 and 80 days of transplanting (table-7). It revealed that differences due to nitrogen splitting were significant at all the growth stages. Data for individual years shown in table-6 However, indicated non-significant effect during 2009 and significant difference only at 20th and 60th day of transplanting during 2010.

Table 7: Dry matter accumulation in g/m^2 at different stages of growth as affected by split application of nitrogen (pooled)

Treatments Symbol	Days after transplanting			
	20	40	60	80
N_1 (75%B+25%AT)	106.80	209.05	638.88	826.05
N_2 (25%B+75%AT)	84.30	224.05	699.72	936.88
N_3 (50%B+50%AT)	101.55	221.88	704.05	942.05
N_4(50%B+25%AT+25%PI)	101.47	201.88	684.38	925.55
S.E.	9.81	10.56	29.80	67.14
S.E. M±	4.90	5.27	14.90	33.57

B= Basal, AT = Active tillering PI = Panicle initiation.

At 20th day the treatment N_2 getting only 25 percent nitrogen at transplanting had significantly lowest dry matter. Plots getting 50 percent (N_3 and N_4) or 75 percent (N_1) nitrogen at that stage did not differ significantly. After top dressing of nitrogen at active tillering stage, the equation changed and treatment (N_2) having lowest dry matter earlier came on top by virtue of receiving the balance 75 percent nitrogen. However, the treatment N_2 was at par with N_3 getting full dose of nitrogen by that time in two equal splits. The treatment N_4(50%B+25%AT+25%PI) and N_1(75%B+25%AT) accumulating lowest dry matter were statistically at par. At 60th day and 80th day after transplanting N_4 completing its full quota of three splits also caught up with the top two treatments (N_3 and N_2) and the three were statistically at par, but significantly superior to N_1, the treatment getting maximum nitrogen (75%) at basal dressing.

Days to 50 percent flowering

Time taken by plants to come to 50 percent heading (Table-8) was significantly affected by split application of nitrogen.

Table-8: Number of days taken to 50 percent flowering as affected by different treatments

Treatments	2009	2010	Pooled
N-Splitting:-			
N_1 (75% B+25% AT)	92.80	94.99	93.90
N_2 (25% B+75% AT)	93.10	95.44	94.26
N_3 (50% B+50% AT)	92.99	95.55	94.27
N_4(50% B+25% AT+ 25% PI)	96.99	99.88	98.44
S.E.	2.02	2.29	2.16
S.E. M±	1.00	1.14	1.07

B- Basal, AT- Active tillering, PI - Panicle initiation and DAF - Days after 50 percent flowering.

The plants earliest to come to 50 percent heading (93.90 days) were under the treatment N_1, which received 75 percent nitrogen as basal and 25 percent at active tillering stage. The plants under treatments N_2(25%B+75 %AT) and N_3(50%B+50%AT) getting higher quantity at active tillering stage took more time to come to 50 percent heading (94.27 days). The plants under the treatment N_4(50%B+25%AT+25PI) took maximum time to achieve 50 percent flowering (98.44 days). However data for individual years indicated that all the three treatments (N_1,N_2 and N_3) completing their full quota of nitrogen by active tillering stages were at par during 2009, whereas in 2010, the treatment N_1 was at par with N_2 and N_2 in turn was par with N_3. The plants under the treatment N_4 (three splitting) took significantly more time to reach 50 percent heading during individual years also. On an average, the plants getting an instalment of nitrogen at their panicle initiation stage took 4.55 days more to come to 50 percent flowering as compared to that under the treatment N_1, which exhibited earliest flowering.

No significant difference as regards 50 percent heading time was observed in the plots to be put under sub-plot treatments indicating thereby the homogeneity of experimental material prior to treatment application.

Grain yield

Grain yield as affected by split application of nitrogen has been presented in table-9 and graphically depicted in fig.-(i).

