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Nutrient Management Strategy in Rice under Calcareous Soils of Bihar

Nitish Kumar, S. K. Chaudhary, Anshul Gupta, Shantanu Kumar, Ravikant Kumar

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Abstract A field experiment was carried out during *kharif* of 2014 to evaluate the effect of different nutrients on growth and yield of hybrid rice ("Arize 6444") and inbred rice ("Rajshree") aimed at establishing the major limiting nutrients and estimation of optimum fertilizer requirements for lowland rice for increased and sustainable production. The factors under study comprised of 9 treatments viz. T_1-Ample dose of N + P + K + S + Zn, T_2-P+K+S+Zn (-N), T_3-N+K+S+Zn (-P), T_4-N+P+S+Zn (-K), T_5-N+P+K+Zn (-S), T_6-N+P+K+S (-Zn), T_7-Inbred variety under unfertilized check, T_8-Inbred variety under ample fertilizer (N+P+K+S+Zn) and T_9-Control (hybrid rice without any fertilizer), results indicated that the maximum plant height (132.56 cm), number of tillers per meter square (444), dry weight (1562.42 g) and leaf are index were recorded with T_8, T_1, T_1 and T_8 respectively. Treatment T_1 for hybrid rice was superior over all the other treatments in grain yield and harvest index.

Keywords Nutrient, Rice, Growth, Yield, Calcareous soil.

N. Kumar*, S. Kumar, R. Kumar
MSc (Ag), Agronomy,
e-mail : nitish.urs@gmail.com

S. K. Chaudhary
Sr Scientist and Associate Professor,
Department of Agronomy,
RAU, Pusa, Samastipur 848125, Bihar, India
e-mail : shantanusingh416@gmail.com

A. Gupta
MSc (Ag), Agronomy,
SKNAU, Jobner 303329, Rajasthan, India
e-mail : ravikant.kumar96@gmail.com
*Correspondence

Introduction

The cultivation of rice represents both a way of life and a means to liveliood. Rice is a leading food crop in India having about 44 million hectare of lands under rice cultivation with a production of 106.54 million tonnes in 2013-14 and an average productivity of about 2454 kg ha^{-1} [1]. It contributes 42% of total food grains production and 45% of the total cereal production in the country. Rice is one of the major staple food crop and plays a pivotal role in national food security and is a means of livelihood for millions of rural households and at the current rate of population growth in India, the requirement of rice is estimated to be around 130—140 million tonnes by 2025. The productivity of rice has been stagnant in the state during the last decades and so. In Bihar rice is grown round the year under different ecosystem and occupies 3.29 million hectare of area with a production of

Table 1. Plant height (cm), number of tillers m^{-2}, dry matter production (g m^{-2}) and LAI at flowering as affected by different treatments at different growth stages.

Treatment	Plant height (cm)					Number of tillers per meter square					Dry matter (gram per meter square)					LAI
	25 DAT	50 DAT	75 DAT	100 DAT	At harvest	25 DAT	50 DAT	75 DAT	100 DAT	At harvest	25 DAT	50 DAT	75 DAT	100 DAT	At harvest	LAI (at flowering)
T_1	52.81	96.45	120.67	124.23	123.76	348	444	433	342	321	124	645	1066	1269	1452	5.55
T_2	45.06	72.85	101.73	104.82	104.80	222	308	237	213	207	99	400	558	685	809	3.45
T_3	48.79	84.72	112.80	118.07	116.46	342	430	413	307	287	115	530	790	1051	1268	4.34
T_4	48.51	85.81	117.87	120.85	119.53	340	429	405	285	267	110	489	750	1010	1250	4.15
T_5	48.13	89.66	118.23	121.03	120.33	329	432	416	310	291	105	540	834	1109	1380	5.32
T_6	51.07	91.12	118.93	121.36	121.23	336	439	420	312	294	113	553	844	1128	1409	5.18
T_7	43.74	69.93	100.13	103.56	103.16	204	275	226	188	170	55	337	477	604	695	3.69
T_8	52.48	96.21	121.67	132.56	132.06	333	428	407	319	301	114	590	1007	1221	1379	5.82
T_9	44.89	70.02	94.06	103.28	103.08	210	302	230	207	197	51	347	487	614	703	2.23
T_{10}	52.21	87.56	117.80	131.69	131.30	320	397	354	292	280	102	575	957	1129	1257	5.69
SEm±	1.37	2.44	2.75	4.40	4.60	9.68	10.40	11.84	10.42	9.93	4.00	14.19	24.29	31.29	52.12	0.36
CD (p =0.05)	4.10	7.30	8.23	13.40	13.79	28.95	31.12	35.42	31.16	29.71	11.98	42.45	72.64	93.58	155.86	1.07

