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Influence of Doses and Split Application of Nitrogen and Potassium on Growth Parameters and Yield of Semi Dry Rice to Enhance Productivity under Southern Dry Zone of Karnataka

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Abstract

A field experiment was conducted at College of Agriculture,Vishweswaraiah Canal Farm, Mandya during the *kharif* season of 2019-20 and 2020-21 to study the influence of different doses and split application of nitrogen and potassium on growth parameters and yield of semi dry rice. The soil of the experimental site was sandy loam in texture, with low in organic matter content and alkaline in reaction. The experiment was laid out in split-plot design with two levels of N and K and seven times of split application. The data revealed significantly higher growth parameters and yield with the higher level of N+K (125% RDNK) compared to lower dose (100% RDNK). Among the different split applications, N at 4 splits (S_6) as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits (50% at basal and 50% at panicle initiation (PI) produced significantly higher growth parameters and yield than other treatments. However, it was comparable with S_5-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) 100 per cent K at basal, S_3-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal and S_4-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Lowest growth parameters and yield was recorded in T_7-NPK as per UAS-B package (50% nitrogen at sowing, 25% at tillering and 25% panicle initiation, 100 per cent K at basal).

Keywords : Semi dry rice, Nitrogen, Potassium, Split application, Yield

Rice (*Oryza sativa* L.) is the staple food for over half of the planet's population. Human consumption accounts 85 per cent of total production of rice and it deserves a special status among cereals as world's most important wetland crop (Lokesh Patil and Gowda, 2018). Importance of semi dry system cultivation is increasing in the present scenario due to shortage of water and scarcity of labour to grow transplanted rice. Lowland rice requires around 1000 to 5000 liters of water for producing one kg grain which is about twice than other field crops. Average water requirement of semi dry rice is 890 mm. Water is becoming scarce with time, declining availability and cost threatens traditional irrigated rice production system. In future we may come across huge labour shortage to carry operation like puddling and transplanting. Semi dry system is suitable in canal areas where release of water from the canal is delayed due to late onset of monsoon, hence seeds are sown in ploughed dry soil with monsoon rains, same as aerobic rice and when the monsoon become active, after release of water from canal the field is converted in to wet and treated same as wetland rice till harvest. This will cut down the initial water consumption 30 per cent by avoiding rasing of seedlings in nursery, puddling, and transplanting under puddled soil and reduce the cost of cultivation by omitting the puddling and transplanting operations (Ajmal *et al*., 2020).

Semi dry rice will pass through both aerobic and anaerobic condition in their life cycle. This results in different nutrient dynamics than conventional system. Hence, semi dry rice requires special agronomic intervention to practice precise nutrient management. Nitrogen is the most important and limiting nutrient in the semi dry system. Nitrogen use efficiency of rice crop is as low as 25-35 per cent and 1 kg of nitrogen is required to produce 15-20 kg of grains (Ajmal, 2018). Hence, efficient nitrogen management such as rate and synchronized nitrogen application with the crop requirement in real time plays an important role in increasing response to added fertilizers thereby improving the grain yield of semi-dry rice. It can be achieved by split application of nitrogen at different growth stages. Split application is one of strategies for efficient use of N fertilizers throughout the growing season by synchronizing with plant demand, reducing de-nitrification losses and improved N uptake for maximum straw and grain yield and harvest index in direct seeded rice. Potassium is the third essential plant nutrient after N and P, which has assured importance as a fertilizer in most of the countries. In the rice cultivation, the farmers are bestowing much attention only to N fertilization and very often K application is partially or completely ignored. This practice of imbalance and inadequate fertilizer application affects the yield adversely. Crops like rice require potassium throughout its growth period but with varying intensity. Acute shortage of potassium during critical period of growth affects the yield of the crop. It is now believed that this may be due to wrong timing of potash application. To obviate the possibility timely application of potassium is essential. It has therefore, become important to know the amount and time of application of potassium. In view of these, the present investigation is prioritized and formulated on 'influence of different doses and split application of nitrogen and potassium on growth parameters and yield of semi dry rice'.