Table 9: Grain yield as affected by different treatments

Treatments Symbol	Grain yield (q/ha)		
Main Plot :	**2009**	**2010**	**Pooled**
N1 (75% B+25% AT)	47.83	51.54	49.68
N2 (25% B+75% AT)	50.37	55.61	52.99
N3 (50% B+50% AT)	51.29	56.34	53.81
N4(50%B+25%AT+25% PI)	48.98	54.74	51.85
S.E.	1.52	2.12	1.79
S.E. M±	0.76	1.05	0.89

B- Basal, AT- Active tillering, PI - Panicle initiation and DAF - Days after 50 percent flowering

Effect of split application of nitrogen

The maximum grain yield of 53.81 q/ha was obtained from the plants getting nitrogen in two equal splits at transplanting and active tillering stage (N_3). However, the treatment N_3 was at par with N_2(52.99 q/ha) getting 25 percent nitrogen at transplanting and 75 percent at active tillering stage. These two treatments N_2 and N_3 were significantly superior to N_4 (50%B+25%AT+ 25% PI) yielding 51.85 q/ha. The lowest grain yield was obtained from the treatment N_1 (49.68 q/ha) getting 75 percent nitrogen as basal application and 25 percent at active tillering stages.

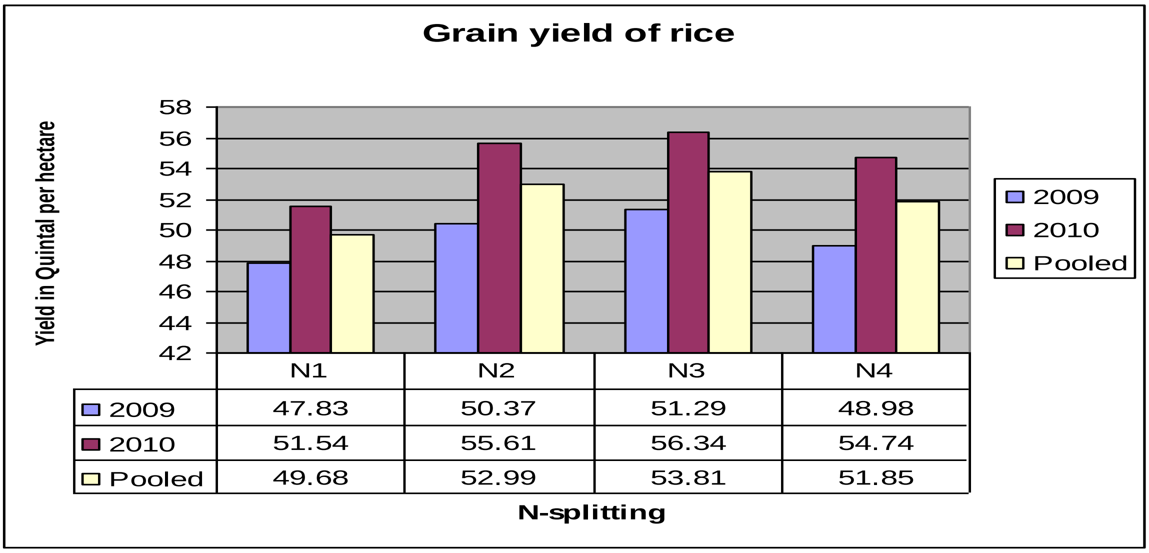

Fig. 1:

Although the sequence of N-splitting treatments in terms of grain yield was similar in the individual years, the level of significance left the mark of difference. During 2009 the treatments N_3, N_2 and N_4 did not differ significantly among themselves and these three were significantly superior to N_1, the lowest yielding treatment.

DISCUSSION

The experimental rice crop passed its entire vegetative phase under the influence split application of nitrogen. Plant height and leaf area index observed at 20th day of transplanting were the function of amount of nitrogen applied as basal dressing. Plots getting higher doses at transplanting had better expression of these characters. After application of second instalment of nitrogen at active tillering stage, when the treatments completed 75 to 100 percent quota of the full dose of nitrogen, there was no significant difference in plant height and leaf area index in the subsequent observations. As observed in case of plant height and leaf area index, the amount of nitrogen applied at transplanting also regulated number of tillers and dry matter production up to 20th day of transplanting. However, when the nitrogen was top dressed at active tillering stage, this instalment became the key factor in tillering and dry matter accumulation. The plants receiving higher doses of nitrogen at active tillering stage continued to have higher number of tillers. Application of nitrogen at panicle initiation stage helped in dry matter accumulation, but not in tillering.