4.99 million tonnes and productivity of 1,517 kg ha^{-1} [2].

Rice is life to majority of perople in the state. But in present era, as production stability has been attained, there is a need of more production per unit area as land is limited and rice cultivation is beset with problems of declined organic carbon content from 5 to 2 g kg^{-1} [3] and increasing multiple deficiencies of major nutrients (N, P, K and S) and micronutrients (Zn, Fe and Mn) due to their overmining [4]; increasing salinity [5]. Unbalanced use of fertilizers not only resulted in deficiency of phosphorus (P), potassium (K), sulfur (S) and micronutrients but also proves uneconomical [6]. In soils of Bihar, the nutrient deficiency is increasing day by day and in general soil is low in N, Zn, S, B and medium to low in K and P. Use of higher dose of nitrogen containing fertilizers and low rate of K containing fertilizer is a common practice which has resulted in drop of partial factor productivity of N, P, and K for food grain production from about 81 kg grain per kg of N, P and K in 1966-67 to 15 kg grain per kg N, P and K [7].

Nutrient management must be sound for achieving the production target in sustainable manner. Hybrid rice in very much responsive to adequate and timely application of fertilizers. Rice hybrids would play a greater role in sustaining food security. Among the various option available to enhance the rice productivity, hybrid rice appears to be the practically feasible and readily adoptable one. Hybrid rice has yield advantage of 15–20% over inbred varieties, as hybrid rice has better and more extensive root system, higher growth rate during vegetative stage, greater sink and greater carbohydrate rranslocation from source to sink.

Judicious and proper use of these fertilizers can markedly increase the yield and improve the quality of rice. The availability of N, P, K and other essential nutrients could be assessed by the omission plots' techniques where a particular essential nutrient is omitted from the fertilization schedule keeping the supply of other limiting nutrients in ample quantity. The objective of this study was to measure the extent of each major nutrient exclusion effect on yield and simultaneously their application in soil to increase rice yield.

Materials and Methods

The present investigation was carried out during *kharif* of 2014 at the Research Farm of Rajendra Agricultural University, Bihar, Pusa (Samastipur). It is situ-

Table 2. Effect of different treatments on yield attributes and yield.

Treatments	No. of panicles m^{-2}	No. of filled grains $panicle^{-1}$	No. of un-filled grains $panicle^{-1}$	Length of panicle (cm)	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
T_1	291	162	19	27.30	23.88	68.37	69.25	49.68
T_2	201	130	31	24.70	21.86	35.14	43.21	44.92
T_3	279	158	25	26.47	23.57	59.16	61.57	49.01
T_4	262	154	28	26.03	23.08	56.53	62.16	47.64
T_5	282	160	24	26.50	22.88	63.46	67.05	48.64
T_6	284	160	26	26.73	23.55	63.95	69.82	47.75
T_7	161	103	41	24.33	21.37	23.34	43.21	34.98
T_8	262	141	21	26.90	23.32	48.03	83.24	36.59
T_9	188	110	40	24.43	22.33	30.91	36.22	45.98
T_{10}	259	140	28	25.93	22.45	46.80	73.10	39.53
SEM±	9.10	4.81	4.21	0.62	0.36	2.27	4.01	0.13
CD (p=0.05)	27.25	14.40	12.60	1.84	1.07	6.61	12.04	0.41

