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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(4): 112-117

www.thepharmajournal.com
Received: 08-02-2022
Accepted: 16-03-2022

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Spad meter reading, nutrient uptake and nitrogen use efficiency of semi dry rice under varied doses and time of application

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Abstract
Management practices needed to be developed for semi dry rice which is grown in both aerobic and anaerobic condition during their growth cycle. Low nutrient use efficacy is one of the most limiting factor for production of the rice. A field experiment was conducted at Agricultural Research Institute, PJTSAU, Rajendranagar during the *kharif* season of 2017 to study the SPAD meter reading, nutrient uptake and nitrogen use efficiency of semi dry rice under varied doses and time of application. The experiment was laid out in randomized block design with ten treatment and three replications. Application of 160 kg N ha^{-1} 25% each at sowing, 20 DAS, 40 DAS and 60 DAS recorded the highest SPAD meter reading, nutrient uptake and nitrogen use efficiency compared to the other treatments. However, this was found to be on par with the growth in the treatments having 160 and 140 kg N ha^{-1}applied at various splits and with application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS. The lowest observation was found to be with application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS (farmer's practice). The study conclusory proved that application of the 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS enhanced the SPAD meter reading, nutrient uptake and nitrogen use efficiency in semi dry rice.

Keywords: Semi-dry rice system, time and dose of nitrogen application, SPAD meter, nutrient uptake, nitrogen use efficiency

Introduction
Rice is most important food crop and a major food grain for more than a 60% of the world's population. Worldwide, rice is being cultivated in an area of 158 million hectare, which is more than 10 per cent of the arable land. In India, rice is cultivated in an area of 42 million hectares with the production of 117 million tonnes, which contributes to 42 per cent of total food grain production of our country. Aerobic rice is the method of growing of the rice where seeds are grown sown in the non-puddled aerated dry soil by broadcasting or drilling and grown as rainfed crops with out standing water. They have many advantages such as less water consumption and reduced cost of cultivation and less methane emission research results revealed that aerobic rice not producing the satisfied yield as transplanted rice. Semi dry rice system is the new method of growing rice in which seeds are sown as an upland crop taking advantage of monsoon rains. At fourth or fifth leaf stage, when the rainfall intensifies or sufficient water is released from the tank or irrigation projects, the field is converted to wet land rice (Raj *et al*., 2014) [6]. In future we may come across acute labour shortage for undertaking the transplantation and other operations. They cut down the initial water consumption and cost of cultivation 30% by avoiding rising of seedlings in nursery, puddling, and transplanting under puddled soil.

The major constrain in the rice production is the inappropriate and imbalance application of the plant nutrients. Nitrogen (N) is the kingpin nutrient for rice production to determine the yield and economics. Nitrogen use efficiency of rice crop is as low as 25-35%. Inappropriate and insufficient fertilizer nitrogen management may account for one half to two thirds of the gap between actual and potential yields. Fertilizer being an expensive and precious input, determination of an appropriate dose and method of application would reduce the cost of production and enhance the productivity, and consequently increase the profits of the grower under given situations (Manzoor *et al*., 2006) [4]. Proper management of N is essential for achieving higher productivity, maximizing nutrient use efficiency (NUE), and improving environmental safety by ensuring minimal losses of applied N.

Increasing nitrogen use efficiency will help farmers to reduce the amount of fertilizer inputs, increase their income, and facilitate their adoption of semi dry system to cope with water scarcity.

Material and Methods

The experiment study was conducted during *kharif*, 2017 at Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad. This is situated at an altitude of 542.6 m above mean sea level on 17° 19' N latitude and 78° 23' E longitude. Before the initiation of the experiment soil samples were drawn at random spots in the experimental field from 0-15 m soil depth. The soil was mixed thoroughly and samples of about 1/2 kg were obtained by quartering technique and dried under shade, pounded, passed through 2 mm sieve and stored in neatly labelled polythene bag for soil analysis. The soil of the experimental field was clay loam in texture with a pH of 8.51 and EC of 0.32 dS m^{-1}, low in organic carbon (0.22%) and available nitrogen (195 kg ha^{-1}), high in available phosphorus (51 kg ha^{-1}) and potassium (404 kg
ha^{-1}). The study was conducted with ten treatments and laid out in randomized block design with three replications. The treatments comprised of three doses of nitrogen (120, 140 and 160 kg ha^{-1}) and three schedules of nitrogen application (25% each at sowing, 20 DAS, 40 DAS and 60 DAS, 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30 at 60 DAS,10% at sowing, 10% at 20 DAS, 40% at 40DAS and 40% at 60 DAS.) and were evaluated against the farmers practice (120 kg ha^{-1} N at 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). The crop was sown in non puddle field by giving one pre sowing irrigation and grown as irrigated dry crop up to 40 DAS and there after converted to wet and maintained the optimum water column till harvesting. In this study a short duration (120 days) variety JGL-18047 (Bathukamma) was used. Nitrogen was applied accordingly experimental specification in the form of urea at four splits application with different doses (120, 140 and 160 kg ha [1]). Phosphorous @ 60 kg ha^{-1} in the form of SSP and potassium @ 40 kg ha^{-1} in the form of MOP were applied at the time of sowing as basal. Data recorded on various parameters during investigation was statistically analysed following the analysis of variance (ANOVA) technique for randomized block design as suggested by Panse and Sukhame (1978) [5].