Material and Methods

The field experiment was conducted during *kharif* season of 2019-20 and 2020-21 at College of Agriculture Vishweswaraiah Canal Farm, Mandya. The soil was sandy loamy in texture with pH 8.97. It was moderately fertile, being low in available organic carbon (0.35 %), available nitrogen (212.53 kg ha^{-1}) and higher in available phosphorous (104.38 kg ha^{-1}). The experiment was laid out in split plot design replicated thrice, comprising of treatments with two doses (100% RDNK and 125% RDNK) assigned to main plots. Each main plot was further divided into seven sub-plots to accommodate split applications (S_1= N at 3 splits as, 20 per cent at sowing, 40 per cent at tillering (T) and 40 per cent at panicle initiation (PI), 100 per cent K at basal, S_2= N at 3 splits as, 20 per cent at sowing, 40 per cent at tillering (T) and 40 per cent at panicle initiation (PI), K at 2 splits [50% at basal and 50 per cent at panicle initiation (PI)], S_3= N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal, S_4= N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)], S_5= N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal, S_6= N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits (50% at basal and 50 per cent at panicle initiation (PI) and S_7= NPK as per UAS-B package. A fertilizer dose of 50 kg ha^{-1} P_2O_5 was applied to all the plots as basal dose. The variety of rice used was KMP 175. Fisher's method of analysis of variance (ANOVA) was used in the analysis. Significance between the treatments was tested by F test. Whereas, difference between the treatments mean were tested by critical difference (CD) at 5 per cent level of significance.

Results and Discussion

Plant Height (cm)

The data on plant height (cm) of semi dry rice as influenced by doses and time of nitrogen and potassium application recorded at 30, 60, 90 DAS and at harvest are presented in Table 1.

At 30 DAS, there was no significant difference in plant height among doses of nitrogen and potassium (32.53 to 30.73 cm), (32.88 to 31.12 cm), their split application (33.09 to 30.27 cm), (33.06 to 31.29 cm), and their interaction effect during both 2019 and 2020, respectively.

At 60 DAS, 90 DAS and harvest plant height significantly influenced by different doses and split application of nitrogen and potassium. Among the different doses of nitrogen and potassium taller plant (69.14 cm and 67.10 cm, 77.43 cm and 80.02 cm) was recorded in 2019 and 2020, respectively with application of 125 per cent RDNK. Lowest plant height was found in 100 per cent RDNK (59.59 cm and 60.48 cm, 71.65 cm and 73.23 cm, respectively). At harvest plant height was found non significant during both years. Among the different split applications, higher plant height (66.12 cm and 67.04 cm, 78.40 cm and 81.26 cm, 91.12 cm and 93.38 cm) during 2019 and 2020, respectively was recorded with with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits [50% at basal and 50% at

TABLE 1

Plant height (cm) of semi dry rice as influenced by doses and time of nitrogen and potassium application

