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Nutrient dynamics of Rice Varieties Influenced by Planting Geometry under Semi Dry Cultivation

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ABSTRACT: Rice is the most important food crop grown in India. Lack of suitable varieties and improper planning geometry are the major challenges in the direct seeded rice ecosystem. A study was conducted at College of Agriculture, (V.C. Farm), Mandya, University of Agricultural Sciences, Bengaluru during *kharif* 2019 and 2020 to find out optimum planting geometry for rice varieties under semi dry condition for higher productivity. The experiment was laid out in split-plot design and replicated thrice comprising of treatments two row spacing's (20 cm and 30 cm) assigned to main plots. Each main plot was further divided into eight sub-plots to accommodate eight plant varieties (V_1-KMP-175, V_2- RNR-15048, V_3- RNR-15038, V_4- Rasi, V_5- MTU-1001, V_6- MTU-1010, V_7- IR-64, V_8- Gangavathi sona). 20 cm row spacing recorded significantly higher nutrient uptake and nutrient use efficiency compared to 30 cm row spacing. Whereas in varieties KMP-175 recorded higher nutrient uptake and nutrient use efficiency over other varieties.

Keywords: Semi dry rice, row spacing, nutrient uptake, nutrient use efficiency.

INTRODUCTION

Rice is a staple food for more than 60% of the Indian population (Mahesh *et al*., 2022). It accounts for approximately 43% of total food grain production and 46% of total cereal production in the country. Rice is an inefficient water user, accounting for half of all developed fresh water resources. Rice, unlike other cereal crops such as wheat, maize, and sorghum, requires more water per unit grain output. On an average, 2500 L of water are applied, ranging from 800 to more than 5000 L, to produce 1 kg of rough rice. In the near future, the possibility of increasing the area under rice cultivation is limited. As a result, the additional rice production required must come from increased productivity. The main challenge will be to achieve this gain while using less water, labour and chemicals, assuring long-term sustainability. Furthermore, puddling and transplanting require a large amount of water and labour, both of which are becoming scarce and expensive, resulting in less profitable rice production. Submerged water cultivation practises also reduce soil productivity by destructing soil structure and organic matter (Sridhara *et al*., 2011).

Farmers are changing their rice establishment methods from transplanting to dry direct sowing in unpuddled soil to save water, depending on water and manpower scarcity. Semi dry system is an alternative source for increasing productivity under command areas.

Higher crop yield can be obtained by combining optimum genotypes in the right environment and implementing appropriate agronomic methods. The microclimate can be regulated through suitable agronomic practises and the maintenance of optimal soil moisture in the root zone, which will aid in the production of semi dry rice. The row spacing influences the availability of sunlight, leaf area, and nutrient to the plant, photosynthesis and respiration (Gautam *et al*., 2018; Kipgen *et al*., 2018). Row spacing affects crop yield as it not only determines the optimum crop stand, but also facilitates inter-culture and convenient herbicide application for effective and efficient weed control (Kiran *et al*., 2015). Yield may be reduced with narrow spacing due to increased plant competition for available resources and in wider spacing due to high weed problem and less plant stand per unit area (Satyamurthy *et al*., 2018). It is necessary to determine the optimum density of plants population per area unit for obtaining maximum yields.

Developing high yielding varieties and optimum planting geometry with good management practices play an important role in semi-dry rice production systems with limited water. For the southern dry zone of Karnataka, information on suitable rice varieties and planting geometry under semi dry conditions is limited. Hypothesis of the current study is designed to evaluate optimal spacing and varieties under semi-dry conditions.

MATERIAL AND METHODS

The field experiment was conducted at College of Agriculture, (V. C. Farm), Mandya, University of Agricultural Sciences, Bengaluru during *kharif* 2019 and 2020, which comes under Southern Dry Zone of Karnataka (Zone-VI). The experiment was replicated trice in split plot design with two row spacing viz., 20 cm and 30 cm row spacing in main plots and eight plant varieties (V_1-KMP-175, V_2-RNR-15048, V_3-RNR-15038, V_4-Rasi, V_5-MTU-1001, V_6-MTU-1010, V_7- IR-64, V_8-Gangavathi sona). Random allocation of treatment was done both in main and sub plots. The experimental plots were sandy loam in texture, low in nitrogen and potassium availability and high phosphorous availability. The crop was line sowned in pre marked lines and pre emergent application of herbicide was done 3 DAS and subsequent weeding as and when required. Rice was sown under dry condition and it was rainfed up to 45 days after sowing and converted to wet with the availability of canal water and thereafter irrigation was given from 40 DAS and 2-5 cm standing water was maintained up to the harvesting stage of the crop. The water was withdrawn 10 days before harvesting. At the time of sowing phosphorus and potassium were applied @ 50 kg ha^{-1} as per the treatment plan using single super phosphate and muriate of potash as source, respectively. The nitrogenous fertilizer were applied @ 100 kg ha^{-1} given in three aplits as (50% as basal at sowing, 25% at maximum tillering and 25% at panicle initiation stage) as urea. Other cultural practices and plant protection measures were followed as per recommendations.