Results and Discussion

SPAD meter reading

Chlorophyll content in the leaves is the most important parameters which affect the photosynthetic rate. The SPAD meter has been used to predict the need for additional N fertilizer in rice plants for producing higher chlorophyll (Kumagai *et al*., 2009) [1]. SPAD meter reading influenced by dose and time of nitrogen application at 20 DAS, 40 DAS, 60 DAS, 80 DAS and harvest in semi dry rice is presented in Table 1.

Table 1: Spad meter reading of semi dry rice as influenced by dose and time of nitrogen application

T. No	Treatment	SPAD meter reading				
		20 DAS	40 DAS	60 DAS	80 DAS	Harvest
T_1	Farmer's practice (120 kg ha^{-1} N in 3 splits of 12% at sowing, 44% at 40 DAS and 44% at 60 DAS)	14.0	28.8	30.6	30.4	11.6
T_2	120 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	16.7	34.5	35.0	35.3	15.0
T_3	120 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS.	13.6	32.0	32.7	32.6	13.0
T_4	120 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	14.4	33.3	33.1	32.8	13.5
T_5	140 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	17.3	35.9	36.1	36.1	15.5
T_6	140 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	13.7	32.9	34.5	34.9	14.1
T_7	140 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	15.5	34.4	35.1	36.6	14.3
T_8	160 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	18.9	36.4	37.6	37.2	16.2
T_9	160 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	14.0	33.1	35.4	36.2	14.6
T_{10}	160 kg ha^{-1} N in 4 splits of 20% at sowing, 20 at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	17.1	35.8	37.8	36.5	15.0
	SE(m) ±	0.9	1.3	1.4	1.3	0.7
	CD (p=0.05)	2.8	3.9	4.1	3.6	2.2

At 20 DAS, highest SPAD meter reading (18.9) was recorded with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS compared to the other treatments. However, this was found to be on par with the other lower doses of nitrogen *viz*., 120 and 140 kg N ha^{-1} when they were applied in four equal splits of 25% each at sowing, 20, 40 and 60 DAS and T_{10}-160 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS. Application of lesser quantities of nitrogen in the initial growth stages of the crop like in 120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_3) recorded the lowest SPAD reading (13.6) than all other treatments and it was on par with farmer's practice (T_1-14.0) wherein only 12% of nitrogen was applied as basal.

At 40 DAS, treatment T_8- application of nitrogen @ 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS continued to the highest SPAD meter reading (36.4) was found to be on par with the all the treatments of different doses and time of application of fertilizers except T_3 (120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS) and farmer's practice (T_1). Lowest SPAD meter reading (28.8) was noticed in the farmers practice (T_1- application of nitrogen at 120 kg ha-1 N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS) and was significantly lower than all the doses (120, 140 and 160 kg N ha^{-1}) applied at different times and splits except the T_3-application of 120 kg N ha^{-1} in 3 splits at 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS.

At 60 DAS, highest SPAD meter reading (37.6) was recorded with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS compared to the other treatments. However it was found to be on par with the treatments having 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest SPAD meter reading (30.6) was noticed in the farmer's practice which was

significantly inferior with the treatments *viz*., T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS) and various splits applied in 160 and 140 kg N ha^{-1} except T_6- application of 140 kg N ha-1 in 3 splits at 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS. At 80 DAS and harvest same treatment T_8 - application of nitrogen @ 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS continued to record the highest SPAD meter reading (37.2 and 16.2 respectively) compared to other treatments. It was found to be on par with the all the treatments having 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest SPAD meter reading was noticed in the farmer's practice (30.4 and 11.6 respectively) which was found to be significantly inferior than all the treatments having 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Similar finding was recorded by Rani (2012) in aerobic rice.

