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Journal of Applied and Natural Science 7 (2) : 616 – 620 (2015)

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Effect of timing and graded levels of nitrogen and potassium in SRI cultivation

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Received: September 1, 2014; Revised received: July 3, 2015; Accepted: July 31, 2015

Abstract: A field experiment was carried out at Annamalai University Experimental farm, Annamalai nagar, during Kuruvai and Navarai in the year 2008-09. To study the timing and graded levels of nitrogen and potassium in rice crop under SRI (System of rice intensification) cultivation. The experiment was laid out on deep clay soil by adopting randomized block design with factorial technique (FRBD). The results of field experiment revealed that the maximum growth and yield attributes were recorded in the treatment which received P_2O_5 as fully basal dose and nitrogen as three split doses viz., 50% basal and 25% each at tillering and panicle initiation stages. Potassium was applied as 33.3% K_2O each at 15, 30 and 45 DAT. This treatment significantly recorded higher grain yield of 6278.7 kg ha^{-1} in field experiment – I and 6577.9 kg ha^{-1} in field experiment – II; and the straw yield of 7010.3 and 7309.7 kg ha^{-1} in field experiment I and II respectively. The shoot and grain uptake of nutrients (N, P and K) were high during 15, 30 and 45 DAT and at harvest which received 33.3 % K_2O each at 15, 30 and 45 DAT.

Keywords: Graded levels, Nutrient uptake, Nitrogen, Potassium, SRI

INTRODUCTION

Rice is the one of the staple food grain crop for more than half of the world's population. It provides 60 – 70 % of body calories intake of the consumers (FAO, 2003). India rank first in productive land about 45 million hectares (M ha) and second in production about 88 million tones (Mt) next only China in the world. The system of rise intensification (SRI) is one of the new methodologies for increasing yield (Productivity) of irrigated rice crop. The SRI cultivation uses of much less irrigation, seed rate and fertilizer applications compare to the traditional rice cultivation practices (Janitha, 2007).

Nitrogen is the most improtent element which impacts yield and quality in crops (Cassman *et al.* 2002; Shanahan *e tal*. 2008). That has profound effect on growth and yield of rice with the total fertilizer N consumption of about 12 Mt. (IASRI, 2003). Currently nitrogen fertilizer is often applied in excess of crop needs, resulting in economic loss and environmental pollution (Ju *et al*. 2009). Therefore, precision management of crop N status is important, and real time and precise evaluation of crop N status in the field was proved to be an effective way to improve N use efficiency, crop yield and quality (Raun *et al*., 2002). Potassium has an important role in enzyme activation, especially Rubiso activity, protein synthesis and the establishment of trasmembrane pH and electric charge gradients. Insufficient K^+ supply to plants leads to growth retardation and old leaves become chlorotic and necrotic (Marschner, 1995; Mengel, 2007). K is attracting more and more attention fallowing the increased application of N and P fertilizers and use of high yielding varieties. Manzoor *et al*. (2008) reported that the problem of K fixation can be reduced to some extent and efficiency may be improved by different K application methods. The sources of K and their time of application may also affect the K recovery. K is vital to the process of photosynthesis. It reduces N losses by inhibiting denitrification. K concentration can influence the permeability of crops (Janitha, 2007). Arivazhagan and Ravichandran (2005) reported that in general, nutrient uptake, grain and straw yields increased with increased levels of N and K.

Rice (*Oryza sativa*) is a cereal grain of the grass family (Graminae) probably it is native to the atlas of the great Asian rivers- the Ganges, the Chang (Yuangtze) and the Tigris and Euphrates. Rice, one of the most important food crops in the world, forms the staple diet

ISSN : 0974-9411 (Print), 2231-5209 (Online) All Rights Reserved © Applied and Natural Science Foundation www.ansfoundation.org

of 2.7 billion people. It is grown in all the continents except Antartica, occupying 150 million ha and producing 573 million tones paddy with an average productivity of 3.83 ton / ha. Rice provides 32 – 59 % of the dietary energy and 25 – 44 % of the dietary protein in 39 (Janitha, 2007).

In India, it accounts for more than 40 % of food grain production. One of the way to solve the water crisis for rice cultivation may be the System of rice intensification (SRI) developed in the early 1980s in Madagascar by *Fr. Henri de Laulanie* has undergoing some changes within the country and in other countries as the basic SRI methodology gets introduced and evaluated. SRI is otherwise called as "Aerobic rice cultivation" and in Tamil it is called as "Semmai Nel-Sagupadi". Vijay Kumar *et al*., Studied the yield attributes, yield and water productivity of rice under SRI cultivation. The grain yield, water productivity were significantly increased when following SRI with 14 days old seedlings planted at 25 X 25 cm spacing to achieve the yield. Hence, the field investigation was carried out with the different timing and levels of N and K application on the growth and yield attributes, nutrient uptake of grain and straw in SRI cultivation.

