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Research Article

RESPONSE OF RICE TO AGE OF SEEDLINGS, CROP GEOMETRY AND NANO-FERTILIZERS IN TERMS OF YIELD, ECONOMICS, NUTRIENT CONTENT AND UPTAKE PATTERN IN KONKAN REGION

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Abstract: The present investigation was carried out at Agronomy farm, College of Agriculture, Dapoli, Dist. Ratnagiri during *Kharif* season of 2018. The experiment was laid out in split plot design with replicated thricely. Growth observations of rice were noted periodically from 40 DAS till at the harvest at an interval of 30 days and yield contributing characters and yield were recorded at harvest to evaluate the treatment effects. The experimental results revealed that the transplanting of 10 days old seedlings produced higher growth attributes as well as higher number of panicles hill^{-1}, number of filled grains panicle^{-1}. While 20 cm x 15 cm recorded significantly taller plants, significantly higher number of unfilled grains panicle^{-1} and higher grain and straw yield. In case of growth attributing and yield attributing characters, the spray of nano P + nano K recorded predominantly maximum values than rest of the treatments. Due to higher growth attributing and yield attributing values, the grain and straw yield was higher under spray of nano P + nano K. Regarding the nutrient content, the spray of nano P + nano K showed significantly higher N content in grain and straw, spray of nano P showed higher P content in grain and straw, spray of nano K showed higher K content in grain and straw. The spray of nano P + nano K showed significantly higher grain, straw and total uptake. The spray of nano P recorded significantly higher grain and total P uptake. While in case of P uptake in straw spray of nano P and spray of nano P + nano K were at par with each other and significantly higher than spray of nano K.

Keywords: Rice, Age of seedling, Spacing, Nano-fertilize, Yield, Economics and nutrient uptake

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Introduction

Rice (*Oryza sativa* L.) is the staple food crop of the world considering the area under rice cultivation and the number of people depending on the crop. There are 111 rice-growing countries in the world. They include all Asian countries, most countries of West and North Africa, some countries in Central and East Africa, most of the South and Central American countries, Australia, and four states in the United States. The importance of rice as a daily food is expressed differently in different countries. Rice occupies an area of 43.19 million hectares with production of 110.15 million tonnes and productivity of 2.55 tonnes ha^{-1}. Area coverage under rice is estimated to have decreased from 389.49 lakh hectares in 2016-17 to 387.16 lakh hectare in 2017-18 [1]. Rice is cultivated on 15.35 lakh hectares area with production of 35.81 lakh tonnes and productivity of 2.33 tonnes ha^{-1} [2]. There are huge operations required for the production process some of those like seedling age at transplanting is an important factor for uniform stand of rice [3] and regulating its growth and yield [4]. Tillering is an important parameter that decide the yield and per unit land area. The use of over aged seedling ultimately affects the general performance of crop and the yield of the crop reduces drastically. So, it is very important to find out the optimum age of seedlings of a variety for a particular season. Planting geometry is an important aspect in boosting yield of rice. The optimum plant density depends on different factors. Desired plant spacing per unit area is a considerable one for getting maximum yields. Inadequate spacing reduces rice yield up to 20-30%, while optimum spacing ensures better plant growth through efficient utilization of solar radiation and nutrients [5]. For achieving maximum rice grain yield, it is necessary to maintain a critical level of rice plant population in field. The plants that are spaced more widely can absorb more solar radiation which improves their photosynthetic ability and performance as individual plants.

According to the suggestions by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, the rice should be transplanted at 20 cm x 15cm spacing. Nutrient management is crop need to be manipulate and practises very systematically for achieving higher yield and sustaining soil health is ultimate and unbiassed goal of any farmer and agronomist. However, to achieve this there are different methods of application of nutrient via various sources, forms and manners. There are some conventional methods already in vogue, some of those because of there is no alternative. Nanotechnology has showed the possibility of operating nanoscale or nanostructured material as a source of fertilizer carrier or controlled release vector for building as being popularized “smart fertilizer” to augment nutrient use efficiency and reduce the cost of ecological contamination. Of all the major nutrients, phosphorus is the element in shortest supply in the world economy. It is the one for which agronomists of different countries express the greatest fear of ultimate exhaustion. Unlike many other plant nutrients, phosphorus added to soil as fertilizer generally does not move appreciably from the area of placement. The rapid and tenacious fixation of fertilizer phosphorus added to most soils is general knowledge. Plants recover only a small proportion of the phosphorus supplied as fertilizer. Thus, it is necessary to search out ways and means to develop a phosphorus management system by nutrient supply through conjunctive use of chemical fertilizers. Potassium is taken up in large quantities by plants, is highly mobile within plant vascular systems and plays an essential role in a number of metabolic functions. Over 60 enzymes require K for catalytic activity, some of which play a role in protein synthesis and sugar degradation. Water relations of plant cells rely on the rapid movement of K ions in order to maintain and regulate and stomatal control can be affected if K is deficient.

