International Journal of Plant & Soil Science

Volume 36, Issue 3, Page 277-282, 2024; Article no.IJPSS.113019
ISSN: 2320-7035

Effect of Continuous Application of Nitrogen, Phosphorus and Potassium on Growth Parameters and Yield of Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2024/v36i34424

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/113019

Original Research Article

Received: 06/12/2023
Accepted: 13/02/2024
Published: 13/02/2024

ABSTRACT

A Long term (37 years) field experiment was conducted at Agronomical Research farm of Birsa Agricultural University, Kanke, Ranchi during Kharif season in 2020 to study the effect of Nitrogen, phosphorus and potassium on growth parameter and yield of rice. The experiment was conducted in Partially Confounded Design with nineteen treatments replicated four times. The rice variety used was Sahabhagi Dhan. Nitrogen, Phosphorus and potassium level used were 40, 80 and 120 kg N

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ha^{-1}, 0, 40 and 80 kg P_2O_5 ha^{-1} and 0 and 40 kg K_2O ha^{-1}.Application of 120 kg N ha^{-1}, 80 kg P kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} significantly increased plant height, produced maximum numbers of tillers, dry matter and leaf area index at 30, 60, 90 DAS and at harvest. The maximum grain and straw yield was recorded under with application of 120 kg N ha^{-1}, 80 kg P kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}.

Keywords: Growth parameters; yield; kharif season; soil fertility; crop growth; nitrogen level; rice consumption.

1. INTRODUCTION

"The success of Indian agriculture has received worldwide appreciation as food grain production increased from 50.8 million tons (mt) in 1950-51 to 182.57 mt in 2002-03, and this total food grain production comprised of 66.51 mt of rice, 69.32 mt of wheat, 26.22 mt of coarse cereals, and 11.31 mt of pulses" [1]. In India, rice plays a major role in diet, economy, employment, culture and history.It is the staple food for more than 65% of Indian population contributing approximately 40% to the total food grain production, thereby, occupying a pivotal role in the food and livelihood security of people. The country has the world's largest area under rice i.e., about 43 million hectare (Mha) and the second highest production i.e., about 110 Mt of milled rice at productivity of 2.56 t ha-1 as per 2016-17 statistics. Global demand of rice needs to increase from the current 493 Mt to about 550 Mt in 2030 However, rice farming, particularly in the rainfed regions, faces multiple risks from uncertain climate, degraded soil, water shortage and underdeveloped markets. Introduction of high yielding varieties, irrigation and high analysis fertilizer accelerated the mining of nutrient other than supplied eternally from soil. To sustain the productivity it was essential to maintain the supply of nutrient. Since large amount of nutrient has to be applied to soil in chemical form which may have impact on soil properties and soil productivity in long term. The concept of balanced fertilization cannot be confined to N, P and K alone. Balanced fertilization includes application of all the plant nutrients essential for high agriculturalproductivity and health of the soil. Therefore, a paradigm shift is required for enhancing the rice productivity and sustainability. Hence the study focuses on the effect of continuous application of fertilizer on growth parameter and yield of rice.

2. MATERIALS AND METHODS

A long term (37 year) field experiment was conducted at Agronomical Research farm of Birsa Agricultural University, Kanke, Ranchi during Kharif season in 2020. The experimental plot was a medium land having well drained soil and uniform topography. The soil was sandy loam in texture with bulk density 1.54 Mgm^{-3} and good water retention (FC 21.5 % and PWP 11.36 %) and water holding capacity (38.7%) was also observed in soil. Soil reaction was acidic in nature with low available N and P, medium in available K. The experiment was conducted in Partially Confounded Design with nineteen treatments replicated four times. The rice variety used was Sahabhagi Dhan. Nitrogen, Phosphorus and Potassium level used were 40, 80 and 120 kg N ha^{-1}, 0, 40 and 80 kg P_2O_5 ha^{-1} and 0 and 40 kg K_2O ha^{-1} respectively. The inorganic source of Nitrogen (N), Phosphorus (P) and Potassium (K) were applied through urea , Diammonium phosphate and muriate of potash as per treatment.The full dose of P and K along with one third of N were applied at the time of sowing and remaining N in 2 equal splits top dressed as per treatment at 30 and 60 DAS. The data on growth parameter were recorded at 30, 60, 90 DAS and at harvest.

3. RESULTS AND DISCUSSION

3.1 Effecton Growth Parameter

In general optimum supply of N, P and K contributed to the plant growth and development. The study of data (Tables 1 and 2) revealed that plant height,number of tillers and dry matter accumulation of rice differed markedly in different fertilizer doses at all growth stages of rice. The data shows consistent increase in plant heightnumber of tillers and dry matter accumulation with advancement of crop growth stages. It is also evident from the data that more than 50% height of rice and Number of tillers was attained by 60 DAS in all treatments.