MATERIALS AND METHODS

The field experiments were conducted during Navarai (January - April 2008) and Kuruvai (June-September 2008) seasons. The experiments were conducted in the field of wetland block of experimental farm, Annamalai University, Annamalainagar. The experimental farm is geographically located at 11°24′ N latitude and 79°41′ E longitude at an altitude of +5.79m above mean sea level and 6 km away from Bay of Bengal. The soil of experiment field was deep moderately drained, clay in texture with pH (8.19) and EC (0.96 dSm^{-1}). The soil is medium in available nitrogen (348 kg ha^{-1}), medium in available phosphorus (13 kg ha^{-1}) and high in available potassium (448 kg ha^{-1}). Experiments were laid out in a randomized block design (FRBD) with factorial technique and three replications. Three different fertilizer doses *viz*., 90:38:28.5 (F_1), 120:38:38 (F_2) and 150:38:47.5 (F_3) kg N, P_2O_5 and K_2O ha^{-1} was applied according to the treatment schedule. Phosphorus was applied fully as basal dose and nitrogen as three split doses *viz*., 50% at basal 25% at tillering and remaining 25% at panicle initiation stage. The treatment (T_2) which received 50% K_2O as basal and the remaining 50% K_2O split into two equal halves and applied at 20 DAT (days after transplanting) and 40 DAT. The treatment (T_3) which received 33.3% K_2O as basal and the remaining 66.6% K_2O split into two equal halves and applied at 20 DAT and 40 DAT. In the rest of the treatments basal skipping of K_2O was followed and applied in 50% K_2O at 20 DAT and remaining 50% K_2O at 40 DAT (T_4) and in the treatment (T_5) each of 33.3% K_2O applied at 15 DAT, 30 DAT and 45 DAT. The treatment T_1 is absolute control. The N, P_2O_5 and K_2O were applied through urea, superphosphate and muriate of potash, respectively.

RESULTS AND DISCUSSION

Growth, yield and yield attributes: The studies on the influence of different levels of nitrogen and potassium applied at different time intervals of SRI cultivation revealed that, number of panicle $hill^{-1}$, panicle length, number of filled grain $panicle^{-1}$ and one thousand grain weight. The treatment which received 50 % N basal and 25 % each at tillering and panicle initiation stages and 33.3% K_2O applied @ 15 DAT, 30 DAT and 45 DAT (basal skipping of K_2O) was significantly increased the panicle length (19.30 cm), One thousand grain weight (20.76 g) and number of filled grain panicle $hill^{-1}$ (159) (Table 1) . The usefulness of increased N application on tiller production was also increased by Singh *et al*. (2006). Split application of potassium with nitrogen was more effective in improving the yield attributing characters. This corroborates with the finding of Mondal *et al*. (1989) and Venkitaswamy *et al.* (1997). Under SRI cultivation the total number of panicles and their individual grain sizes, consequently total grain yield are potentially increased (Uphoff *et al.,* 2002; Stoop, 2003).

The effect of different levels of nitrogen and potassium applied at different time intervals on the yield attributes of the SRI cultivation significantly increased the grain and straw yield. The treatment which received each of 33.3% K_2O at 15 DAT, 30 DAT and 45 DAT (basal skipping of K_2O) was significantly incr eased the grain and straw yield. The highest grain and straw yield was recorded in field experiment I and II (6278 and 7010.3 Kg ha^{-1}) (Fig. 1 and 2) and (6577.9 and 7309.7 Kg ha^{-1}) (Table 2). Basal skipping of K and application of 33.35 K_2O at 15 DAT, 30 DAT and 45 DAT significantly increased the grain yield as compare to basal application and top dressing. This may be due to higher nutrient availability, growth and yield parameters at different stage of crop growth and ultimately the grain yield. Samrathlal *et al.* (2003) claimed that grain and straw yields of rice crop were increased significantly owing to potash fertilization in two equal splits. Ali *et al*., (2005) recorded that among the different methods and time of potash application treatments, maximum paddy yield was obtained from the treatments of basal skiping of potassium. Awan *et al*. (2007) while performing field experiments across six districts of Punjab concluded that potash application at two splits resulted in more number of grains $panicle^{-1}$, highest 1000 grain weight and maximum paddy yield. Ravichandran and. Sriramachandrasekharan (2011) also reported the similar result was basal skipping of K_2O and application of entire quantity of K_2O into two equal splits resulted in higher growth, grain and straw yields of rice in both *kharif* and *rabi* seasons.