The physiological changes in plant body due to nitrogen application have been explained by several workers. According to Thatcher[16] nitrogen is an energy store in plant body. Being a constituent of amino acids, nucleotides, nucleic acids, a number of coenzymes, auxins, cytokinins and alkaloids, it induces cell elongation, cell enlargement and cell division[12]. Murata and Matsushima[9] describing tillering in rice have summed up that the number of tillers attain its highest value about one month after transplanting, decreasing thereafter, because of death of some of the last tillers to emerge, as a result of their failure in competition for light and nutrient. They further said that emergence and development of tillers are greatly influenced by such factors as nitrogen supply, solar radiation and temperature. The most important of these being nitrogen supply. Evans and Wardlaw[6] dealing with rice plant height reported that stem growth ceases soon after anthesis and the developing grain then become the dominant sink for assimilates. Thus, the variation in dose of nitrogen at one or the other stage is bound to influence metabolic activities involved in physiological phenomenon at that particular stage, which reflects in growth parameters. Besides, the period of tillering in rice is fixed and is regulated by temperature and genotype of the variety[4]. Thus, under the environmental amplitude of Dighwadubauli, the test variety behaved true to the established principles. The results of the present investigation in respect of growth characters is in conformity with those reported earlier by Yoshida[18], Nagre Mahajan[10] and Choubey *et al.* [3].

Proportion and stage of nitrogen application played an important role in influencing time of panicle emergence. The plants splitting most of nitrogen (75%) as basal dressing and the rest at active tillering stage took minimum time to come to 50 percent heading. The plants taking maximum time for flowering were those receiving nitrogen in three splits including top dressing with 25 percent nitrogen at panicle initiation stage. The other two statements, which also did not get nitrogen at panicle initiation stage, but received higher doses at active tillering stage, took less time to come to heading. This indicated that a saving of 4-5 days in maturity period can be made simply by skipping nitrogen application at panicle initiation stage. De Datta[4] reported that nitrogen applied at panicle initiation or at flowering reduced rate of senescence of the lower leaves, probably as a result of a reduction in the amount of nitrogen that was translocated from the lower to the upper leaves. Activity of succinic dehydrogenase is instrumental in regulating senescence in rice plant. Higher content of nitrogen in reproductive stage increases dehydrogenase activity and senescence is delayed[5]. The present finding in regard to days taken to 50 percent flowering are quite in agreement with those reported by Nair[11], Singh[14], Huh et al.[7], Sangliene[13], De Datta[4], Bhapkar and Deore[1] and Singh et al.[15].

CONCLUSION

Plant height and leaf area index increased up to 20th day of transplanting proportionate to the quantity of nitrogen applied as basal. After application of nitrogen at active tillering stage, plants remained statistically at par in respect of height and LAI in the subsequent observations. Plants raised with higher proportion of nitrogen (50% or 75%) at active tillering stage had more tillers than those getting only 25 percent. Dry matter accumulation was minimum in plots supplied with maximum nitrogen (75%) at transplanting. Remaining N-split treatments synthesising more dry matter were comparable among themselves. Nitrogen application at panicle initiation stage delayed heading by 4 to 5 days. Crop with maximum (75%) N-feeding at transplanting was earliest to come to 50 percent heading closely followed by the crop getting nitrogen in 50:50 or 25:75 ratios at transplanting and active tillering stage. Two splitting of nitrogen proved superior to three splitting in inducing formation of ear bearing tillers. The present finding is quite approx. to reported by Islam *et al.*[8]. The maximum being under a 50:50 ratios at transplanting and active tillering stage. A ratio of 25:75 at the same stages was next in order in production of ear bearing tillers. The plants forming lower number of tillers produced longer panicles. The plots getting major part of nitrogen at transplanting end those getting nitrogen at panicle initiation were comparable among themselves, but superior to those getting higher proportion at active tillering stage in respect of length of panicle. The plots earliest to be harvested had minimum number of fertile spikelets and maximum number of sterile spikelets. Increase in fertility and decrease in sterility of spike lets borne on panicles were observed up to 35th day of 50 percent flowering. Plants raised with maximum basal dressing (75%) had the minimum number of fertile and maximum number of sterile spikelets. Other treatments were comparable with the exception that plants getting 75 percent nitrogen at active tillering had also higher number of sterile spikelets. Spikelets increased in weight only up to 30th day of 50 percent flowering. Plots getting nitrogen in two equal splits either in 50:50 or 25:75 ratio at transplanting and active tillering stage produced highest grain yields. Very high basal dressing (75%) was associated with production of lowest grain yields.

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