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To find out the Suitable Source of Nutrient Management and Optimum Level of Nutrients for Maximum Rice Production

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ABSTRACT: A field experiment was planned out during Kharif season 2019, at the research farm of Soil Science and Agricultural Chemistry, College of Agriculture, JNKVV, Jabalpur (M.P.), India to find out the suitable source of nutrient management and optimum level of nutrients for maximum rice production. The experiment was laid out in a split plot design with three replications. The result indicated that the application of chemicals significantly increased the plant height over integrated source of nutrient and organics. Whereas application of chemicals and integrated sources of nutrients significantly increased the dry matter production at all growth stages, number of effective tillers plant^{-1}, number of panicles plant^{-1}, number of grain panicle^{-1}, panicle length, test weight, over organics. Application of 100, 150, 200% NPK and STV based NPK significantly increased plant height, number of effective tillers, number of panicles plant^{-1}, number of grains panicles^{-1}, panicle length, test weight, N, P and K over control. Application of 100, 150, 200% NPK and STV based NPK with chemicals and integrated sources of nutrients were found significantly superior to the same level of NPK over organics for plant height. While the application of 100, 150 and 200% NPK with chemicals and integrated sources of nutrients were found significant over organics at the same level of NPK dry matter production at 60 and 90 DAS. However, 100 and 150% NPK with chemicals was found significantly superior to integrated sources of nutrients for number of panicles.

Keywords: Chemical, Organic, INM, Rice, Yield attributing characters, Straw and grain yield.

INTRODUCTION

Rice (*Oryza sativa*) is one of the most important food crops of the world. Approximately 90% of the annual production is consumed in Asia because it is an excellent source of carbohydrate containing approximately 87% in grain, 7 to 8% protein, which has higher digestibility, biological value and more nutritious, possesses lower crude fiber and lower fat (1-2%). In India rice is grown in 43.30 M ha with annual production of 105.42 MT and productivity of 2412 kg ha^{-1}. In Madhya Pradesh, it is grown in an area of 2.29 M ha with production of 4.23 MT and productivity of 1847 kg ha^{-1} (Anonymous, 2018). The food grain requirement in India is gradually increasing every year and it may reach around 350 MT due to increasing population pressure expected to 1.8 billion up to 2050. Presently, the productivity of rice in Madhya Pradesh is lower than national average.

The productivity of the crop is low compared to the potential of this crop. One possible way to enhance crop productivity by chemical fertilization, no doubt it enhanced the crop productivity due to their function of directly feeding the crop, which is the result of their high or complete solubility in water. It is recognized that fertilizers must be used properly and in the correct form and amount to suit the needs of the soil and the crop. An unsuitable balance of nutrients may adversely affect the yield and composition of the crop (Ogg, 1953). Due to injudicious uses of chemical input in agricultural system detonated the soil deterioration, food, environmental and human health hazards, chemical fertilization also increasing their prices 21st century (Jat *et al*., 2015).

The most desirable way to meet the food grain requirements is maintenance of good soil health and stability in production through use of organic and biological resources (Kulshreshtha, 2018) and they are very cost effective. But the release of organically bound nutrients in soil through biological activity is not necessarily synchronized with crop demands and occurs even at times when there is no crop growth. Nutrient additions on organic forms are designed to maintain soil fertility, but not to directly feed plants (Kirchmann and Ryan 2004). Inorganic fertilizers are crucial to increase crop yield, they are generally not affordable by small-scale subsistence farmers of developing world. On the other hand, the soil-derived as well as the externally-supplied organic sources of nutrients will not be sufficient to achieve high yield. Organic and inorganic fertilizers have different functions in soil and complement with each other. While input of organic manures contributes to the build-up of soil organic matter, increases the cation exchange capacity, supports soil structure, helps to chelate micronutrients, increases soil moisture retention, etc., inorganic fertilizers supply crops with nutrients at times when their demand is large. Keeping the above aspects in view the study was conducted to "To find out the suitable source of nutrient management and optimum level of nutrients for maximum rice production".