Table 1. Effect of graded levels and timing of nitrogen and potassium application on panicle length (cm), One thousand grain

Fertilizer schedule Treatment No.	Panicle length (cm)				Thousand grain weight (g)				Number of filled grains panicle^{-1}			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	16.6	17.1	17.2	16.9	20.0	20.1	20.2	20.1	79	82	83	81.3
T_2	17.0	19.2	19.3	18.5	20.80	20.82	20.84	20.80	155	167	175	165.6
T_3	17.2	19.5	19.6	18.8	20.81	20.83	20.85	20.83	159	169	177	168.3
T_4	17.5	19.9	20.0	19.1	20.87	20.84	20.86	20.84	162	170	180	170.6
T_5	17.9	20.2	20.4	19.5	20.83	20.85	20.87	20.87	164	172	182	172.6
Mean	17.2	19.2	19.3	18.6	20.64	20.70	20.75	20.75	143.8	152	159	151.7

	SE_D	CD(P=0.05)	SE_D	CD(P=0.05)	SE_D	CD(P=0.05)
F	0.10	0.20	NS	NS	1.32	2.72
T	0.13	0.26	NS	NS	1.71	3.51
F × T	0.22	0.46	NS	NS	2.97	6.08

F: Factors; T: Treatments

Table 2. Effect of graded levels and timing of nitrogen and potassium application on grain yield and straw yield (kg ha^{-1}) in SRI cultivation (Field experiment – II).

Fertilizer schedule Treatment No.	Grain yield Kg ha^{-1}				Straw yield Kg ha^{-1}			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	2897.2	2909.2	3020.9	2942.4	3519.9	4690.2	4751.2	4320.4
T_2	5398.1	5787.4	5791.3	5658.9	5402.2	7257.5	7451.5	6703.7
T_3	5507.5	5901.6	5918.7	5775.9	5688.5	7500.9	7631.5	6940.3
T_4	5857.8	6133.6	6151.7	6047.7	5997.5	7579.5	7797.5	7124.9
T_5	5988.2	6864.3	6881.2	6577.9	6280.9	7740.5	7907.9	7309.7
Mean	5129.7	5519.2	5552.7	5400.5	5377.8	6953.7	7107.9	6479.8

	SE_D	CD(P=0.05)	SE_D	CD(P=0.05)
F	45.2	92.7	20.3	41.6
T	58.4	119.7	26.2	53.8
F × T	101.2	207.4	45.5	93.2

F: Factors; T: Treatments

Nutrient uptake: The highest shoot and grain uptake was obtained in basal skipping of K_2O and application of 33.3% K_2O each at 15, 30 and 45 DAT. The present finding corroborates with the result of Arivazhagan (1999) in rice Var. IR 20 and Janitha (2007) in rice Var. ADT 36. Fertilizer N was applied with 50 per cent as basal and the remaining 50 per cent in two equal splits at active tillering and panicle initiation stages of rice crop. Such situation of comfortable level of instantly usable nitrogen favors optimum nitrogen uptake by rice crop at different growth stage (Radha Kumar and Srinivasulu *et al.,* 2009). The total uptake of nutrient is the product of its concentration. Split application of K resulted in higher nutrient uptake (N, P and K) in shoot and grain as compared to basal application. This might be due to the efficient absorption and translocation of nutrients from soil to foliage. Inherent limitation associated with fully application at the time of transplanting viz. dilution, penetration and fixation was efficiently circumvented by split application (Majumdar and Ghosh, 1980). Among the fertilizer schedules tried, the highest mean value of N (36.9 kg ha^{-1}) in shoot uptake was observed in F_3(150:38:47.5 N, P and K_2O kg ha-1) followed by F_2(120:38:38 N, P and K_2O kg ha-1) and F_1(90:38:28.5 N, P and K_2O kg ha-1) (Table 3). Increase in grain N(59.5 kg ha^{-1}), P(14.6 kg ha^{-1}) and K(14.1 kg ha^{-1}) nutrient uptake was observed in T_5 which received 33.3% K_2O each at 15, 30 and 45 DAT (Table 4). This may be due to the favorable possible interaction of N and K and the nutrient availability of more nutrients at critical stages of crop growth. Stoop *et al,* (2002) suggested that SRI practice develops deeper and stronger root system due to intermittent irrigation practices on soils without physical barriers on soils to root growth, planting of young seedling at wider spacing and application of slow releasing nutrient source such as compost.

Conclusion

The present study concluded that the System of Rice Intensification (SRI) method is effective, when

Table 3. Effect of graded levels and timing of nitrogen and potassium on shoot nitrogen uptake (Kg ha-1) at tillering, panicle initiation and harvest stages in SRI cultivation.