Treatments	30 DAS		60 DAS		90 DAS		At Harvest	
	2019	2020	2019	2020	2019	2020	2019	2020
Main plots = Nitrogen and potassium level (2)								
M_1	30.73	31.12	59.59	60.48	71.65	73.23	79.17	85.15
M_2	32.53	32.88	69.14	67.10	77.43	80.02	85.78	90.97
S. Em±	0.88	0.50	0.92	0.93	0.94	1.09	1.39	1.32
CD (p= 0.05)	NS	NS	5.60	5.65	5.72	6.60	NS	NS
Sub plots= Split application of nitrogen and potassium (7)								
S_1	30.39	30.41	59.92	60.74	70.95	72.25	81.29	83.44
S_2	30.58	30.44	59.40	61.55	71.81	74.52	83.12	85.72
S_3	32.22	32.59	64.58	65.44	76.55	78.15	87.21	89.42
S_4	32.08	32.38	64.28	65.95	77.18	79.52	89.17	91.61
S_5	32.76	33.84	66.12	67.04	77.94	80.29	90.16	91.48
S_6	33.09	33.06	65.57	66.62	78.70	81.26	91.12	93.38
S_7	30.27	31.29	57.86	59.17	68.64	70.41	79.75	81.35
S. Em±	0.89	0.65	1.50	1.39	1.62	1.64	1.80	1.93
CD (p= 0.05)	NS	NS	4.38	4.07	4.72	4.78	5.27	5.61
Interaction (M x S)								
S. Em±	1.27	0.92	2.13	1.97	2.40	2.32	2.55	2.72
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Note : M_1- 100% RDNK, M_2- 125% RDNK, S_1= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), 100% K at basal, S_2= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S_3= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S_4= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S_5= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S_6= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits (50% at basal and 50% at panicle initiation (PI) and S_7= NPK as per UAS-B package panicle initiation (PI)] which was on par S_5-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal, S_3-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal and S_4-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Lowest plant height (57.86 cm and 59.17 cm, 68.64 cm and 70.41 cm and 79.75 cm and 81.35 cm) was recorded respectively during 2019 and 2020 in S_7-NPK as per UAS-B package. Interaction between nitrogen, potassium levels and time of application was not found significant.

Application of 125 per cent RDNK produced higher plant in all the growth stages, because nitrogen plays a dominant role in the meristematic activity and cell division which in turn increased number of cells leading to improved vegetative growth and plant height, whereas potassium activates enzymes which are involved in protein synthesis and carbohydrate translocation which might helped for vigorous root development, growth and development of plant leading to increased plant height. Among the different split applications higher plant height was recorded with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. It was mainly due to constant supply of nitrogen and potassium throughout the growth stage, which fulfils the requirement of the crop at peak stage. Similar findings were observed by Anusha, 2016. This observation indicated that K has increased plant height as it enhances transportation of N, P and other nutrients. The results showed that application of K - fertilizer increased the plant height which was comparable to that of recommended fertilizer dose. These results are in line with Vinod Birla *et al*. (2020).

Tillers m^{-2}

The data on plant tillers m^{-2} of semi dry rice as influenced by doses and time of nitrogen and potassium application recorded at 30, 60, 90 DAS and at harvest are presented in Table 2.

At 30 DAS the tillers m^{-2} observed during 2019 and 2020 did not differ significantly due to different doses of nitrogen and potassium, split applications and their interaction effect.

At 60 DAS, 90 DAS and at harvest tillers m^{-2} of semi dry rice significantly influenced by different doses and split application of nitrogen and potassium. Among the different doses of nitrogen and potassium significantly higher tillers m^{-2} was recorded with applications of 125 per cent RDNK (308.76 and 339.05, 392.14 and 463.10, 322.86 and 358.33), respectively in 2019 and 2020. Lowest tillers m^{-2} was found in 100 per cent RDNK (260.24 and 295.24, 346.67 and 410.24, 285.95 and 303.10). Among the different split applications, significantly higher tillers m^{-2} (308.33 and 363.33, 396.67 and 445.83 , 332.50 and 358.33) was recorded with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits [50% at basal and 50% at panicle initiation (PI)] followed by S_5-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal. However it was found on par with S_3-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal and S_4-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Lowest tillers m^{-2} (254.17 and 305.83, 326.67 and 367.50, 262 and 292.50, respectively) was recorded in S_7-NPK as per UAS-B package. Interaction between nitrogen, potassium levels and time of application was not found significant.