MATERIAL AND METHODS

The experiment was conducted on rice during Kharif 2019 in the field of Research Farm, Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur which is situated in the South-Eastern part of M.P. at 23°10′ North latitude, 79°58′ East longitudes at an altitude of 393 meter above mean sea level. The experiment was laid out in split plot design with 3 replications, the main treatments were nutrient management, M_1 = Chemical, M_2 = Organic and M_3 = INM. The sub plot treatments were levels of NPK, S_1 = 0% NPK (Control), S_2= 100%NPK (120-60-40 NPK), S_3 = 150%NPK (180-90-60 NPK), S_4 = 200%NPK (240-120-80 NPK) and S_5 = STV based NPK (149-176-33 NPK). The climate of Jabalpur region is typically sub-humid, featured by hot dry summer and cool dry winter. The soil of the experimental field was Vertisol, belonged to Kheri series of the montmorillonitic hyperthermic family of Typic Haplusterts and popularly known as medium black soil. Rice variety Kranti was used as a test variety in this experiment. This variety was sown on 1 Aug 2019 and harvested at 23 Nov 2019. Five randomly selected plants were tagged in net plot area and growth and yield attributing parameters *i.e* plant height, numbers of tillers per plant, dry matter of plants at 40, 60, 90 DAS and at harvest, no. of panicle, no. of seeds per panicle, panicle length, test weight, grain and straw yield, harvest index were recorded.

Statistical analysis. The data pertaining to each character of the rice crop were tabulated variance for split plot design was worked out and significance of treatments were tested to draw valid conclusions as described by Gomez and Gomez (1984). In the split plot design the differences of treatments mean were tested by 'F' test of significance on the basis of null hypothesis. Critical Differences were calculated at 5% level of probability if 'F' test was significant the Standard error of mean (SEm) were calculated accordingly.

RESULT AND DISCUSSION

Plant height and dry matter accumulation. The data presented in (Table 1&2) revealed that application of chemicals significantly increased the plant height and dry matter production over integrated sources of nutrients at 40 and 60 DAS but the difference between the two treatment was found non-significant in plant height at 40, 90 DAS and at harvest and 90 DAS in dry matter production and the application of chemicals and integrated sources of nutrients significantly increased the dry matter production at all the growth stages over organics except at 40 DAS with integrated sources of nutrients at 40, 90 DAS and at harvest. The result have close conformity with the findings of Aruna and Mohhamad (2005); Barik *et al*. (2006); Krishna *et al*. (2008); Dutt and Chauhan (2010); Murthy (2012); Sarker *et al.* 2017).

Table 1: Effect of Chemical, Organic and INM under different fertility levels on plant height (cm) at different growth stages of rice.

Level of NPK	40 DAS				60 DAS				90 DAS				At harvest			
	Source of nutrients				Source of nutrients				Source of nutrients				Source of nutrients			
	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean
Control	37.53	35.09	37.20	36.61	50.93	47.93	49.60	49.49	60.03	54.80	59.53	58.12	56.60	52.87	57.67	55.71
100%NPK (120-60-40 NPK)	47.07	37.90	41.60	44.19	71.73	52.20	68.20	64.04	79.80	60.07	75.10	71.66	79.60	57.13	73.70	70.14
150%NPK (180-90-60 NPK)	51.10	42.30	50.31	47.90	76.20	59.07	72.93	69.40	83.15	77.73	80.80	80.56	85.60	65.03	81.70	77.44
200%NPK (240-120-80 NPK)	48.50	39.57	42.47	43.51	75.47	56.13	63.60	65.07	87.60	57.70	83.20	76.17	82.07	58.55	77.80	72.81
STV based on targeted yield	49.97	41.23	49.73	46.98	76.20	54.33	72.33	67.62	82.10	67.55	82.87	77.51	83.03	61.80	79.33	74.72
Mean	46.83	39.22	44.26	43.44	70.11	53.93	65.33	63.12	78.54	63.57	76.30	72.80	77.38	59.08	74.04	70.17
Sem± (main plot)	1.208				1.133				1.032				0.879			
CD(p=0.05)	4.750				4.454				4.057				3.457			
Sem±(Sub plot)	0.652				1.174				1.013				0.963			
CD(p=0.05)	1.903				3.426				2.956				2.812			
Interaction (MXS) Between two S at same M																
Sem +	1.129				2.033				1.754				1.668			
CD(p=0.05)	3.295				5.934				5.119				4.870			
Between two M at same S																
Sem +	2.619				2.905				2.592				2.306			
CD (p=0.05)	7.644				6.480				7.567				6.732			

Table 2: Effect of Chemical, Organic and INM under different fertility levels on dry matter per plant at different growth stages of rice.