RESULTS AND DISCUSSION

A. Nutrient uptake by grain (kg ha^{-1})

The data on nutrient uptake by grain (kg ha^{-1}) of semi dry rice at harvest as influenced by planting geometry and varieties at harvest are presented in Table 1.

(a) Nitrogen uptake (kg ha^{-1}). 20 cm row spacing recorded significantly higher nitrogen uptake (66.96 kg ha^{-1}) over 30 cm row spacing (61.73 kg ha^{-1}). Among the different rice varieties, higher total nitrogen uptake was recorded in KMP-175 (73.21 kg ha^{-1}) and it was on par with MTU-1010 (71.50 kg ha^{-1}) and significantly higher compared to all other varieties. The lower nitrogen uptake was recorded in Gangavathi sona (57.22 kg ha^{-1}). Interaction between planting geometry and varieties was found non significant.

(b) Phosphorous uptake (kg ha^{-1}). 20 cm row spacing recorded significantly higher phosphorous uptake (24.17 kg ha^{-1}) compared to 30 cm row spacing (22.29 kg ha^{-1}). Among the different rice varieties, higher total phosphorous uptake was recorded in KMP-175 (27.30 kg ha^{-1}) and it was on par with MTU-1010 (26.45 kg ha^{-1}) and significantly higher compared to all other varieties. The lower phosphorous uptake was recorded in Gangavathi sona (19.92kg ha^{-1}). Interaction between planting geometry and varieties was found non significant.

(b) Potassium uptake (kg ha^{-1}). Significantly higher potassium uptake was noticed in 20 cm row spacing (18.99 kg ha^{-1}) over 30 cm row spacing (17.23 kg ha^{-1}). Among the different rice varieties, higher potassium uptake was recorded in KMP-175 (21.40 kg ha^{-1}) and it was on par with MTU-1010 (20.21 kg ha^{-1}) and significantly superior to other varieties. The lower potassium uptake was recorded in Gangavathi sona (15.69 kg ha^{-1}). Interaction between planting geometry and varieties was found non significant.

Among the different spacings, higher nutrient uptake was obtained in 20 cm row spacing compared to wider spacing. The higher nutrient uptake was mainly attributed to proportionate increase in dry matter production and an increase in total biological yield (grain + straw yield) which ultimately increased the total uptake of nitrogen. High density planting recorded more nitrogen uptake than low density due to higher biomass production (Sampath *et al*., 2017). In wider spacing presumably, the excessive weed growth prevented rice plants from absorbing nutrients. Similar findings were obtained by Jacob and Syriac (2005); Ranjita *et al*. (2011).

Among the different varieties, higher nutrient uptake was obtained in KMP-175 followed by MTU-1010 compared to other varieties. This might be due to proper establishment of roots higher absorption of mineral nutrients from the soil, transport of more nutrients to seed, vigorous plant growth and higher seed and straw yields. Difference in nitrogen content may be ascribed to the difference in grain and straw yields and nitrogen uptake. These results are in accordance with Kiran *et al*. (2015) in aerobic rice.

B. Available nutrient status

The data regarding change in available nutrient status of the soil at harvest is presented in Table 2.

(i) Available nitrogen (kg ha^{-1}). There was no significant difference on available nitrogen due to spacing and varieties. However higher available nitrogen content in soil was noticed in 30 cm row spacing (149.38 kg ha^{-1}) compared to 20 cm row spacing (141.72 kg ha^{-1}). Among the different varieties, higher available nitrogen content in soil was recorded in Gangavathi sona (151.45 kg ha^{-1}) and lower (136.29 kg ha^{-1}) was observed in KMP-175. Interaction between planting geometry and varieties was found non significant.

