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Effect of long term balance fertilizer application on growth parameters of rice (*Oryza sativa* L.)

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Abstract
The present study "Effect of long term balance fertilizer application on growth parameters of rice (*Oryza sativa* L.)" was conducted at A2 block of N. E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) during *kharif* 2017. These treatments were a part of long-term fertility experiment since 1984. Nine treatments out of fourteen consisting different combination of N, P, K, Znf and FYM were tested in a Randomized Block Design with four replications. The variety sown was HKR47. It was noticed that compared to recommended dose of fertilizer ($N_{120}P_{40}K_{40}$ +Znf), plant height, shoots /m^2 and dry matter accumulation were significantly higher in all the inorganic treatments while addition of farm yard manure further increased the all the growth parameters significantly over all the other treatments. The highest values of plant height, shoots m^{-2}and plant dry matter accumulation were recorded with $N_{120}P_{40}K_{40}$+Znf+FYMr treatment which was followed by $N_{120}P_{40}K_{40}$ +FYMr treatment, both being at par with each other. The better growth and development in FYM added plots was due to an adequate supply of nutrients and improvement in soil physical and biological conditions of soil. Chemical fertilizer treatment of $N_{120}K_{40}$, $P_{40}K_{40}$, $N_{120}P_{40}$ and N_{120} alone resulted in poor growth, reduced plant height, shoot number and plant dry matter accumulation of crop. However, the lowest values of these characters were obtained with unfertilized control plot. The reduced growth due to the imbalanced application of nutrients was due to depletion of other nutrients, especially P. The experiment thus suggests the importance of balanced nutrition in proper growth and development of rice.

Keywords: HKR 47, Znf, FYMr, long-term fertility experiment, balanced nutrition

Introduction

The study of soil fertility and crop productivity under long-term cropping has long been the subject of immense importance. There are indications of declining productivity due to depletion in soil organic matter, over mining of nutrients reserves and losses of nutrients as clearly evolved through long-term fertilizer experiments being conducted in different parts of the country. Sustainable high yields of crops can support food security of the rapidly growing population (Palm *et al.*, 2014) [4]. Management of rice production is the keystone for sustainability and productivity of rice-wheat cropping system as rice (*Oryza sativa* L.) is a staple food for billions of people around the world. Rice consumption is increasing and demand for rice will outstrip supply if production does not increase faster than its current rate. This means there is a need to produce even more rice for food security. Improved fertility status of soil health and could support sustainable crop production. Long-term fertility experiments have significantly contributed to our understanding of soil fertility management and sustainable crop production in different agro ecosystems (Rawal *et al.*, 2017) [6]. The general recommendation of NPK fertilizers resulted in soil fatigue, proving their diseased efficiency and thus requires upward refinement and a proper balance among the macro and micronutrient (Yadav and Kumar, 2009) [8].

Balanced nutrition plays a very important role in growth of rice. Variable response to Nitrogen had observed at various places. Response to Nitrogen was considerable in light alluvial soil (Ludhiana) and in Foothill (Pantnagar) soil (Nambiar and Abrol, 1989) [2]. Phosphorus is important for root development, tillering, early flowering and ripening. It is mobile within the plant, but not in the soil. However, crop yield was improved considerably with the application of Phosphorus fertilizer which was further improved with the balanced use of N, P and K fertilizer in almost all the locations. Maujumdar *et al.* (2013) [1] reported that Phosphorus is too essential to all form of life and important for its contribution toward aiding the native soil fertility and sustaining it, especially under intensive agriculture. Potassium (K) is an essential element that improves root growth and plant vigor helps prevent lodging and enhance crop resistance to pest and disease. Singh, 1995 [7] reported that the response of K was not observed after 10 years of continuous rice-wheat cropping the response of K was observed after 18 years of continuous rice-wheat cropping. Apart from these primary nutrients, zinc is also considered as important for better growth and high productivity of rice. Zn is a required for several biochemical processes in the rice plant, including chlorophyll production and membrane integrity. Thus, Zn deficiencies affect plant color and turgor. Zinc is only slightly mobile in the plant and quite immobile in soil. Since most of the rice is taken as transplanted crop and water inundation is required the crop suffers due to deficiency of zinc because zinc uptake is adversely affected. In India, zinc deficiency was first reports by Nene (1966) [3] on paddy field. Zinc deficiency was identified as khaira disease in India, Akagare type II in Japan (Yoshida and Tanaka 1969) [10], Taya-Taya and Apulapaya in Philippines (Yoshida *et al*., 1973) [9]. This warrants proper zinc supply to the rice crop.