Level of NPK	40 DAS				60 DAS				90 DAS			
	Source of nutrients				Source of nutrients				Source of nutrients			
	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean
Control	0.98	0.81	1.16	0.98	2.22	1.92	2.97	2.37	7.75	7.03	8.13	7.64
100%NPK (120-60-40 NPK)	2.25	1.77	1.48	1.84	5.27	2.94	4.21	4.14	22.44	9.29	18.29	16.67
150%NPK (180-90-60 NPK)	2.91	2.28	2.71	2.63	8.04	3.92	5.50	5.82	24.47	19.32	24.30	22.70
200%NPK (240-120-80 NPK)	2.47	1.78	1.85	2.04	7.22	3.28	3.88	4.79	26.26	9.13	24.81	20.07
STV based on targeted yield	2.58	2.34	2.36	2.43	7.67	3.30	4.92	5.30	22.62	22.84	21.54	22.34
Mean	2.24	1.80	1.91	1.98	6.08	3.07	4.29	4.48	20.71	13.52	19.41	17.88
Sem± (main plot)	0.094				0.181				0.790			
CD(p=0.05)	NS				0.712				3.105			
Sem ±(Sub plot)	0.079				0.195				0.387			
CD(p=0.05)	0.231				0.569				1.130			
Interaction (MXS)												
Between two S at same M												
Sem ±	0.137				0.338				0.670			
CD(p=0.05)	0.399				0.986				1.957			
Between two M at same S												
Sem ±	0.224				0.472				0.676			
CD (p=0.05)	0.653				1.377				1.973			

The application of 100, 150, 200% NPK and soil test value (STV) based NPK significantly increased the plant height over control at all the growth stages of rice. The application of 150% NPK level and STV based NPK levels were found significant over 100% NPK at all growth stages and the application of 150 % NPK was also found significantly superior to 200% NPK at all growth stages in plant height but in dry matter it was found at par at 60 DAS. Similar findings were reported Dutt and Chauhan (2010); Murthy (2012).

In interaction, the increasing levels of NPK and STV based NPK levels with all the sources were found significant over control at all the growth stages except @ 100% NPK with organics at 40 and 60 DAS. However, the 150% NPK with all the sources of nutrients were found significant over 100% NPK at 90 DAS and at harvest except 150% NPK with chemicals 90 DAS. Similarly, 150% NPK with organics was also found significant over 200% NPK at 90 DAS and at harvest. The application of 100, 150, 200% NPK and STV based NPK level with chemicals and integrated sources of nutrients were found significant over the same level of NPK with organics at all growth stages except at 100 and 200% NPK with integrated sources of nutrients at 40 DAS and 150% NPK with chemicals and integrated sources of nutrients at 90 DAS in plant height and in dry matter the application of 100, 150 and 200% NPK with chemicals and integrated sources of nutrients were found significant over organics at the same level of NPK at 60 and 90 DAS except 100 and 200% NPK with integrated source at 60 DAS. The STV based NPK was also found significant over organics at the same level of NPK at 60 DAS. The increased the plant height with 150%NPK with chemicals also reported by Meena *et al.* (2003); Awan *et al.* (2011); Singh and Kumar (2014).

Yield attributing characters. The data presented in Table 3&4 showed that the number of effective tillers, number of panicles per plant, panicle length and test weight of rice grain increased with increasing levels of NPK up to 150% NPK then decreased at 200% NPK. The application of 100, 150, 200% NPK and STV based NPK significantly increased the number of effective tillers, number of panicles plant^{-1}, panicle length and test weight of rice grain over control.

Table 3: Effect of Chemical, Organic and INM under different fertility levels on no. of effective tillers at different growth stages of rice.