Nitrogen uptake (kg ha^{-1})

Nitrogen uptake as influenced by dose and time of nitrogen application in semi dry rice is presented in Table 2.

At 20 DAS, highest nitrogen uptake (2.42 kg ha^{-1}) was recorded with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS compared to the other treatments. However, this was found to be on par with the other application of 140 kg N ha^{-1} in four equal splits of 25% each at sowing, 20, 40 and 60 DAS. Application of lesser quantities of nitrogen in the initial growth stages of the crop like in 120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_3) resulted in lower nitrogen uptake (1.70) than all other treatments.

At 40 DAS, the same T_8 treatment (application of 160 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS) continued to record the highest nitrogen uptake (15.7) compared to the other treatments which was on par with T_{10}- (application of 160 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS). Lowest plant nitrogen uptake (7.2 kg ha^{-1}) was recorded with the farmer's practice (T_1- application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS) which was significantly lower than all the doses (120, 140 and 160 kg N ha^{-1}) when applied in 4 equal splits at sowing, 20, 40 and 60 DAS (T_2, T_5, and T_8) and application of different doses (120,140 and 160 kg N ha^{-1}) applied in 4 splits @ 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS or in splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_6 and T_9). Treatment T_3- (application of 120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS) also recorded lower nitrogen uptake of 8.50 kg ha-1and was found to be on par with farmer's practice.

At 60 DAS, highest nitrogen uptake was observed (39.7 kg ha^{-1}) with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits i.e., at sowing, 20, 40 and 60 DAS which was found to be on par with the all the treatments having 160 and 140 kg N ha^{-1} applied at various splits. Lowest nitrogen uptake (25.9 kg ha^{-1}) were noticed in farmer's practice (application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS) which was significantly inferior to the doses of 140 and 160 kg N ha^{-1} when applied 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS (T_5 and T_8), the doses of 140 and 160 kg N ha^{-1} when applied in splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS (T_7 and T_{10}) or applied as 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS. However nitrogen uptake in farmer's practice was on par with T_2 (application of 120 kg N ha^{-1} 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS), T_3 (120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS) and T_4 (120 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS).

Table 2: Nitrogen uptake (kg ha^{-1}) of semi dry rice as influenced by dose and time of nitrogen application

T. No	Treatment	N Uptake (kg ha^{-1})						
		20 DAS	40 DAS	60 DAS	80 DAS	Harvest		
						Grain	Straw	Total
T_1	Farmer's practice (120 kg ha^{-1} N in 3 splits of 12% at sowing, 44% at 40 DAS and 44% at 60 DAS)	1.84	7.2	25.9	61.8	36.1	28.4	64.5
T_2	120 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	2.21	10.2	30.2	73.4	40.8	35.6	76.4
T_3	120 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS.	1.70	7.8	27.7	66.9	38.9	30.5	69.4
T_4	120 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	2.10	9.8	29.6	69.8	39.7	34.3	74.0
T_5	140 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	2.33	12.6	34.4	77.4	44.8	38.4	83.2
T_6	140 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	1.83	10.1	33.1	74.3	43.0	36.1	79.1
T_7	140 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	2.24	11.2	33.5	74.6	44.5	36.4	80.9
T_8	160 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	2.42	15.7	39.7	84.6	47.3	43.9	91.2
T_9	160 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	2.07	12.4	38.1	81.5	46.2	41.2	87.4
T_{10}	160 kg ha^{-1} N in 4 splits of 20% at sowing, 20 at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	2.30	15.3	39.1	83.6	45.3	43.5	88.8
	SE(m) ±	0.29	2.0	2.3	4.1	2.3	2.7	5.0
	CD (p=0.05)	0.10	0.7	6.8	12.3	6.7	8.2	14.9

At 80 DAS also application of nitrogen @ 160 kg ha^{-1} in 4 equal splits 25% each at sowing, 20, 40 and 60 DAS had recorded the highest nitrogen uptake (84.6 kg ha^{-1}) which was found to be on par with the treatments having 160 and 140 kg N ha^{-1} applied at various splits . Lowest nitrogen uptake was noticed in the farmer's practice (61.8 kg ha^{-1}) which was significantly inferior to all the higher doses of nitrogen (T_5toT_{10} with 140 and 160 kg ha^{-1}).