Under intensive cropping system, high use of fertilizer can cause a deficiency of primary, secondary and micronutrients which have a negative effect on rice growth. Presently farmer is using only NPK, that too in imbalance ratio and there is no attention paid for secondary and micronutrients. Long-term fertility experiments, however, are a good indicator for monitoring soil quality and crop growth and are of vital importance in nutrient management as well as soil health also (Paul *et al.*, 2013) [5]. The present study was thus carried out to reinvestigate the effect of long term balance fertilizer application on growth parameters of rice.

Material and methods

In *Kharif*, 1984, the long-term fertility experiment on rice-wheat cropping system was initiated under the flagship of International Network on Soil Fertility and Fertilizer Evaluation for Rice (INSFER) programme of Indian Council of Agricultural Research (ICAR) and International Rice Research Institute (IRRI) and the same rice-wheat cropping system with same sets of treatments is practiced on the same piece of experimental site.

Field experiment was conducted in *kharif* season 2017 at A2 Block of Norman E. Borlaug Crop Research Center (NEBCRC) of G.B.P.U.A&T. Pantnagar, Udham Singh Nagar, (Uttarakhand). This center is situated at an altitude of 243.84 m above mean sea level, 29°N Latitude and 79.3° E longitude. It falls under foot hills of Shivalik range of Himalayas as a narrow belt called "*Tarai*". The *Tarai* belt falls under the sub-humid and sub-tropical climate zone with hot dry summers and cool winters. The soils are originated from alluvial sediments. The chemical analysis of top 15 cm soil showed that it was rich in organic matter and medium in phosphorus and potassium, and neutral to slightly alkaline in reaction. In the long term fertility experiment, fourteen treatments were tested in a Randomized Block Design 4 replications, however only nine important treatments (Control, N_{120}, $N_{120}P_{40}$, $P_{40}K_{40}$, $N_{120}K_{40}$, $N_{120}P_{60}K_{40}$, $N_{120}P_{40}K_{40}$ + Znf, $N_{120}P_{40}K_{40}$ + FYMr and $N_{120}P_{40}K_{40}$+Znf + FYMr) considered in the present study. The above mentioned symbols represent: N_{120}-120 kg Nha^{-1}, P_{40}-40 kg $P_2O_5ha^{-1}$, K_{40}-40 kg K_2Oha^{-1}, Znf-Foliar Zinc (0.5% $ZnSO_4$+0.25% Slaked lime), FYMr- Farm Yard Manure applied @ 5 t ha^{-1} on the dry weight basis in rice crop only.

Results and discussion

Plant height

The plant height on an average increased at a faster rate initially up to 30 days after transplanting (DAT) later the plant height increased a bit slower rate during panicle formation to flowering stage. Thereafter it attained stationary phase up to maturity. At 30 DAT, plant height under all fertilizer treatments significantly increased over control and recommended dose of fertilizer while maximum height was recorded due to $N_{120}P_{40}K_{40}$+ Znf + FYMr (57cm) which was significantly higher than all other treatments. At 60 DAT, all the fertilizer treatments increased the plant height significantly, the maximum height was recorded due to $N_{120}P_{40}K_{40}$ +FYMr (95cm) which being at par with $N_{120}P_{40}K_{40}$ +Znf + FYMr (94cm), caused significantly taller plant than all other treatments. At 90 DAT, all the fertilizer treatments increased the plant height significantly over control, the maximum height was recorded due to $N_{120}P_{40}K_{40}$+Znf+FYMr which was a significantly higher (113cm) than all other treatments. Similarly at maturity, all the fertilizer treatments enhanced the plant height significantly, the treatment $N_{120}P_{40}K_{40}$+Znf+FYMr (112cm) and $N_{120}P_{40}K_{40}$ + FYMr (112cm), caused significantly taller plant than all other treatments. Compared to all the inorganic treatments, recommended dose of fertilizer, $N_{120}P_{40}K_{40}$+Znf, gave significantly higher plant height while addition of FYM further increased the plant height significantly over all the other treatments. The data pertaining to plant height (cm) has been tabulated in Table 1.