Level of NPK	40 DAS				60 DAS				90 DAS			
	Source of nutrients				Source of nutrients				Source of nutrients			
	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean
Control	2.13	2.07	1.70	1.97	2.23	1.83	2.17	2.08	3.17	3.30	3.17	3.12
100%NPK (120-60-40 NPK)	2.80	2.30	2.00	2.37	2.30	2.27	2.60	2.39	3.70	3.00	4.30	3.67
150%NPK (180-90-60 NPK)	3.00	2.53	2.67	2.73	3.80	3.30	3.67	3.39	5.30	3.23	5.17	4.57
200%NPK (240-120-80 NPK)	3.20	2.20	2.40	2.60	3.43	2.33	3.03	2.93	4.90	3.23	4.20	4.11
STV based on targeted yield	3.00	2.30	2.80	2.70	3.50	2.77	3.53	3.27	4.30	3.63	4.37	4.10
Mean	2.83	2.28	2.31	2.47	3.05	2.50	3.00	2.85	4.27	3.23	4.24	3.91
Sem± (main plot)	0.130				0.076				0.150			
CD(p=0.05)	NS				0.299				0.591			
Sem ±(Sub plot)	0.155				0.073				0.129			
CD(p=0.05)	0.452				0.212				0.376			
Interaction (MXS)												
Between two S at same M												
Sem±	0.268				0.126				0.223			
CD(p=0.05)	NS				0.367				0.651			
Between two M at same S												
Sem ±	0.354				0.187				0.610			
CD (p=0.05)	NS				0.552				1.053			

Table 4: Effect of Chemical, Organic and INM under different fertility levels on yield attributing characters of rice.

Level of NPK	No. of panicle per plant				No. of grain per panicle				Panicle length (cm)				Test weight (g)			
	Source of nutrients				Source of nutrients				Source of nutrients				Source of nutrients			
	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean
Control	1.30	1.20	1.13	1.21	124.67	106.00	116.33	115.67	15.48	14.91	16.83	15.74	19.52	18.56	20.08	19.39
100% NPK 60-40 NPK)	2.40	1.20	1.60	1.73	138.00	111.67	133.67	127.78	20.32	15.95	19.08	18.45	21.64	19.20	20.41	20.41
150% NPK 90-60 NPK)	3.50	1.40	2.60	2.50	184.00	150.67	180.00	171.56	20.63	19.15	21.28	20.35	24.63	21.85	23.86	23.45
200% NPK 120-80 NPK)	2.67	1.70	2.27	2.21	152.33	120.33	153.00	141.89	20.22	16.04	18.67	18.31	23.44	19.58	21.97	21.66
STV based targeted yield	2.67	1.80	2.47	2.31	167.67	132.67	164.00	154.78	19.81	19.40	19.65	19.62	23.82	20.04	22.97	22.28
Mean	2.51	1.46	2.01	1.99	153.33	124.27	149.40	142.33	19.29	17.09	19.10	18.49	22.61	19.85	21.86	21.44
Sem± (main plot)	0.067				5.020				0.364				0.227			
CD(p=0.05)	0.263				19.738				1.431				0.893			
Sem± (Sub plot)	0.077				6.107				0.356				0.223			
CD(p=0.05)	0.226				17.825				1.040				0.652			
Interaction (MXS)																
Between two S at same M																
Sem±	0.134				10.577				0.617				0.387			
CD(p=0.05)	0.391				NS				1.802				1.129			
Between two M at same S																
Sem±	0.180				13.796				0.913				0.571			
CD (p=0.05)	0.525				NS				2.666				1.667			

However, the application of 150% NPK and STV based NPK level were found significantly superior to 100% NPK for number of tillers per plant, number of panicles per plant, panicle length but the difference between the two treatment was found non-significant for number of panicles and panicle length. While the 150% was found significantly superior to 100 and 200% NPK and STV based NPK level for test weight of rice. The increase of number of tillers with increasing levels of nutrients also supported by Krishna *et al*. (2008); Dutt and Chauhan (2010); Murthy (2012). The increase of number of panicles with supply of NPK was also confirmed by Singh *et al*. (2013); Imade *et al*. (2017). Similarly, the application of NPK increased the panicle length was also reported by Hasanuzzaman *et al*. (2010); Awan *et al*. (2011); Alim (2012); Ramalakshmi *et al*. (2012). Arif *et al*. (2014); Tiwari *et al*. (2017).