At harvest, grain and straw uptake were computed separately. Highest grain uptake (47.3 kg ha^{-1}) was noticed with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_8). It was on par with treatments having 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest uptake (36.1 kg ha^{-1}) was observed in the farmer's practice (T_1). It was significantly inferior when compared with treatments having 160 and 140 kg N ha^{-1} applied at various splits. Similar trend was observed

in straw uptake with highest straw uptake (43.9 kg ha^{-1}) in application of nitrogen @ 160 kg ha^{-1} in 4 equal splits 25% each at sowing, 20, 40 and 60 DAS (T_8). It was on par with treatments having 160 and 140 kg N ha^{-1} applied at various splits. Lowest uptake (28.4 kg ha^{-1}) was observed in the farmer's practice (T_1). It was significantly inferior when compared with treatments having 160 and 140 kg N ha^{-1} applied at various splits.

The total nitrogen uptake at harvest was maximum with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits 25% each at sowing, 20, 40 and 60 DAS (91.2 kg ha^{-1}). It was on par with treatments having 160 and 140 kg N ha-1 applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest uptake (64.5 kg

ha^{-1}) was recorded in the farmer's practice (T_1) and was significantly inferior when compared with treatments having 160 and 140 kg N ha^{-1} applied at various splits. Mahajan *et al*. (2012) also found the highest plant nitrogen uptake of direct seeded rice with application of 120 kg N ha^{-1} compared to 60 and 180 kg N ha^{-1} in loamy sandy soil at research farm of the Punjab Agricultural University (PAU), Ludhiana.

Phosphorous uptake (kg ha^{-1})

Phosphorus uptake as influenced by dose and time of nitrogen application in semi dry rice is presented in Table 3.

At 20 DAS, highest phosphorous uptake (1.31 kg ha^{-1}) was recorded with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS compared to the other treatments. which was found to be on par with the other lower doses of nitrogen *viz*., 120 and 140 kg N ha^{-1} when they were applied in four equal splits of 25% each at sowing, 20, 40 and 60 DAS or application of 140 and 160 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS or T_9- application of 160 kg N ha^{-1} in 4 splits at 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS. Application of 120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_3) resulted in lower phosphorous uptake (0.98) than all other treatments.

At 40 DAS, the same T_8 treatment had continued with the highest phosphorous uptake (7.9 kg ha^{-1}) and was found to be significantly superior over all other treatments. Lowest phosphorous uptake (5.1 kg ha^{-1}) was recorded with the farmer's practice (T_1- application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). It was significantly inferior than the treatments T_5 and T_8 (140 and 160 kg N ha^{-1} when applied 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS), and T_{10} (application of 160 kg N ha^{-1} in 4 splits at 20% at sowing, 20% at 20 DAS, 40% at 30 DAS and 30% at 60 DAS). At 60 and 80 DAS, application of 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_8) had showed the highest nutrient uptake (15.9 and 20.5 kg ha^{-1} respectively) compared to other treatments. However the uptake was found to be at par with that of in the treatments with 140 and 160 kg N ha^{-1} applied in various splits. Farmer's practice (T_1- application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS) had continued to record the lower uptake than other treatments.

At harvest grain and straw uptake was computed separately. Highest grain (13.9 kg ha^{-1}) and straw uptake (7.9 kg ha^{-1}) was noticed with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits 25% each at sowing, 20, 40 and 60 DAS (T_8). It was on par with the uptake in the treatments having 160 or 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest phosphorous uptake (9.1 and 4.6 kg ha^{-1} of grain and straw respectively) was observed in the farmer's practice (T_1). It was found to be significantly inferior compared to treatments having 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS.

At harvest maximum total phosphorous uptake (21.8 kg ha^{-1}) was noticed with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits 25% each at sowing, 20, 40 and 60 DAS (T_8) . It was on par with treatments having 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest uptake (13.7 kg ha^{-1}) was observed in the farmer's practice (T_1). It was significantly inferior with treatments having 140 and 160 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS).