ated on the southern bank of the river *Burhi Gandak* in Samastipur district at 25°59 North latitude and 84°40 East longitudes with an altitude of 52.3 m above the mean sea level. The experiment was conducted under a running project (sponsored by International Plant Nutrition Institute-South Asia Program, IPNI). The climate is sub-tropical, greatly influenced by hot-dry summer and too cold winter. The total rainfall of 996.2 mm was recorded during the cropping period and average temperature ranged between 24.9 to 32.9°C. The average bright sunshine hour per day was higher with 8.80 h in *kharif* season of 2014. The soil was calcareous (pH 8.28) in nature with low organic carbon (0.33%), available nitrogen (212 kg N ha^{-1}), potassium (103.48 kg K_2O ha^{-1}) and zinc was close to critical limit (0.72 mg Zn kg^{-1}); medium phosphorus (38.93 kg P_2O_5 ha^{-1}) and high sulfur (52.80 mg S kg^{-1}) status. The factors under study comprised of 9 treatments viz. T_1-Ample dose of N+P+K+S+Zn, T_2-P+K+S+Zn (-N), T_3-N+K+S+Zn (-P), T_4-N+P+S+Zn (-K), T_5-N+P+K+Zn (-S), T_6-N+P+K+S (-Zn), T_7-Inbred variety under unfertilized check, T_8-Inbred variety under ample fertilizer (N+P+K+S+Zn), T_9-Control (hybrid rice without any fertilizer). The experiment was conducted in RBD with three replications. The nutrient dose for hybrid rice (at yield target of 7 t ha^{-1}) was 175 kg N ha^{-1}, 70 kg P_2O_5 ha^{-1} and 80 kg K_2O ha^{-1} and for inbred rice (at yield target of 5 t ha^{-1}), 125 kg N ha^{-1}, 50 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1}. S @ 30 kg ha^{-1} and Zn @ 3 kg ha^{-1} was applied in all the treatments except treatments T_7 and T_9. Hybrid rice was grown in all the treatments except T_7 and T_8.

Results and Discussion

Effect on growth parameters

Results indicated that application of ample dose of N, P, K, S and Zn in hybrid rice (T_1) gave maximum plant height at 25 and 50 DAT whereas at subsequent crop growth stages maximum plant height was recorded in inbred variety-Rajshree (T_8) may be due to its genetic makeup and characteristic feature. Similar findings in plant height were reported by Mauriya et al. [8] and Shankar et al. [9].

The maximum number of tillers m^{-2} at 25 DAT was observed in T_1 (348.10) ample dose of N, P, K, S and Zn and it was at par with treatments T_3, T_4, T_5, T_6 and T_8 but significantly superior over T_2, T_7 and T_9. Similar trend was observed at 50 and 75 DAT (Table 1). However a different trend was observed at 100 DAT and at harvest where T_1 was statistically at par with T_5, T_6 and T_8 only. This might be due to higher production of meri-stems with increasing levels of NPKS and Zn and balanced proportion of all the nutrients resulted in higher uptake of these nutrients by the crop. These findings were supported by Mandal et al. [10] Chaudhary and Pandey [11] and Reddy et al. [12].

Dry matter production was maximum in treatment

T_1 having ample dose of N, P, K, S and Zn in hybrid and it was significantly superior over treatment T_2, T_7 and T_9 at all the crop growth stages. This might be due to availability of all the nutrients as per the crop need during its growth. Shankar et al. [9] also stated that dry matter per meter square was highest for hybrid rice with the use of all the nutrients.

The maximum LAI was in T_8 (5.82) having ample dose of N, P, K, S and Zn in inbred variety and it was at par with treatments T_1, T_5 and T_6 and significantly superior over rest of the treatments LAI is a function of shoots per unit area, length, width and number of leaves and these maintained characters were more in inbred variety-Rajshree. This findings were confirmed by Chaudhary and Pandey [11] and Pal et al. [13].

Among the omission of nutrients in hybrid rice, treatment T_6 (-ZN) recorded the maximum plant height, number of tillers m^{-2}, dry matter accumulation and LAI over control (T_9). Zn showed least detrimental effect on increase in plant height as it has no direct role in plant cell elongation but acts as a metal constituent in an enzymes or as cofactors of number of enzymes and in synthesis of tryptophan, which in turn is precursor of IAA [14, 15]. Dash et al. [16] also reported that omission of Zn and S had no significant effect on biometric characters of rice. Minimum plant height, number of tillers m^{-2}, dry matter accumulation and LAI were obtained with T_9 (control) followed by T_2 (-N). As compare to omission of other nutrients as nitrogen is very important constituent of major cell parts and protein production. Choudhary and Pandey [11] also concluded that increasing level of N upto 120 kg ha^{-1} increased the growth components like plant height, tillers per meter square, dry matter and LAI of rice.