In the interaction, the application of 150% NPK with integrated sources was found significant over 100 and 200% NPK for panicle length and test weight of rice. The application of 100 and 200% NPK with chemicals and 100%NPK with integrated sources of nutrients were found significantly superior to organics at the same level of NPK for panicle length. might be due to higher level of NPK increased the availability of NPK nutrients as the fertilizer nutrients are readily available to plants which increased the yield components of rice. The increase of number of tillers with NPK level was confirmed by Dash *et al*. (2011). The increase of number of panicles with NPK levels was supported by Singh and Agarwal (2001); Mirza *et al*. (2010). The increase of test weight with NPK level were reported by Ramalakshmi *et al*. (2012); Arif *et al.* (2014).

Grain and Straw yield. The data presented in Table 5 indicated that the maximum grain yield (3760 kg ha^{-1}) and straw yield (5681 kg ha^{-1}) were observed with the application of chemicals followed by integrated sources of nutrients (grain 3514 kg ha^{-1} and straw 4876 kg ha^{-1}) and organics (grain 2637 kg ha^{-1} and straw 4029 kg ha^{-1}). The application of chemicals and integrated sources of nutrients significantly increased the grain yield over organics but the sources were found at par. The results are in agreement with the finding of Sowmya *et al*. (2011); Singh *et al*. (2011); Majumdar *et al*. (2007); Tiwari *et al*. (2017).

The grain and straw yield increased with increasing levels of NPK up to 150% NPK (grain 3954 kg ha^{-1} and straw 5921kg ha^{-1}) then decreased at 200% NPK (grain 3405 kg ha^{-1} and straw 5119 kg ha^{-1}). The application of 100,150,200% NPK and STV based NPK level significantly increased the grain and straw yield over control but the treatments were found at par amongst themselves. Similar results reported by Yadav and Meena, (2014) and Baishya *et al*. (2015).

In the interaction application of 100, 150, 200 % NPK and STV based NPK levels with chemicals and integrated sources of nutrients were found significant over the same level of NPK with organics for grain yield except 100% NPK and 200% NPK with integrated sources of nutrients. The maximum grain yield of 4479 kg ha^{-1} and straw yield of 6929 kg ha^{-1} were observed with 150% NPK with chemicals respectively might be due to the continuous supply of nutrients in balanced amount throughout the growth period augmented production of sufficient photosynthates and their effective translocation from source to sink resulted in higher grain and straw yield. While the 200 % NPK level produced the excessive growth of rice plant resulted the highest straw yield. Similar, findings were reported by Sowmya *et al.* (2011); Sepehya *et al.* (2012); Singh *et al*. (2014); Shrivatava *et al*. (2013); Nanda *et al*. (2016); Tiwari *et al*. (2017).

Harvest Index. The data presented in Table 5 showed that the maximum harvest index (42.1%) was observed with the application of integrated followed by chemical sources of nutrients (40.36%) and organics (39.51%)

but the sources were found non-significant also reported by Kandel *et al*. (2018). The interaction between sources of nutrients and levels of NPK were found non-significant for harvest index of rice. The maximum harvest index of 43.73% was observed with control.

Available N, P and K. The data presented in table 6 indicated that the maximum available Nitrogen (219 kg ha^{-1}), phosphorous (13.01kg ha^{-1}) were observed with the application of chemicals followed by integrated and organics. While, the maximum available potassium (251kg ha^{-1}) was observed with the application of integrated sources of nutrients followed by chemicals (247kg ha^{-1}) and organics (237kg ha^{-1}) but the sources of nutrients were found non- significant for available N and K. The application of chemicals and integrated sources of nutrients significantly increased postharvest available P over organics but the sources of nutrients were found at par (Gupta *et al*. 2006).

Table 5: Effect of Chemical, Organic and INM under different fertility levels on Grain and Straw Yield and HI.