Table-1 *Effect of different treatments on grain, straw yield of rice and their nutrient content (%) and economics as influenced by different treatments*

Treatments	Mean yield		Content of nutrient (%)						Economics			
	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Nitrogen		Phosphorous		Potassium		Cost of cultivation (₹ ha^{-1})	Gross Return (₹ ha^{-1})	Net Return (₹ ha^{-1})	B:C Ratio (₹ ha^{-1})
			Grain	Straw	Grain	Straw	Grain	Straw				
I) Main plot treatments												
A) Age of seedlings (A)												
A1: 10 days old seedlings	55.78	62.7	1.29	0.74	0.22	0.16	0.29	0.85	80265	113284	33019	1.41
A2: 20 days old seedlings	56.97	64.05	1.41	0.84	0.23	0.18	0.27	0.9	80670	115708	35039	1.43
A3: 30 days old seedlings	54.17	60.9	1.15	0.72	0.2	0.14	0.26	0.82	79721	110018	30297	1.38
S.E. ±	0.36	0.39	0.02	0.02	0.003	0.003	0.003	0.004				
C.D. at 5%	1.4	1.54	0.08	0.07	0.01	0.01	0.01	0.02				
B) Crop geometry (S)												
S1: 20 cm x 15 cm	57.49	64.63	1.27	0.77	0.22	0.16	0.27	0.85	83835	116769	32934	1.39
S2: 25 cm x 25 cm	53.78	60.47	1.29	0.76	0.21	0.16	0.28	0.86	76602	109238	32635	1.43
S.E. ±	0.12	0.14	0.02	0.02	0.003	0.002	0.003	0.003				
C.D. at 5%	0.41	0.49	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.				
II) Sub plot treatments												
Nano-fertilizers spray (W)												
W0: No spray	50.77	56.02	1.1	0.62	0.19	0.14	0.21	0.7	78161	102861	24701	1.32
W1: Spray of Nano-P	57.68	65.17	1.35	0.82	0.24	0.18	0.25	0.81	80808	117229	36420	1.45
W2: Spray of Nano-K	54.56	61.11	1.24	0.68	0.21	0.16	0.34	1	79731	110765	31034	1.39
W3: Spray of Nano-P + Nano-K	59.54	67.87	1.44	0.96	0.22	0.17	0.3	0.92	82175	121159	38984	1.48
S.E. ±	0.21	0.24	0.02	0.02	0.004	0.003	0.004	0.01				
C.D. at 5%	0.61	0.7	0.06	0.05	0.01	0.01	0.01	0.02				
General Mean	55.64	62.55	1.28	0.77	0.22	0.16	0.28	0.86				

Table-2 *Effect of different treatments on nutrient uptake pattern of in grain, straw and total uptake in rice*