The maximum plant height, number of tillers and dry matter accumulation was recorded in crop fertilized with 120 kg of N ha^{-1} at 30 DAS , 60 DAS, 90 DAS and at harvest. The lowest plant height number of tillers, leaf area index and dry matter accumulation is recorded in Control(no fertilizer) at all growth stages.The application of 120 kg of N increased plant height by 32.15% , 51.90% , 54.75% and 39.42 % at 30 DAS, 60 DAS, 90 DAS and at Harvest respectively over control.Similarly, application of 120 kg N ha^{-1} increase tillers by 21.5%. 20.92%, 63.34% and at 30 DAS, 60 DAS, 90 DAS and at harvest compared to control. [2 and 3] recorded similar result. N Application of 120 kg N ha-1 produced maximum dry matter over other fertility level and was 89.23%, 115.33%, 125.21% and 138.62% higher over control at 30,60,90 and harvest respectively. [4 and 5] recorded similar findings for dry matter accumulation. However fertility level of 120 kg N ha^{-1} remained at par with fertility level of 80 kg N ha^{-1} for plant height and number of tillers at all growth stages. However [6] found that application of high nitrogen levels up to 160 kg N ha^{-1} significantly produced higher growth parameters. The enhancement of the rice plant due the application of N is apparent as N is major nutrient element in plant since it is an essential constituent of cell, plays a vital role in cell division and elongation by virtue of being essential element for metabolically compound like amino acid, purines and pyramidine nucleotides and chlorophyll present in major portion of plant body. The optimal level of N favors greater absorbtion of nutrients resulting in rapid expansion of foliage better accumulation of photosynthates and eventually resulting increased growth structure. There greater availability of nitrogen might have enhanced protein synthesis leading thus to rapid cell division and cell elongation which ultimately resulted into vigorous plant growth.

In case of phosphorus (Tables 1 and 2), perusal of data revealed that application of 80 kg P_2O_5ha^{-1}recorded maximum plant height, number of tillers, leaf area index and dry matter accumulation compared to other levels of phosphorus and control at all crop growth stages.The application of 80 kg of P_2O_5 ha^{-1} increased plant height by 35.51% (30DAS), 61.36%(60 DAS), 68.65%(90 DAS) and 47.73%(at harvest) as compared to control. [7] recorded similar findings. It may be due to phosphorous is a major constituents of ADP and ATP, which is the source of energy that drives the multitude of chemical reactions within the plants,plays fundamental role in virtually every plant process that involves energy transfer. Furthermore, as an intergral part of chromosome, it stimulates cell division and meristematic growth of plant.

Table 1. Effect of continuous application of nitrogen, phosphorus and potassium on plant height and tillers of rice

Fertilizer level	Plant height (cm)				Tillers (m^{-2})			
	30	60	90	Harvest	30	60	90	Harvest
N_{40}	14.47	69.38	81.70	92.19	64.13	319.17	283.38	236.46
N_{80}	15.07	74.06	91.25	102.29	67.46	336.50	299.38	253.96
N_{120}	15.33	77.06	93.55	103.52	69.00	341.00	304.63	258.33
SEm±	0.30	1.48	1.88	1.86	1.41	7.11	6.13	4.50
CD at 5%	0.84	4.19	5.33	5.27	4.00	20.18	17.40	12.77
P level								
P_0	13.68	62.64	71.00	83.91	59.67	293.00	244.75	219.58
P_{40}	15.48	76.00	93.55	104.39	69.92	341.17	311.13	257.50
P_{80}	15.72	81.86	101.95	109.69	71.00	362.50	331.50	271.67
SEm±	0.30	1.48	1.88	1.86	1.41	7.11	6.13	4.50
CD at 5%	0.84	4.19	5.33	5.27	4.00	20.18	17.40	12.77
K Level								
K_0	14.75	71.63	84.97	96.82	66.08	323.44	285.39	242.22
K_{40}	15.16	75.37	92.70	101.84	67.64	341.00	306.19	256.94
SEm±	0.24	1.21	1.54	1.52	1.15	5.81	5.01	3.68
CD at 5%	0.69	3.42	4.36	4.30	3.26	16.48	14.21	10.43
Control	11.60	50.73	60.45	74.25	56.58	282.00	186.50	150.42
CV%	10.06	10.30	10.87	9.50	10.56	10.72	10.72	9.37

Table 2. Effect of continuous application of nitrogen, phosphorus and potassium dry matter accumulation, LAI and yield of rice