Fertilizer Schedule Treatment No.	Tillering				Panicle initiation				Harvest stage			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	16.53	16.50	16.53	16.51	25.33	23.60	25.06	24.66	28.17	28.40	28.64	28.40
T_2	17.32	18.37	19.14	18.27	29.46	25.46	32.80	29.24	36.70	38.57	39.84	38.37
T_3	17.52	18.94	19.66	18.70	30.80	27.06	34.00	30.62	37.41	38.96	40.32	38.89
T_4	17.78	19.10	20.68	19.18	32.00	228.4	35.20	31.86	38.02	39.26	40.53	39.27
T_5	17.98	19.34	21.86	19.72	33.20	29.60	36.80	33.20	38.29	40.46	40.78	39.84
Mean	17.42	18.43	19.57	18.47	30.15	26.82	32.77	29.91	35.71	37.13	38.02	36.95
	SE_D		CD(P=0.05)		SE_D		CD(P=0.05)		SE_D		CD(P=0.05)	
F	0.028		0.058		0.17		0.34		0.39		0.081	
T	0.037		0.075		0.22		0.45		0.051		0.104	
F × T	0.064		0.131		0.38		0.78		0.088		0.181	

F: Factors; T: Treatments

Table 4. Effect of graded levels and timing of nitrogen and potassium on grain nitrogen, phosphorus and Potassium uptake (Kg ha-1) in SRI cultivation.

Fertilizer schedule Treatment No.	Nitrogen				Phosphorus				Potassium			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	47.4	48.8	49.6	48.6	9.6	9.8	10.1	9.8	12.7	12.9	13.0	12.9
T_2	50.3	53.2	54.0	52.5	12.0	13	14.2	13.0	13.3	13.6	14.0	13.6
T_3	51.6	58.0	58.5	56.0	13.0	13.6	14.3	13.6	13.3	13.9	14.2	13.8
T_4	52.5	61.3	61.6	58.4	13.6	16.9	14.4	16.9	13.6	14.0	14.2	13.9
T_5	53.0	62.0	62.6	59.5	14.2	14.1	15.6	14.6	13.7	14.2	14.5	14.1
Mean	50.9	56.6	57.1	55.0	12.1	12.8	13.7	13.0	13.3	13.7	14.0	13.7
	SE_D		CD(P=0.05)		SE_D		CD(P=0.05)		SE_D		CD(P=0.05)	
F	0.26		0.54		0.14		0.29		0.04		0.10	
T	0.34		0.69		0.18		0.38		0.06		0.13	
F × T	0.59		1.21		0.32		0.66		0.11		0.22	

F: Factors; T: Treatments

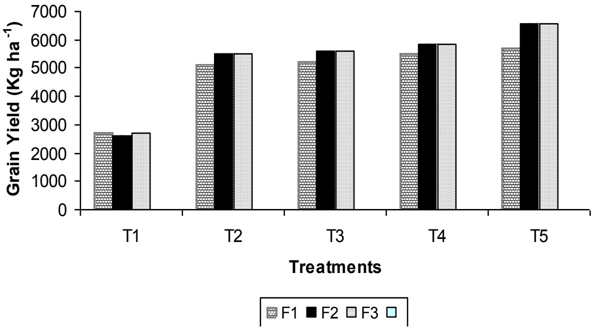

Fig. 1. *Effect of graded levels and timing of nitrogen and potassium application on grain yield (kg ha-1) in SRI cultivation. (Field experiment – I).*

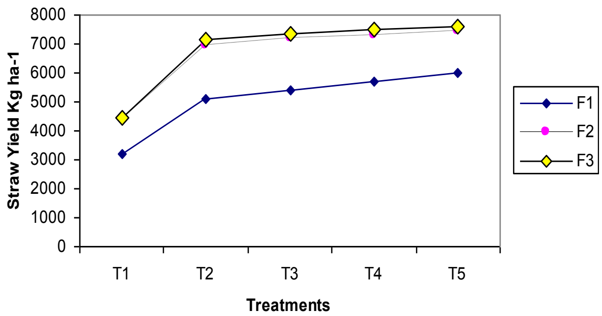

Fig. 2. *Effect of graded levels and timing of nitrogen and potassium application on straw yield (kg ha-1) in SRI cultivation. (Field experiment – I).*

recommended dose of fertilizer schedule applied with time interval based on soil nutrient. It helps to increase the fertilizer use efficiency (FUE) and improve crop yield. In soils where the initial status of K is high, skipping of basal K_2O and application of 33.3% K_2O each at 15, 30 and 45 DAT with recommended fertilizer dose of N, P and K_2O 150:38:47.5 kgha-1 can be recommended under SRI cultivation to the farming community.

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