(ii) Available phosphorous (kg ha^{-1}). Non significant difference was noticed in available phosphorous between spacing and varieties. 30 cm row spacing (53.87 kg ha^{-1}) recorded higher available phosphorous content in soil over 20 cm row spacing (49.83 kg ha^{-1}). Whereas in different varieties, Gangavathi sona recorded higher available phosphorous content in soil (57.84 kg ha^{-1}) and KMP-175 recorded lower available phosphorous content in soil (44.80 kg ha^{-1}). Non significant interaction was found between planting geometry and varieties.

(iii) Available potassium (kg ha^{-1}). Higher available potassium content in soil (91.09 kg ha^{-1}) was recorded in 30 cm row spacing compared to 20 cm row spacing (88.43 kg ha^{-1}). Among the different varieties, higher available potassium content in soil (94.09 kg ha^{-1}) was recorded in Gangavathi sona and lower available potassium content (83.84 kg ha^{-1}) was recorded in

KMP-175 followed by MTU-1010 (85.74 kg ha^{-1}). However, treatments between planting geometry, varieties and their interaction was found non significant.

C. Nutrient use efficiency

The data on nutrient use efficiency of semi dry rice as influenced by planting geometry and varieties at harvest are presented in Table 3.

(i) Nitrogen use efficiency (kg grain kg^{-1} N). The pooled data showed significantly higher nitrogen use efficiency in 20 cm row spacing (46.05 kg grain kg^{-1} N) compared to 30 cm row spacing (41.15 kg grain kg^{-1} N). Among the different rice varieties, higher nitrogen use efficiency was recorded in KMP- 175 (50.86 kg grain kg^{-1} N) followed by MTU-1010 (48.78 kg grain kg^{-1} N) and was significantly superior over rest of the varieties. Lower nitrogen use efficiency was recorded in Gangavathi sona (37.36 kg grain kg^{-1} N). Interaction between planting geometry and varieties was found non significant.

Higher nitrogen use efficiency was noticed in 20 cm row spacing. This might be due to higher uptake of nitrogen and dry matter production leading to better yield attributes and grain yield. In case of wider spacing nitrogen use efficiency was low due to competition with weeds and different losses. Among the different varieties, higher nitrogen use efficiency was noticed in KMP-175. This might be due to effective uptake and production of grain yield with the same amount of input nitrogen compared to other varieties. The same kind of results were also recorded by Mallareddy and Padmaja (2013); Sampath and Srinivas (2017) in aerobic rice.

(ii) Phosphorous use efficiency (kg grain kg^{-1} P_2O_5). Among the different spacings, significantly higher phosphorous use efficiency was noticed in 20 cm row spacing (92.10 kg grain kg^{-1} P_2O_5) compared to 30 cm row spacing (82.30 kg grain kg^{-1} P_2O_5). Whereas in rice varieties, higher phosphorous use efficiency was recorded in KMP-175 (101.71 kg grain kg^{-1} P_2O_5) followed by MTU-1010 (97.56 kg grain kg^{-1} P_2O_5) and was statistically superior over rest of the varieties. Lower phosphorous use efficiency was recorded in Gangavathi sona (74.72 kg grain kg^{-1} P_2O_5). Interaction between planting geometry and varieties was found non significant.

Among the different spacing, 20 cm row spacing recorded higher phosphorous use efficiency over 30 cm row spacing. This might be due to higher grain yield compared to wider spacing. KMP-175 recorded higher phosphorous use efficiency over other varieties. It might be due to effective uptake and production of higher yield parameters and grain yield with application of nutrient. Similar observation was noticed by Sampath and Srinivas (2017); Nataraja *et al*. (2021) in aerobic rice

(iii) Potassium use efficiency (kg grain kg^{-1} K_2O). Among the different spacings, significantly higher potassium use efficiency was noticed in 20 cm row spacing (92.10 kg grain kg^{-1} K_2O) compared to 30 cm row spacing (82.30 kg grain kg^{-1} K_2O). Whereas in rice varieties, higher potassium use efficiency was recorded in KMP- 175 (101.71 kg grain kg^{-1} K_2O) followed by MTU-1010 (97.56 kg grain kg^{-1} K_2O) and significantly higher than other varieties.

Lower potassium use efficiency was recorded in Gangavathi sona (74.72 kg grain kg^{-1} K_2O). Interaction between planting geometry and varieties was found non significant.