Fertlizer level	Dry matter accumulation ($g\ m^{-2}$)				Leaf area index			Grain yield ($q\ ha^{-1}$)	Straw yield ($q\ ha^{-1}$)
	30	60	90	harvest	30	60	90		
N Level									
N_{40}	45.35	170.51	470.94	622.42	0.60	2.44	2.76	21.75	33.99
N_{80}	47.02	178.25	495.92	667.01	0.65	2.61	2.92	25.79	39.73
N_{120}	47.97	184.41	519.58	709.02	0.68	2.75	3.12	27.01	41.42
SEm±	0.96	2.98	9.84	13.16	0.01	0.05	0.06	0.44	0.77
CD at 5%	2.73	8.47	27.93	37.35	0.04	0.15	0.16	1.26	2.18
P Level									
P_0	39.94	145.04	391.03	486.73	0.47	2.05	2.20	16.23	26.55
P_{40}	48.12	185.20	517.50	707.45	0.71	2.67	3.12	26.83	40.86
P_{80}	52.29	202.93	577.91	804.27	0.74	3.08	3.48	31.48	47.74
SEm±	0.96	2.98	9.84	13.16	0.01	0.05	0.06	0.44	0.77
CD at 5%	2.73	8.47	27.93	37.35	0.04	0.15	0.16	1.26	2.18
K Level									
K_0	45.81	172.33	476.66	637.22	0.62	2.51	2.88	23.85	37.18
K_{40}	47.76	183.11	514.30	695.08	0.66	2.68	2.99	25.84	39.58
SEm±	0.78	2.44	8.04	10.75	0.01	0.04	0.05	0.36	0.63
CD at 5%	2.23	6.91	20.80	30.49	0.03	0.12	NS	1.03	1.78
Control	25.35	85.64	230.70	297.13	0.40	1.82	1.90	13.71	22.90
CV%	10.88	8.78	10.16	10.26	10.94	10.24	9.93	9.34	10.39

The critical study on potassium (Tables 1and 2) revealed that the application of 40 kg K_2O ha^{-1} gave maximum plant height, number of tillers, dry matter accumulation and Leaf area index. Fertility level of 40 kg K_2O ha^{-1} increased dry matter accumulation by 88.40%, 113.81%, 112.93% and 133.93% over fertility level of 0 kg K_2O ha^{-1} at different growth stages. As potassium is involved in many regulatory roles in plant growth and development such as activation of enzymes, protein and starch synthesis, regulates photosynthesis via help in stomatal opening , membrane permeability and pH control , water and nutrient transport and improving stress tolerance and enhancing crop quality [8,9] recorded similar result with application of 40kg K_2O ha^{-1} [10] experimentation indicated that 80 kg K_2O ha^{-1} significantly increased growth parameters but remained statistically at par with 40 kg K_2O ha^{-1}.

3.2 Effect on Grain and Straw Yield

The data of grain and straw yield (Table 2) revealed that application of full dose of nutrients nitrogen i.e., 120 kg N ha^{-1}provided maximum grain and straw yield. “Application of 120 kg N ha^{-1} increased grain and straw yield over imbalance and control, however remained at par with application of 80 kg N ha^{-1}. The increase in grain yield at higher nitrogen rates might be primarily due to increase in chlorophyll concentration in leaves leading to higher photosynthetic rate and might be due to the cumulative effect of increased translocation of photosynthates to sink resulting in the increase in yield compared to lower levels” [11,12,13] recorded similar findings [14] reported that “increased nitrogen levels significantly increased rice grain and straw yield”.

“Application Phosphorous at the rate 80 kg ha^{-1} produced maximum grain and straw yield i.e., 31.48 q ha^{-1} and 47.74 q ha^{-1} respectively. Phosphorous level of 80 kg ha^{-1} increase grain yield by 93.96% and straw yield by79.81% over application of 0 kg P_2O_5 ha^{-1}. The phosphorus fertilization improves various metabolic and physiological process in life cycle of plant. The higher yields associated at increased levels of phosphorus are due to better root growth and increased uptake of nutrients favoring better crop growth” [15].

“Application of potassium exerted a positive influence on yield. Application of 40 kg K_2O ha^{-1} recorded maximum grain and straw yield which was 8.34 % and 6.45% more over 0 kg ha^{-1} application of P_2O_5” [16,17] also registered “26.97% more grain yield with application of 30 kg K_2O ha^{-1} compared to control”. “Grain acts as physiological sink and the strength of this sink depends on the number of endosperm cells.Potassium application has a beneficial influence on thedevelopment of endosperm cells and on the grain weight of cereals" [18]. Optimum supply of potassium aid in supply of photosynthate to the developing sink.

4. CONCLUSION

Therefore, taking the findings of the present study into consideration, it may be concluded that Application of 120 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}resulted in maximum plant height, number of tillers, dry matter accumulation and leaf area index at all growth stages. Fertility level of 120 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} produced highest grain and straw yield ha^{-1}. This study indicated that application of 120 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} contributed towards better vegetative growth and yield mainly due to higher absorption of nutrients which increased phostosynthates accumulation and high biomass production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/113019