Effect on yield

Results further indicated that maximum number of panicles m^{-2} and number of grains $panicle^{-1}$ were in treatment T_1 which was statistically at par with treatments T_3, T_5 and T_6 and maximum panicle length (27.30 cm) and 1000-grain weight were in treatment T_1 which was statistically at par with treatments T_3, T_4, T_5, T_6 and T_8 and significantly superior over rest of the treatments (Table 2). The yield attributes increased significantly with application of ample dose of fertilizers in hybrid variety which might be due to better nutrition of panicle primordial which resulted in higher number of filled grains per panicle and more length of panicle. These findings were supported by Singh and Singh [11] and Stinivas et al. [18]. Among the treatments having omission of nutrients, T_6 (-Zn) was found to have maximum number of panicles m^{-2} (286) and panicle length and was statistically at par with treatments T_3, T_4, T_5 and significantly superior over T_2 (-N) and T_9 (control). Number of grains $panicle^{-1}$ and test weight were observed highest in treatment T_5 (-S), T_6 (-Zn) and T_3 (-P) respectively as compared to other nutrients and lowest value recorded in treatment was in T_9 (control) and T_2 (-N). Zn and S has important role in reproduction and pollination [19] but in present investigation its omission doesn't have much influence on fertile grains per panicle as these were already in substantial amount in soil. These findings were supported earlier Shankar et al. [9] and Avasthe [20].

Grain yield (hybrid rice) found maximum grain in treatment T_1 (68.37 q ha^{-1}) and it was statistically at par with treatments T_5 and T_6 but significantly superior over rest of the treatments. Grain yield of T_1 was found to be 54.7% superior over treatment T_9 (control in hybrid). Higher yield with application of all the nutrients might be due to increased availability of all the nutrients at distinct phenological phases resulting into better assimilation of photosynthates towards grain. These findings were supported by the result of Mauriya et al. [8], Chaudhary and Pandey [11]. However, the maximum straw yield (83.24 q ha^{-1}) obtained with Rajshree variety (T_8) and it was significantly superior to all other treatments. It might be due to higher plant height, more LAI and lesser conversion of photosynthates to grain yield and also due to difference in genetic makeup of this variety. Among the various treatments with omission of nutrients in hybrid variety, T_6 recorded the maximum grain yield (63.95 q ha^{-1}), superior over T_2 (-N), T_3 (-P), T_4 (-K) and T_5 (-S) and straw yield which were superior over T_2 and T_9. Experimental soil was high in Zn level and it was also close to critical limit resulting into lesser impact on grain production due to their omission. These findings were close in conformity with Shankar et al. [9]. Maximum harvest index was in treatment T_1 and it was significantly superior over all other treatments. Among the treatment having omission of nutrient, treatment T_3 recorded higher harvest index and was it statistically at par with treatment T_5 (-S) only. Harvest index was maximum in treatment T_1 which might be due to vigorous vegetative growth and better translocation of photosynthates and minimum in treatment T_7 (control in inbred-Rajshree) due to lesser number of effective tillers and grain yield. These findings were confirmed by Chaudhary and Pandey [11] and Avasthe [20].

Conclusion

The result of the study revealed that application of N (175 kg ha^{-1}) in three splits (75 kg ha^{-1} as basal + 50 kg ha^{-1} at active tillering stage + 50 kg ha^{-1} at panicle initiation), P_2O_5 (70 kg ha^{-1}) as basal, K_2O (80 kg ha^{-1}) in two equal splits (40 kg ha^{-1} basal + 40 kg ha^{-1} at panicle initiation), S and Zn @ of 30 kg ha^{-1} and 3 kg ha^{-1} respectively as basal dose in hybrid rice (T_1) was found to be most suitable for attaining higher grain yield.

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