Higher potassium use efficiency was recorded in 20 cm row spacing compared to 30 cm row spacing. This might be due to higher uptake by the crop which resulted in higher grain yield. KMP-175 recorded potassium use efficiency over other varieties. The difference in the phosphorus and potassium was perhaps due to effective uptake and production of higher yield parameters and grain yield with same amount of nutrients. Similar observation was noticed by Sampath and Srinivas (2017) in aerobic rice.

Table 1: Nutrient uptake by grain (kg ha^{-1}) of semi dry rice at harvest as influenced by planting geometry and varieties.

Treatments	Nitrogen uptake (kg ha^{-1})			phosphorous uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Row spacing (M)									
M_1- 20 cm	65.75	68.18	66.96	23.74	24.61	24.17	18.81	19.18	18.99
M_2- 30 cm	61.06	62.40	61.73	21.74	22.84	22.29	17.04	17.43	17.23
S. Em±	0.71	0.72	0.71	0.26	0.27	0.27	0.21	0.23	0.22
CD (p= 0.05)	4.34	4.41	4.31	1.61	1.67	1.63	1.28	1.41	1.34
Varieties (V)									
V_1 - KMP-175	71.77	74.65	73.21	26.67	27.94	27.30	21.21	21.58	21.40
V_2 - RNR-15048	57.30	58.25	57.77	19.80	20.35	20.08	16.19	16.22	16.20
V_3 - RNR-15038	58.05	59.07	58.56	20.00	21.45	20.73	16.32	16.72	16.52
V_4 -Rasi	67.48	71.17	69.32	24.43	25.53	24.98	19.00	20.20	19.60
V_5 - MTU-1001	62.45	63.12	62.78	22.57	23.53	23.05	17.50	16.85	17.17
V_6 -MTU-1010	70.14	72.86	71.50	26.00	26.90	26.45	19.77	20.65	20.21
V_7 - IR-64	63.08	65.75	64.42	22.83	23.85	23.34	17.73	18.52	18.12
V_8- Gangavathisona	56.97	57.47	57.22	19.62	20.23	19.92	15.67	15.71	15.69
S. Em±	1.32	1.30	1.27	0.50	0.52	0.51	0.39	0.44	0.41
CD (p= 0.05)	3.82	3.76	3.68	1.45	1.52	1.48	1.12	1.28	1.20
Interaction (M × V)									
S. Em±	3.13	3.41	3.20	0.75	0.78	0.76	0.59	0.66	0.62
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Available nutrient status of the soil after harvest as influenced by planting geometry and varieties.

Treatments	Available nitrogen (kg ha^{-1})			Available phosphorous (kg ha^{-1})			Available potassium (kg ha^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Row spacing (M)									
M_1- 20 cm	140.65	142.79	141.72	49.52	50.13	49.83	87.39	89.47	88.43
M_2- 30 cm	148.05	150.51	149.28	53.28	54.47	53.87	90.18	91.99	91.09
S. Em±	2.45	2.72	2.58	1.67	2.76	2.38	3.33	3.42	3.08
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Varieties (V)									
V_1 - KMP-175	136.11	136.46	136.29	43.94	45.66	44.80	83.77	83.92	83.84
V_2 - RNR-15048	149.53	151.20	150.37	56.24	57.16	56.70	91.81	94.97	93.39
V_3 - RNR-15038	146.98	149.11	148.04	56.91	57.33	57.12	92.08	95.1	93.59
V_4 -Rasi	140.59	144.04	142.32	47.19	48.40	47.79	86.20	87.23	86.72
V_5 - MTU-1001	147.54	151.49	149.52	52.20	52.61	52.41	89.25	91.8	90.53
V_6 -MTU-1010	139.09	142.58	140.84	46.44	47.25	46.84	85.52	85.97	85.74
V_7 - IR-64	144.09	146.24	145.17	50.80	51.80	51.30	89.00	91.33	90.17
V_8 - Gangavathisona	150.86	152.04	151.45	57.49	58.18	57.84	92.65	95.52	94.09
S. Em±	5.40	3.84	4.13	3.43	3.98	3.95	4.42	4.21	4.12
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (M x V)									
S. Em±	6.93	7.68	5.75	4.72	7.81	6.23	6.77	6.84	6.21
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Nutrient use efficiency of semi dry rice as influenced by planting geometry and varieties.