Application of 125 per cent N + K produced higher tillers m^{-2} in all the growth stages. It might be due to higher availability of nitrogen and potassium at higher level increases efficient translocation of nutrients with the plant, which may finally attribute tiller production and better synchronization in supply and

TABLE 2

Tillers m^{-2} of semi dry rice as influenced by doses and time of nitrogen and potassium application

Treatments	30 DAS		60 DAS		90 DAS		At Harvest	
	2019	2020	2019	2020	2019	2020	2019	2020
Main plots = Nitrogen and potassium level (2)								
M_1	131.67	132.86	260.24	295.24	346.67	410.24	285.95	303.10
M_2	147.86	151.67	308.76	339.05	392.14	463.10	322.86	358.33
S. Em ±	2.94	3.45	4.32	5.73	6.76	6.51	5.98	7.33
CD (p= 0.05)	NS	NS	26.30	34.88	41.13	39.64	36.38	44.62
Sub plots= Split application of nitrogen and potassium (7)								
S_1	133.33	130.00	268.33	315	350.83	382.50	274.17	306.67
S_2	131.67	129.17	267.33	320	354.17	395.83	285	316.67
S_3	143.33	145.83	295	350	380.83	423.33	315	339.17
S_4	140.83	148.33	293.33	346.67	382.50	429.17	328.33	346.67
S_5	149.17	157.50	305	363.33	394.17	437.50	328.33	350
S_6	149.17	159.17	308.33	359.17	396.67	445.83	332.50	358.33
S_7	130.83	125.83	254.17	305.83	326.67	367.50	262	292.50
S. Em ±	3.31	4.14	6.50	7.05	7.90	9.20	7.73	7.77
CD (p = 0.05)	9.67	12.10	18.98	20.59	23.05	26.86	22.57	22.70
Interaction (M x S)								
S. Em ±	4.69	5.86	9.20	9.98	11.17	13.01	10.98	11.04
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Note : M1- 100% RDNK, M2- 125% RDNK, S1= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), 100% K at basal, S2= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S3= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S4= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S5= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S6= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits (50% at basal and 50% at panicle initiation (PI) and S7= NPK as per UASB package.

demand of nitrogen at all the critical growth stages (Shrinivas and Krishnamurthy, 2017). Among the different split applications, higher tillers m^{-2} was recorded with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [(50% at basal and 50% at panicle initiation (PI)]. it might be due to constant availability of nitrogen during initial stages, increased cell division, improved metabolic activity, which in turn resulted in better production of tillers (Devi and Sumathi, 2011). The potassium is capable of spurring root development and affecting the absorption of other nutrients. Split application of potassium also reduced the tiller abortion in later stages.

Dry Matter Production (g hill^{-1})

The data on dry matter production (g hill^{-1}) of semi dry rice as influenced by doses and time of nitrogen and potassium application recorded at 30, 60, 90 DAS and at harvest are presented in Table 3.

At 30 DAS dry matter production of semi dry rice significantly influenced by split application of nitrogen and potassium. Among the different doses of

TABLE 3

Dry matter production (g $hill^{-1}$) of semi dry rice as influenced by doses and time of nitrogen and potassium application

Treatments	30 DAS		60 DAS		90 DAS		At Harvest	
	2019	2020	2019	2020	2019	2020	2019	2020
Main plots = Nitrogen and potassium level (2)								
M_1	1.71	1.78	16.43	17.53	82.98	88.33	132.56	140.12
M_2	1.97	2.05	19.96	21.04	95.61	104.59	153.64	161.06
S. Em±	0.03	0.04	0.29	0.50	1.47	2.05	2.11	2.40
CD (p= 0.05)	0.19	0.25	1.75	3.03	8.96	12.50	12.81	14.60
Sub plots= Split application of nitrogen and potassium (7)								
S_1	1.51	1.56	17.14	17.53	84.30	90.53	134.90	143.07
S_2	1.49	1.47	16.48	17.29	86.43	92.37	138.50	146.90
S_3	2.08	2.15	19.01	21.07	91.13	98.05	146.22	152.95
S_4	2.02	2.12	18.95	20.33	92.72	101.03	150.02	156.97
S_5	2.19	2.33	19.72	21.49	94.08	102.97	151.20	156.25
S_6	2.17	2.32	20.14	20.76	96.51	105.65	153.98	161.28
S_7	1.40	1.45	15.94	16.55	79.90	84.62	128.45	136.70
S. Em±	0.07	0.08	0.51	0.50	1.91	2.24	3.18	2.79
CD (p= 0.05)	0.19	0.22	1.50	1.46	5.59	6.54	9.28	8.14
Interaction (M x S)								
S. Em±	0.09	0.11	0.73	0.71	2.71	3.17	4.50	3.94
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Note : M1- 100% RDNK, M2- 125% RDNK, S1= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), 100% K at basal, S2= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S3= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S4= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S5= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S6= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits (50% at basal and 50% at panicle initiation (PI) and S7 = NPK as per UAS-B package