Table 3: Phosphorous uptake (kg ha^{-1}) of semi dry rice as influenced by dose and time of nitrogen application

T. No	Treatment	P Uptake (kg ha^{-1})						
		20 DAS	40 DAS	60 DAS	80 DAS	Harvest		
						Grain	Straw	Total
T_1	Farmer's practice (120 kg ha^{-1} N in 3 splits of 12% at sowing, 44% at 40 DAS and 44% at 60 DAS)	1.00	5.1	10.2	13.4	9.1	4.6	13.7
T_2	120 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	1.27	5.7	12.8	17.6	12.3	6.7	19.0
T_3	120 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS.	0.98	5.2	12.1	14.5	9.9	5.1	15.0
T_4	120 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	1.18	5.6	12.5	15.5	10.5	5.7	16.2
T_5	140 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	1.28	6.5	14.3	19.3	13.4	7.3	20.7
T_6	140 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	1.05	5.4	13.9	18.1	12.8	7.1	19.9
T_7	140 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	1.22	5.7	14.0	19.0	13.1	7.5	20.6
T_8	160 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	1.31	7.9	15.9	20.5	13.9	7.9	21.8
T_9	160 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	1.16	5.6	14.8	18.9	12.9	7.5	20.4
T_{10}	160 kg ha^{-1} N in 4 splits of 20% at sowing, 20 at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	1.27	6.4	15.1	19.9	13.2	7.8	21.0
	SE(m) ±	0.05	0.2	0.7	0.8	1.0	0.4	1.5
	CD (p=0.05)	0.14	0.7	2.1	2.6	3.1	1.4	4.5

Potassium uptake (kg ha^{-1})

Uptake of potassium as influenced by dose and time of nitrogen application in semi dry rice is presented in Table 4.

At 20 DAS, highest potassium uptake (1.44 kg ha^{-1}) was recorded with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS compared to the other treatments. However, this was found to be on par with the uptake by the crop with other lower doses of nitrogen

viz., 120 and 140 kg N ha^{-1} when they were applied in four equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_2 and T_5) and with application of 140 and 160 kg N ha^{-1}in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS (T_7 and T_{10}). Application of lesser quantities of nitrogen in the initial growth stages of the crop like in 120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_3) resulted in lower potassium uptake (0.99) than all other treatments.

At 40 DAS, the same T_8 treatment had continued to register the maximum potassium uptake (12.3 kg ha^{-1}). However, it was found to be on par with uptake in T_5 (application of 140 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS), T_2 (application of 120 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS), T_7 (application of 160 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS and T_{10} (application of 160 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS). Lowest potassium uptake (8.2 kg ha^{-1}) was recorded with the farmer's practice (T_1- application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). It was significantly inferior when compared to all the doses of (120, 140 and 160 kg N ha^{-1}) when applied in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_2, T_5 and T_8), T_7 (application of 140 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS) and T_{10}- (application of 160 kg N ha^{-1} in 4 splits of 20% at sowing, 2 0% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS).

At 60 DAS, the trend was similar with highest potassium uptake (35.5 kg ha^{-1}) on application of nitrogen @ 160 kg ha^{-1} in 4 equal splits i.e., at sowing, 20, 40 and 60 DAS and was found to be on par with all the doses of 160 kg N ha^{-1} applied various splits and T_5 (application of 140 kg N ha^{-1} applied 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS). Lowest potassium uptake (26.6 kg ha-1) was recorded with the farmer's practice (T_1- application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). It was found to be significantly inferior when compared to the treatments having application of 140 and 160 kg N ha^{-1} applied at various splits (T_5 to T_{10}) and T_2 (application of 120 kg N ha^{-1} applied 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS).

Potassium uptake at 80 DAS was the highest with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits i.e., at sowing, 20, 40 and 60 DAS (55.3 kg ha^{-1}) which was found to be on par with the treatments having 160 and 140 kg N ha^{-1} applied at various splits except T_6 and T_2- application of 120 kg N ha^{-1} applied 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS. Lowest uptake (43.2 kg ha^{-1}) was found in farmer's practice (T_1). However it was significantly inferior with all the treatments except the treatments of T_3, T_4 and T_6.

At harvest grain and straw uptake were computed separately. Highest grain uptake (27.6 kg ha^{-1}) was noticed with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits 25% each at sowing, 20, 40 and 60 DAS (T_8). It was on par with treatments having 160 and 140 kg N ha^{-1} applied at various splits (T_5 to T_{10}) and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest uptake (21.9 kg ha^{-1}) was observed in the farmer's practice (T_1). It was significantly inferior when compared with treatments of 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS).

Highest straw uptake (65.6 kg ha^{-1}) was also noticed with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits 25% each at sowing, 20, 40 and 60 DAS (T_8) . It was on par with treatments having 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest uptake (54.4 kg ha^{-1}) was observed in the farmer's practice (T_1) and was significantly inferior with treatments having 160 and 140 kg N ha^{-1} applied at various splits.