Level of NPK	Grain Yield (kg ha^{-1})				Straw Yield (kg ha^{-1})				Harvest Index (%)			
	Source of nutrients				Source of nutrients				Source of nutrients			
	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean
Control	2330	2101	2109	2180	2952	3286	2833	3024	43.73	38.61	42.80	41.71
100%NPK (120-60-40 NPK)	3745	2458	3393	3199	6000	3762	5071	4944	39.12	39.14	40.23	39.50
150%NPK (180-90-60 NPK)	4479	3041	4341	3954	6929	4905	5929	5921	39.21	39.01	42.30	40.18
200%NPK (240-120-80 NPK)	4071	2560	3584	3405	6095	4048	5214	5119	40.38	38.56	41.47	40.14
STV based on targeted yield	4174	3027	4143	3781	6429	4143	5333	5302	39.37	42.22	43.71	41.77
Mean	3760	2637	3514	3304	5681	4029	4876	4862	40.36	39.51	42.10	40.66
Sem± (main plot)	187				310				1.614			
CD(p=0.05)	733				1217				NS			
Sem± (Sub plot)	111				255				1.355			
CD(p=0.05)	324				746				NS			
Interaction (MXS)												
Between two S at same M												
Sem±	192				442				2.347			
CD(p=0.05)	561				NS				NS			
Between two M at same S												
Sem±	411				735				3.851			
CD (p=0.05)	1199				NS				NS			

Table 6: Effect of Chemical, Organic and INM under different fertility levels on available N, P and K in soil.

Level of NPK	N (kg ha^{-1})				P (kg ha^{-1})				K (kg ha^{-1})			
	Source of nutrients				Source of nutrients				Source of nutrients			
	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean	Chemical	Organic	INM	Mean
Control	142.17	121.26	158.89	140.77	9.90	8.57	9.75	9.41	218.00	186.00	206.67	203.56
100%NPK (120-60-40 NPK)	204.89	163.07	188.16	185.37	10.92	9.53	11.25	10.57	226.00	217.30	257.00	233.44
150%NPK (180-90-60 NPK)	275.97	221.61	267.61	255.06	16.31	14.30	15.35	15.32	263.33	300.00	280.00	281.11
200%NPK (240-120-80 NPK)	221.61	188.16	217.43	209.07	12.89	10.13	11.25	11.42	267.67	231.30	239.33	246.11
STV based on targeted yield	250.88	209.07	229.97	229.97	15.03	12.37	13.26	13.55	258.33	250.00	272.00	260.11
Mean	219.10	180.63	212.41	204.05	13.01	10.98	12.17	12.05	246.67	236.90	251.00	244.87
Sem± (main plot)	6.585				0.278				6.940			
CD(p=0.05)	25.888				1.091				NS			
Sem± (Sub plot)	9.717				0.206				5.472			
CD(p=0.05)	28.362				0.600				15.972			
Interaction (MXS)												
Between two S at same M												
Sem±	16.830				0.356				9.478			
CD(p=0.05)	NS				NS				27.665			
Between two M at same S												
Sem±	20.001				0.640				16.268			
CD (p=0.05)	NS				NS				47.485			

The application of 150% NPK was found significant over 100, 200% NPK and STV based NPK level for available N, P and K. Though the STV based NPK level was also found significant over 100 and 200% NPK for available N, P and K except available K with 200% NPK. Similar findings were also reported by Sepehya *et al*. (2012); Tiwari *et al*. (2017).

In interaction, the application of 150% NPK with chemicals and organics were found significant over 100% NPK. The application of 150% NPK with organics was found significant over 200% NPK and STV based NPK level. While the 150% NPK with integrated sources of nutrients was found significant over 200% NPK. Similar result reported by Sharma and Subehia, (2014).

CONCLUSION

The findings revealed that among the sources, the chemical source of nutrient found the best for maximum yield of rice. Among the levels of NPK, the application of 150% NPK was found best with respect to growth and yield attributing characters & yield of rice. The finding suggested that further research needed is take up more research on improving efficiency and minimizing losses of nutrients in rice.

FUTURE SCOPE

(i) This method can also be used for different crops to improve their production and to find out their optimum level of nutrients.

(ii) Different variation of NPK can also be applied for the same method other than these five levels of NPK.

(iii) The application of other fertilizer can also be implemented to see changes in rice production.

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