Treatments	Nitrogen uptake (kg ha^{-1})			Phosphorous uptake (kg ha-1)			Potassium uptake (kg ha^{-1})		
	N uptake in grain (kg ha^{-1})	N uptake in straw (kg ha^{-1})	Total N uptake (kg ha^{-1})	P uptake in grain (kg ha^{-1})	P uptake in straw (kg ha^{-1})	Total P uptake (kg ha^{-1})	K uptake in grain (kg ha^{-1})	K uptake in straw (kg ha^{-1})	Total K uptake (kg ha^{-1})
I) Main plot treatments									
A) Age of seedlings (A)									
A1: 10 days old seedlings	72.33	47.03	119.37	12.1	10.18	22.28	16.26	53.79	70.04
A2: 20 days old seedlings	80.43	54.58	135.02	13.35	11.45	24.8	15.74	58.01	73.75
A3: 30 days old seedlings	62.6	44.46	107.06	10.98	8.86	19.84	14.4	50.14	64.54
S.E. ±	1.4	1.2	2.24	0.09	0.23	0.19	0.23	0.28	0.49
C.D. at 5%	5.5	4.73	8.8	0.36	0.9	0.74	0.92	1.12	1.91
B) Crop geometry (S)									
S1: 20 cm x 15 cm	73.63	50.54	124.17	12.68	10.41	23.08	15.82	55.39	71.22
S2: 25 cm x 25 cm	69.95	46.84	116.8	11.62	9.92	21.54	15.1	52.57	67.67
S.E. ±	1.26	1.03	1.96	0.15	0.1	0.19	0.2	0.28	0.34
C.D. at 5%	N.S.	3.57	6.78	0.5	0.36	0.64	0.7	0.95	1.18
II) Sub plot treatments									
Nano-fertilizers spray (W)									
W0: No spray	55.69	34.58	90.26	9.73	7.95	17.67	10.6	39.1	49.7
W1: Spray of Nano-P	77.72	53.23	130.96	14.09	11.71	25.8	14.65	53.13	67.77
W2: Spray of Nano-K	67.98	41.45	109.44	11.64	9.63	21.26	18.52	61.05	79.57
W3: Spray of Nano-P + Nano-K	85.77	65.5	151.28	13.13	11.37	24.51	18.08	62.64	80.73
S.E. ±	1.17	1.08	1.46	0.22	0.18	0.31	0.21	0.32	0.41
C.D. at 5%	3.36	3.1	4.19	0.63	0.53	0.88	0.6	0.92	1.16
General Mean	71.79	48.69	120.48	12.15	10.16	22.31	15.46	53.98	69.44

Material and Method

The field experiment was conducted at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri during Kharif season of 2018. The was laid out in split plot design with replicated thricely. The treatments included three age of seedlings at transplanting *viz*., 10 days old seedlings (A_1), 20 days old seedlings (A_2), 30 days old seedlings (A_3) and two crop geometries 20 cm x 15 cm (S_1), 25 cm x 25 cm (S_2) in main plot and different nano-fertilizer sprays *viz*., no spray (W_0), spray of nano P (W_1), spray of nano K (W_2) and spray of nano P + nano K (W_3) in sub plots. Soil of the experimental field was sandy clay loam in texture, slightly acidic in reaction (pH 5.80) and high in organic carbon content. The values of available N, P_2O_5 and K_2O were 257.15, 29.90 and 251.17 kg ha^{-1} respectively. During the course of investigation, growth observations of rice were recorded periodically from 40 DAS till at the harvest at an interval of 30 days and yield contributing characters and yield were recorded at harvest to evaluate the treatment effects.

Result and Discussion

Effect of age of seedlings at transplanting

Transplanting of 10 days old seedlings was at par with transplanting of 20 days old seedlings and they were significantly superior than transplanting of 30 days old seedlings in case of grain and straw yield ha^{-1}. This might be due to early establishment of seedling and there is maximum duration available to the main field. These findings are in line with those reported by Singh and Singh (2009) [6]. Regarding the nitrogen, phosphorous and potassium content in the grain, transplanting of 20 days old seedlings recorded higher nitrogen content in the grain. In case of phosphorous content in the grain transplanting of 10 days old seedlings and transplanting of 20 days old seedlings were found to be at par with each other and significantly higher than 30 days old seedlings. Transplanting of 10 days old seedlings recorded significantly higher potassium content in the grain. Further, transplanting of 20 days old seedlings recorded significantly higher values

of nitrogen, phosphorous and potassium content in straw than the remaining treatments similar results was also reported by Barla *et al*. (2013) [7], Naidu *et al*. (2013) [8]. Transplanting of 20 days old seedlings significantly increased the uptake of nitrogen and phosphorous in the grain, straw as well as the total uptake by the rice. However, in case of potassium transplanting of 10- and 20-days old seedlings were at par and significantly superior over 30 days old seedlings in respect of uptake in the grain. On the other hand, transplanting of 20 days old seedlings recorded significantly more uptake of potassium in the straw as well as the total uptake by the crop than the remaining treatments Barla *et al*. (2013), Naidu *et al*. (2013), Chaudhari *et al*. (2015) [9] and Pawar (2017) [10] also reported that higher nitrogen, phosphorous and potassium uptake was recorded by early transplanting of rice seedlings than the late transplanted seedlings. Transplanting of 20 days old seedlings gave the highest cost of cultivation, gross returns, net returns and B:C ratio than rest of the treatments.