At harvest total potassium uptake was noticed to be the highest (93.2 kg ha^{-1}) with application of nitrogen @ 160 kg ha^{-1} in 4 equal splits 25% each at sowing, 20, 40 and 60 DAS (T_8). It was on par with treatments having 160 and 140 kg N ha^{-1} applied at various splits and T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Significantly lowest uptake (76.3 kg ha^{-1}) was observed in the farmer's practice (T_1). Results of the experiment conducted on nitrogen management in semi dry rice also reported the highest nitrogen, phosphorous and potassium uptake with the application of 120 kg N ha^{-1} nitrogen in 4 splits ¼ at basal + ¼ at conversion to wet + ¼ at panicle initiation + ¼ at flowering) in sandy loam soil at Agricultural College Farm, Naira (Lakshmi Bai, 2012) [2].

Table 4: Potassium uptake (kg ha^{-1}) of semi dry rice as influenced by dose and time of nitrogen application

T. No	Treatment	K Uptake (kg ha^{-1})						
		20 DAS	40 DAS	60 DAS	80 DAS	Harvest		
						Grain	Straw	Total
T_1	Farmer's practice (120 kg ha^{-1} N in 3 splits of 12% at sowing, 44% at 40 DAS and 44% at 60 DAS)	1.03	8.2	26.5	43.2	21.9	54.4	76.3
T_2	120 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	1.20	10.9	31.2	49.7	26.0	60.2	86.2
T_3	120 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS.	0.99	9.0	29.8	45.7	23.0	56.7	79.7
T_4	120 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	1.05	9.9	30.6	46.6	23.6	58.9	82.5
T_5	140 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	1.33	11.4	33.9	52.7	27.5	64.4	91.9
T_6	140 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	0.99	9.2	31.0	48.5	25.3	61.5	86.8
T_7	140 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	1.21	10.1	31.4	49.7	25.6	62.3	87.9
T_8	160 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	1.44	12.3	35.5	55.3	27.6	65.6	93.2
T_9	160 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	1.04	9.8	33.6	50.8	25.1	62.2	87.3
T_{10}	160 kg ha^{-1} N in 4 splits of 20% at sowing, 20 at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	1.32	11.3	34.0	52.9	26.4	63.9	90.3
	SE(m) ±	0.09	0.7	1.3	2.0	0.9	2.1	3.2
	CD (p=0.05)	0.28	2.0	4.0	6.1	2.8	6.3	9.5

Nitrogen use efficiency (%)

Nitrogen use efficiency of semi dry rice as influenced by dose and time of nitrogen application is presented in Table 5.

Highest nitrogen use efficiency (36.3) was recorded with application of 120 kg N ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_2) compared to higher dose of fertilizers. It was found to be on par with T_3 (120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS) and T_4 (120 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS) and T_5 (application of 140 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest use efficiency was observed with application of 160 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_9). It was found to be significantly inferior when compared T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS) and was found to be on par with T_3 (120 kg N ha^{-1} with 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS) and T_4 (120 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS). Mahajan *et al*. (2012) also reported the highest nitrogen use efficiency with application of 120 kg N ha^{-1} compared to 60 and 180 kg N ha^{-1} to dry directed seeded rice in loamy sand soil at research farm of the Punjab Agricultural University (PAU), Ludhiana.

Table 5: Nitrogen use efficiency of semi dry rice as influenced by dose and time of nitrogen application

T. No	Treatment	Nitrogen use efficiency (%)
T_1	Farmer's practice (120 kg ha^{-1} N in 3 splits of 12% at sowing, 44% at 40 DAS and 44% at 60 DAS)	30.6
T_2	120 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	36.2
T_3	120 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS.	33.6
T_4	120 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	34.8
T_5	140 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	32.9
T_6	140 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	31.2
T_7	140 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	31.7
T_8	160 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS	29.6
T_9	160 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS	27.5
T_{10}	160 kg ha^{-1} N in 4 splits of 20% at sowing, 20 at 20 DAS, 30% at 40 DAS and 30% at 60 DAS	28.1
SE(m) ±		1.3

Conclusion

Application of 120 kg N ha^{-1} in 4 equal splits at sowing, 20, 40 and 60 DAS was found to be the optimum for semidry rice compared to higher dose of application and irregular splits.

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