nitrogen and potassium higher dry matter production (1.97 and 2.05 g $hill^{-1}$, respectively) was recorded with application of 125 per cent RDNK during both the years. Lowest dry matter production was found in 100 per cent RDNK (1.71 and 1.78 g $hill^{-1}$). Among the different split applications, significantly higher dry matter production (2.19 and 2.33 g $hill^{-1}$, respectively) during 2019 and 2020 was recorded with S_5-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal, which was on par with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits 950 per cent at basal and 50 per cent at panicle initiation (PI), S_3-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal and S_4-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Lower dry matter production (1.40 and 1.45 g $hill^{-1}$), respectively was recorded in S_7-NPK as per UAS-B package. Interaction between nitrogen, potassium levels and time of application was not found significant.

At 60 DAS, 90 DAS and harvest among the different doses of nitrogen and potassium significantly higher dry matter was recorded with application of 125 per cent RDNK (19.96 and 21.04 g hill^{-1}, 95.61 and 104.59 g hill^{-1}, 95.61 and 104.59 g hill^{-1} and 153.64 and 161.06 g hill^{-1}). Lowest dry matter production was found in 100 per cent RDNK (16.43 and 17.53 g hill^{-1}, 82.98 and 88.33 g hill^{-1}, 82.98 and 88.33 g hill^{-1}, 132.56 and 140.12 g hill^{-1}), respectively during both years. Among the different split applications, significantly higher dry matter production (20.14 and 21.49 g hill^{-1}, 96.51 and 105.65 g hill^{-1}, 153.98 and 161.28 g hill^{-1}) was noticed with S_6- N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits [50% at basal and 50% at panicle initiation (PI)] followed by S_5-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal. However it was found on par with S_3-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal and S_4-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Lower dry matter production (15.94 and 16.55 g hill^{-1}, 79.90 and 84.62 g hill^{-1}, 128.45 and 136.70 g hill^{-1}) respectively was recorded in S_7- NPK as per UAS-B package. Interaction between nitrogen, potassium levels and time of application was not found significant.

Application of 125 per cent RDNK produced higher dry matter production in all the growth stages. Application of higher dose of nitrogen and potassium might have helped in inducing vegetative growth led to better interception of photosynthetically active radiation and greater photosynthesis by crop. It resulted in plant height, more tiller production and more leaf area which encouraged higher dry matter accumulation under high fertility conditions (Anil *et al*., 2014 and Rakesh *et al*., 2017). Among the different split applications, higher dry matter production was recorded with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Four equal splits might have helped in efficient utilization of nitrogen with minimum scope to various nitrogen losses under semi dry conditions as is evidenced by its vigorous root development. The overall impact of split application of nitrogen at respective stages of crop growth is clearly reflected in enhanced plant height, swelled tiller number that contributed to more dry matter (Lakshmi Bai *et al*., 2014). Split application of potassium also increases transportation of photosynthates from leaves to grain, thereby increasing the dry matter content of the plant. These results are confined with the findings of (Nand *et al*., 2020).

Leaf Area

The data on plant leaf area of semi dry rice as influenced by doses and time of nitrogen and potassium application recorded at 30, 60, 90 DAS and at harvest are presented in Table 4.

At 30 DAS leaf area observed during 2019 and 2020 did not differ significantly due to different doses of nitrogen and potassium, split applications and their interaction effect.