Number of shoots

At 30 DAT, the treatment $N_{120}P_{40}K_{40}$+FYMr (152 m^{-2}) being at par with $N_{120}P_{40}K_{40}$+Znf+FYMr (147 m^{-2}), $N_{120}P_{40}K_{40}$+Znf (139 m^{-2}) and $N_{120}P_{40}$ (138 m^{-2}) treatment caused significantly higher shoot (m^{-2}) than remaining treatments. At 60 DAT, the treatment $N_{120}P_{40}K_{40}$+Znf+FYMr (241 m^{-2}) being at par with $N_{120}P_{40}K_{40}$ (239 m^{-2})and $N_{120}P_{40}K_{40}$+FYMr(238 m^{-2}) treatment recorded significantly higher shoot (m^{-2}) than remaining treatments. Similarly at 90 DAT, treatment $N_{120}P_{40}K_{40}$+Znf +FYMr (225 m^{-2}) and $N_{120}P_{40}K_{40}$ +FYMr (225 m^{-2})caused statistically higher no. of shoots which was at par shoot (m^{-2}) to $N_{120}P_{40}K_{40}$+Znf (217 m^{-2})but significantly more than remaining treatments. At maturity maximum shoots was recorded in$N_{120}P_{40}K_{40}$+Znf +FYMr (217 m^{-2}) which was statistically at par with $N_{120}P_{40}K_{40}$ +FYMr (216 m^{-2}) and $N_{120}P_{40}K_{40}$+Znf (207 m^{-2}) but significantly higher than all other treatments. Compared to the recommended dose of fertilizer, $N_{120}P_{40}K_{40}$+Znf, and all other inorganic treatments, the treatments $N_{120}P_{40}K_{40}$+Znf +FYMr and $N_{120}P_{40}K_{40}$+FYMr produced significantly higher shoot (m^{-2}). The mean shoot number m^{-2} varied from 136 to 217 at maturity. The data pertaining to shoots (m^{-2}) has been tabulated in Table 2.

Dry matter production

At 30 DAT, the maximum plant dry matter (g m^{-2}) was recorded in the treatment $N_{120}P_{40}K_{40}$+Znf+FYMr (27g m^{-2}) followed by $N_{120}P_{40}K_{40}$+FYMr (25g m^{-2}) which remained at par with each other but significantly higher than all other treatments. At 60 DAT, the maximum plant dry matter (g m^{-2}) was recorded in the treatment $N_{120}P_{40}K_{40}$+Znf+FYMr (165g m^{-2}) which was significantly higher than all other treatments including a recommended dose of fertilizer $N_{120}P_{40}K_{40}$+Znf.

At 90 DAT, the maximum plant dry matter (g m^{-2}) was recorded in the treatment $N_{120}P_{40}K_{40}$+Znf+FYMr (564g m^{-2}) which was significantly higher than all other treatments. At maturity, the maximum plant dry matter (g m^{-2}) was recorded in the treatment $N_{120}P_{40}K_{40}$ + FYMr (1390g m^{-2}) followed by $N_{120}P_{40}K_{40}$+Znf+ FYMr (1368g m^{-2}). These were at par with each other but significantly higher than all other treatments. The lowest amount of dry matter was recorded in control (692g m^{-2}). Compared to the recommended dose of fertilizer, $N_{120}P_{40}K_{40}$+Znf, and other inorganic treatments it was observed that addition of FYM significantly increased dry matter content in rice plant. The data pertaining to plant dry matter is tabulated in Table 3.