Effect of crop geometry

The 20 cm x 15 cm spacing produced significantly higher grain and straw yield than that of 25 cm x 25 cm spacing. Similar findings were recorded by the nitrogen, phosphorus and potassium content both in the grain as well as in the straw were not influenced significantly due to different levels of spacing. The spacing of 20 cm x 15 cm recorded significantly higher uptake of nitrogen uptake in the straw and total uptake by rice. Further, the 20 cm x 15 cm spacing recorded significantly higher uptake of phosphorous and potassium in the grain, straw and total uptake by rice than that of 25 cm x 25 cm spacing. Similar findings were recorded by Mahato *et al*. (2007) [11], Sampath *et al*. (2017) [12]. The 20 cm x 15 cm spacing gave the highest cost of cultivation, gross returns, net returns than 25 cm x 25 cm spacing. However, the 25 cm x 25 cm spacing gave higher value of B:C ratio than 20 cm x 15 cm spacing.

Effect of nano-fertilizer sprays

The higher yield attributes recorded under W3 (spray of nano-phosphorous + nano-potassium) has further resulted in higher grain and straw yield of the rice crop than the remaining treatments and it was followed by W_1 (spray of nano-phosphorous) which was also significantly superior over W_2 (spray of nano-potassium) and W0 (control). The higher yield in different crops due to use of nano-fertilizers was also reported by Sirisena *et al*. (2013) [13] and Eleyan *et al*. (2018) [14]. The spray of nano-phosphorous + nano-potassium recorded significantly higher nitrogen and potassium content in the grain and straw than rest of the treatments. Further, the spray of nano-phosphorous recorded significantly higher phosphorous content in the grain than rest of the treatments. On the other hand, spray of nano-phosphorous and spray of nano-phosphorous + nano-potassium were found to be at par with each other and significantly higher than rest of the treatments in case of phosphorous content in the straw.

The spray of nano-phosphorous + nano-potassium recorded significantly higher uptake of nitrogen in grain, straw and total uptake by rice. The spray of nano-phosphorous recorded significantly higher uptake of phosphorous in the grain and total uptake by the rice. Further, in case of uptake of phosphorous in the straw spray of nano-phosphorous and spray of nano-phosphorous + nano-potassium were found to be at par with each other and significantly higher than rest of the treatments. In case of uptake of potassium in the grain and total uptake by the rice, the spray of nano-phosphorous + nano-potassium was found to be at par with spray of nano-potassium and significantly higher than rest of the treatments. On the other hand, the spray of nano-phosphorous + nano-potassium recorded significantly higher uptake of potassium in the straw than rest of the treatments. Nano-formulations enhanced production levels of crops through foliar application of nano particles as fertilizer. The experiment conducted at arid environment at jodhpur revealed that the, the use of nanomaterial substantial reduces the fertilizer quantity, nanophosphors. In respect of the available nutrient's status in the soil after harvest of the crop, the control recorded significantly higher values of available nitrogen than rest of the treatments and spray of nano-phosphorous + nano-potassium recorded significantly lower values of available nitrogen. The higher values of available phosphorous in the soil after harvest of the crop was associated with the spray of nano-phosphorous, while control recorded the lowest value of available phosphorous. Further, the spray of nano-potassium recorded highest value of available potassium and control recorded significantly lower value of available potassium. Because of dynamic nature and properties, nanoparticles are having high surface area, high activity, better catalytic surface, rapid chemical reaction, rapidly dispersible and adsorb abundant water. It has shown that nanoparticles get into plant cells through either stomatal or vascular system [15]. It is evident that the stomatal pathway is highly capacitive because of its large size exclusion limit and its high transport velocity. The spray of nano-phosphorous + nano-potassium recorded highest cost of cultivation, gross returns, net returns and B:C ratio than rest of the treatments.

Conclusion

Considering the economics of treatment combinations, transplanting of 20 days old seedlings with 20 cm x 15 cm spacing and spray of nano-P + nano-K (A2S1W3) recorded higher cost of cultivation (₹ 86,402 ha^{-1}), gross returns (₹ 1,28,584 ha^{-1}) and net returns (₹ 42,183 ha^{-1}) than rest of the treatment combinations.

Application of research: The higher values of B:C ratio was recorded by transplanting of 20 days old seedlings with 25 cm x 25 cm spacing and spray of nano-P + nano-K ($A_2S_2W_3$) than rest of the treatment combinations.

Research Category: Agronomy

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Study area / Sample Collection: Agronomy Farm, College of Agriculture, Dapoli

Cultivar / Variety / Breed name: Rice (*Oryza sativa* L.)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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