At 60 DAS, 90 DAS and at harvest leaf area of semi dry rice significantly influenced by different doses and split application of nitrogen and potassium. Among the different doses of nitrogen and potassium significantly higher leaf area (427.33 and 461.14 cm^2, 1035.62 and 1054.29 cm^2, 758.86 and 787.90 cm^2) was recorded with applications of 125 per cent RDNK. Lowest leaf area was found in 100 per cent RDNK (346.38 and 365.14 cm^2, 890.57 and 908.19 cm^2, 673.62 and 688.95 cm^2), respectively during both years. Among the different split applications, significantly higher leaf area (436.33 and 477.33 cm^2, 1038.33 and 1063.67 cm^2, 790.33 and 809.33 cm^2) was recorded with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits [50% at basal and

TABLE 4

Leaf area (cm^2) of semi dry rice as influenced by doses and time of nitrogen and potassium application

Treatments	30 DAS		60 DAS		90 DAS		At Harvest	
	2019	2020	2019	2020	2019	2020	2019	2020
Main plots = Nitrogen and potassium level (2)								
M_1	45.43	51.71	346.38	365.14	890.57	908.19	673.62	688.95
M_2	55.52	57.33	427.33	461.14	1035.62	1054.29	758.86	787.90
S. Em±	1.95	1.66	6.88	7.99	16.66	18.03	11.04	14.22
CD (p= 0.05)	NS	NS	41.85	48.59	101.37	109.68	67.21	86.55
Sub plots= Split application of nitrogen and potassium (7)								
S_1	45.00	51.00	345.67	359.00	885.33	909.67	648.00	661.33
S_2	42.67	49.33	348.33	358.00	931.67	946.00	684.33	709.00
S_3	51.33	54.00	415.00	439.67	989.00	1006.33	735.00	781.33
S_4	53.67	58.33	410.33	436.00	1011.67	1038.33	778.67	794.67
S_5	59.67	59.67	430.00	471.00	1028.67	1050.67	777.00	800.33
S_6	57.00	59.67	436.33	477.33	1038.33	1063.67	790.33	809.33
S_7	44.00	49.67	322.33	351.00	857.00	854.00	600.33	613.00
S. Em±	4.92	4.23	10.12	14.50	23.70	23.14	22.23	26.74
CD (p= 0.05)	NS	NS	29.55	42.33	69.18	67.53	64.87	78.04
Interaction (M x S)								
S. Em±	6.96	5.98	14.32	0.10	33.52	32.72	31.43	37.81
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Note : M1- 100% RDNK, M2- 125% RDNK, S1= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), 100% K at basal, S2= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S3= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S4= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S5= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S6= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits (50% at basal and 50% at panicle initiation (PI) and S7= NPK as per UASB package

50% at panicle initiation (PI)]. However it was found on par with S_5-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal followed by S_3-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal and S_4-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Lowest leaf area was recorded in S_7-NPK as per UAS-B package (322.33 and 351.00 cm^2, 857.00 and 854.00 cm^2, 600.33 and 613.00 cm^2). Interaction between nitrogen, potassium levels and time of application was not found significant.

Leaf area was significantly higher with 125 per cent RDNK. This might be due to early nutrients which promote plant height, primary tillers and thus resulting in more number of leaves.

Among the different split application higher leaf area was noticed N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits [50% at basal and 50% at panicle initiation (PI)] compared to other split application. It was mainly due to continuous supply of nutrient through out the growing period increase the effective uptake of nutrient from soil by reducing losses which leads to put more number of leaves which increases leaf area per unit area.

Yield (kg ha^{-1})

The data on yield (kg ha^{-1}) of semi dry rice as influenced by doses and time of nitrogen and potassium application recorded are presented in Table 5.