The results of the experiment revealed that nutrients supplied to the crop had its direct influence on plant growth. The fertilizer treatments had a significant influence on plant height, number of shoots and plant dry matter production at all the stages and at maturity. Addition of P, K, Zn and FYM along with N was found to increased plant height, shoot number and dry matter accumulation over imbalanced application of nutrients. It is due to the diverse collective physiological role played by N, P, K and Zn in various metabolic activities of rice and improvement of soil physical, chemical and biological properties of soil. However, the lowest values of these characters were obtained with unfertilized control plot. The reduced growth due to the imbalanced application of nutrients was due to depletion of other nutrients, especially P.

Table 1: Effect of treatments on plant height (cm) at different days after transplanting of rice.

Treatment		Days after transplanting			
		30	60	90	At maturity
T_1	Control	41	71	101	100
T_2	N_{120}	46	78	104	104
T_3	$N_{120}P_{40}$	50	83	105	105
T_4	$P_{40}K_{40}$	45	73	104	104
T_5	$N_{120}K_{40}$	48	83	108	108
T_6	$N_{120}P_{40}K_{40}$	54	87	109	109
T_7	$N_{120}P_{40}K_{40}$ + Znf	52	93	110	110
T_8	$N_{120}P_{40}K_{40}$ + FYMr	53	94	112	112
T_9	$N_{120}P_{40}K_{40}$ +Znf + FYMr	57	95	113	112
	S.Em ±	0.6	0.7	0.6	0.5
	C.D. (5%)	2	2	1	2
	C.V. (%)	2	2	1	1

Table 2: Effect of treatments on a number of shoots (m^{-2}) at different days after transplanting of rice.

Treatment		Days after transplanting			
		30	60	90	At maturity
T_1	Control	92	156	144	136
T_2	N_{120}	89	182	168	161
T_3	$N_{120}P_{40}$	138	209	204	195
T_4	$P_{40}K_{40}$	102	166	161	154
T_5	$N_{120}K_{40}$	132	220	207	198
T_6	$N_{120}P_{40}K_{40}$	132	239	214	204
T_7	$N_{120}P_{40}K_{40}$ + Znf	139	224	217	207
T_8	$N_{120}P_{40}K_{40}$ + FYMr	152	238	225	216
T_9	$N_{120}P_{40}K_{40}$ +Znf + FYMr	147	241	225	217
	S.Em ±	5	5	4	3
	C.D. (5%)	15	14	11	10
	C.V. (%)	8	4	4	4

Table 3: Effect of treatments on dry matter (g m^{-2}) at different days after transplanting of rice.

Treatment		Days after transplanting			
		30	60	90	At maturity
T_1	Control	10	42	292	692
T_2	N_{120}	11	44	312	789
T_3	$N_{120}P_{40}$	16	92	398	1142
T_4	$P_{40}K_{40}$	11	56	312	829
T_5	$N_{120}K_{40}$	12	74	377	828
T_6	$N_{120}P_{40}K_{40}$	20	125	482	1172
T_7	$N_{120}P_{40}K_{40}$ + Znf	22	133	514	1165
T_8	$N_{120}P_{40}K_{40}$ + FYMr	25	163	532	1390
T_9	$N_{120}P_{40}K_{40}$ +Znf + FYMr	27	165	564	1368
	S.Em ±	0.6	3	8	43
	C.D. (5%)	2	9	24	125
	C.V. (%)	7	6	4	8

Conclusion

The present study concluded the importance of balanced nutrition in proper growth and development of rice as application of FYM and foliar application of Zinc over the basic N, P and K nutrients in the treatments $N_{120}P_{40}K_{40}$+Znf+FYMr and $N_{120}P_{40}K_{40}$+FYMr showed pronounced effect on plant growth and produced a taller plant, more numbers of shoots per m^{-2} and greater plant dry matter throughout the crop season.

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