Treatments	Nitrogen use efficiency (kg kg N^{-1})			Phosphorus use efficiency (kg kg $P_2O_5^{-1}$)			Potassium use efficiency (kg kg K_2O^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Row spacing (M)									
M_1- 20 cm	45.40	46.70	46.05	90.80	93.41	92.10	90.80	93.41	92.10
M_2- 30 cm	40.11	42.19	41.15	80.22	84.38	82.30	80.22	84.38	82.30
S. Em±	0.78	0.69	0.67	1.55	1.37	1.39	1.55	1.37	1.39
CD (p= 0.05)	4.73	4.18	4.06	9.45	8.36	8.45	9.45	8.36	8.45
Varieties (V)									
V_1 - KMP-175	49.69	52.02	50.86	99.38	104.04	101.71	99.38	104.04	101.71
V_2 - RNR-15048	38.04	38.98	38.51	76.07	77.96	77.02	76.07	77.96	77.02
V_3 - RNR-15038	38.79	40.53	39.66	77.58	81.06	79.32	77.58	81.06	79.32
V_4 -Rasi	46.15	47.98	47.06	92.30	95.95	94.12	92.30	95.95	94.12
V_5 - MTU-1001	41.66	43.49	42.57	83.32	86.98	85.15	83.32	86.98	85.15
V_6 -MTU-1010	47.80	49.76	48.78	95.61	99.51	97.56	95.61	99.51	97.56
V_7 - IR-64	43.06	44.96	44.01	86.11	89.92	88.01	86.11	89.92	88.01
V_8- Gangavathisona	36.86	37.86	37.36	73.71	75.72	74.72	73.71	75.72	74.72
S. Em±	0.92	0.97	0.89	1.84	1.93	1.82	1.84	1.93	1.82
CD (p= 0.05)	2.67	2.80	2.58	5.33	5.60	5.26	5.33	5.60	5.26
Interaction (M x V)									
S. Em±	2.20	1.94	1.89	4.39	3.88	3.93	4.39	3.88	3.93
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Chemical properties of the soil after harvest as influenced by planting geometry and varieties

Treatments	pH			EC (dS m^{-1})			OC (%)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Row spacing (M)									
M_1- 20 cm	8.93	8.75	8.84	0.34	0.31	0.33	0.40	0.43	0.42
M_2- 30 cm	9.05	8.81	8.93	0.39	0.35	0.37	0.37	0.41	0.39
S. Em±	0.05	0.07	0.06	0.01	0.02	0.02	0.01	0.02	0.02
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Varieties (V)									
V_1 - KMP-175	8.96	8.86	8.91	0.37	0.34	0.36	0.44	0.49	0.47
V_2 - RNR-15048	8.92	8.78	8.85	0.36	0.32	0.34	0.35	0.39	0.37
V_3 - RNR-15038	9.14	9.01	9.08	0.37	0.28	0.33	0.35	0.37	0.36
V_4 -Rasi	8.90	8.86	8.88	0.39	0.34	0.37	0.44	0.46	0.45
V_5 - MTU-1001	8.97	9.00	8.99	0.38	0.32	0.35	0.36	0.41	0.39
V_6 -MTU-1010	8.90	8.81	8.86	0.39	0.27	0.33	0.46	0.50	0.48
V_7 - IR-64	9.09	8.85	8.97	0.30	0.29	0.30	0.35	0.38	0.37
V_8 -Gangavathi sona	8.97	8.92	8.95	0.32	0.36	0.34	0.35	0.36	0.36
S. Em±	0.14	0.14	0.13	0.05	0.04	0.04	0.04	0.04	0.04
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (M x V)									
S. Em±	0.13	0.20	0.17	0.04	0.06	0.04	0.04	0.06	0.05
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

D. Chemical properties of soil

Chemical properties of soil after harvest are presented in Table 4. pH, EC and per cent OC was found non significant between different spacings and varieties. However higher pH and EC was noticed in30 cm row spacing (8.93 and 0.37) compared to 20 cm row spacing (8.84 and 0.33). Higher organic carbon was recorded in 20 cm row spacing (0.42%) compared to 30 cm row spacing (0.39%). Interaction between planting geometry and varieties regarding pH, EC and OC were not found significant.

CONCLUSIONS

From the investigation it can be recommended that growing of semi dry rice variety KMP-175 in 20 cm row spacing under semi dry method of rice cultivation is beneficial compared to wider spacing and other varieties under southern dry zone of Karnataka.

FUTURE SCOPE

More studies are to be conducted on other ruling rice varieties and hybrids under semi dry method of rice cultivation under different planting geometry.

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