Among the different doses of nitrogen and potassium higher grain yield (5401 and 5628 kg ha^{-1}) and (7308 and 7508 kg ha^{-1}) was recorded with application of 125 per cent RDNK. Lowest grain yield was found in 100 per cent RDNK (4823 and 5037 kg ha^{-1}) and straw yield (6520 and 6735 kg ha^{-1}), respectively during 2019 and 2020. Among the different split applications, significantly higher grain yield (5453 and 5680 kg ha^{-1}) and straw yield (7445 and 7636 kg ha^{-1}) was noticed with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation

TABLE 5

Yield (kg ha^{-1}) of semi dry rice as influenced by doses and time of nitrogen and potassium application

Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	2019	2020	2019	2020
Main plots = Nitrogen and potassium level (2)				
M_1	4823	5037	6520	6735
M_2	5401	5628	7308	7508
S. Em ±	69	72	90	90
CD (p= 0.05)	422	437	551	548
Sub plots= Split application of nitrogen and potassium (7)				
S_1	4808	5060	6501	6733
S_2	4973	5189	6691	6939
S_3	5213	5440	7067	7269
S_4	5308	5525	7179	7446
S_5	5376	5580	7290	7444
S_6	5453	5680	7445	7636
S_7	4650	4855	6229	6382
S. Em ±	90	94	145	143
CD (p= 0.05)	263	273	424	418
Interaction (M x S)				
S. Em±	127	132	205	203
CD (p= 0.05)	NS	NS	NS	NS

Note : M1- 100% RDNK, M2- 125% RDNK, S1= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), 100% K at basal, S2= N at 3 splits as, 20% at sowing, 40% at tillering (T) and 40% at panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S3= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S4= N at 4 splits as, 10% at sowing, 30% each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits (50% at basal and 50% at panicle initiation (PI), S5= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), 100% K at basal, S6= N at 4 splits as, 25 % each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) , K at 2 splits (50% at basal and 50% at panicle initiation (PI) and S7= NPK as per UASB package

(PI)], which was on par with S_5-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI) 100 per cent K at basal, S_3-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), 100 per cent K at basal and S_4-N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Lower grain yield (4650 and 4855 kg ha^{-1}) and straw yield (6229 and 6382 kg ha^{-1}) was recorded in S_7-NPK as per UAS-B package. Interaction between nitrogen, potassium levels and time of application was not found significant.

Application of 125 per cent RDNK produced significantly higher grain and straw yield compared to 100 per cent RDNK. Application of higher doses of nitrogen and potassium induced enhancement of photosynthetic activity and these resulted in the translocation of photo synthates and amino acids from the leaves and culms to the grain. Adequate nutrient with more N applied which would have led to increased growth and yield components. Similar results were reported by (Shekara *et al.,* 2010). Increased grain yield associated with added potassium fertilizer levels might be due to the cumulative effect of increased translocation of photosynthates to sink resulting in enhanced level of yield components. Similar finding was observed by Dakshina Murthy *et al*., 2014.

Among the different split applications, higher grain yield and straw yield was recorded with S_6-N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Split application of nitrogen and potassium produced the synergistic effect in improving the yield of semi-dry rice by assuring constant supply of nutrient at critical stages for translocation of photosynthates from source to sink. It has resulted in better growth characters *viz.,* total tillers, LAI and dry matter production and yield attributes. These findings were in accordance with (Anusha, 2016 and Nand e*t al*., 2020).

Thus, the study revealed that application of 125 per cent Recommended dose of Nitrogen of Potassium (RDNK) has produced higher growth parameters and yield compared to 100 per cent RDNK during both years. Among different split applications, N at 4 splits as, 25 per cent each at sowing, early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)] has produced significantly higher growth attributes and yield but was on par with N at 4 splits as, 10 per cent at sowing, 30 per cent each at early tillering (ET), tillering (T) and panicle initiation (PI), K at 2 splits [50% at basal and 50% at panicle initiation (PI)]. Hence 125 per cent RDNK as four splits of nitrogen and two splits of potassium at different growth stages is best tool for nutrient management in order to increase growth attributes, yield and nutrient use efficiency of semi dry rice for the Southern dry zone of Karnataka.

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