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Impact of long term inorganic and integrated nutrient management practices on growth and yield of rice in rice (*Oryza sativa* L.): Wheat (*Triticum aestivum* L.) cropping system

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Abstract
Experiments were conducted during *kharif 2018* and 2019 at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya Raipur (C.G.). The soil of experimental field was clayey (*Vertisols*) in texture, locally known as "*Kanhar*" which was low, medium and high in available N, P_2O_5 and K_2O, respectively. Experiment with both the crops *i.e.* rice and wheat was laid out in randomized block design with four replications having ten treatments. The treatments for both the crops were T_1: control, T_2: 50% RDF, T_3: 100% RDF, T_4: 150% RDF, T_5: 100% RDF+$ZnSO_4$ ($ZnSO_4$ Applied only *kharif*). T_6: 100% NP, T_7: 100% N and T_8: 100% RDF+FYM (FYM applied only *kharif*), T_9: 50% RDF+BGA (BGA applied only *kharif*), T_9: 50% RDF+GM (GM Applied only *kharif*). The application of T_4: 150% RDF produced the highest growth yield and yield attributing parameters which was statistically similar to the treatments of T_3: 100% RDF, T_5: 100% RDF + $ZnSO_4$, T_6: 100% N and P_2O_5 and T_8: 100%+FYM, at all stages of crop growth. The lowest growth and yield attributing parameters were observed under control where no nutrient was applied during both the years and on mean basis.

Keywords: Inorganic, nutrient, *Oryza sativa* L., *Triticum aestivum* L.

Introduction

Cropping system in the country has attained great significance in term of area, production and productivity. Rice-wheat cropping system is now a days becoming popular in the state due to increase in irrigated area. Rice, (*Oryza sativa* L.) is an important cereal crop and serves as a major source of energy for more than half of the global population. In India, total production of rice during 2019-20 was estimated to be 117.47 million tonnes. It is higher by 9.67 million tonnes than the five years' average production of 107.80 million tonnes. In this country, rice is grown in 43.86 million ha with the production of 104.80 million tonnes having the productivity is 2390 $kgha^{-1}$. In Chhattisgarh, according to rice is grown in 3.71m ha area having production of 83.94 lakh MT during 2018-19.

Long term Fertilizer experiments are the best tool to assess the influence the continuous application of fertilizers, organic manures used alone or combined on sustainability and soil fertility. To achieve the higher yield of rice, inorganic fertilizers were used with little or no addition of organic manure. Even though the inorganic fertilizers were resulted in higher crop yield, over reliance on them associated with declined soil properties and degraded soils by especially organic matter, soil biota and in turn decreased yield in subsequent period. This have also caused environmental hazards such as ground and surface water pollution by nitrate leaching that may deteriorate human and animal health (Pimentel, 1996) [3]. Majority of small and marginal farmers do not have financial resources to purchase sufficient fertilizers to replace soil nutrients removed through crop harvests. As a result, soil fertility has declined, and yields of staple food crops are typically low (Sanchez *et al*., 1997) [2].

So to reduce the amount of chemical fertilizers applied the field without resulting in its deficiency will be the main challenge in fertilizer management in the field. One of the possible options to reduce their use could be recycling of locally available organic wastes, viz. crop residue, green manure and farmyard manure (FYM), which can be a valuable and inexpensive source of plant nutrients. Positive effects of organic wastes on soil structure, aggregate stability and water-holding capacity have been well documented (Odlare *et al*., 2008 and Wells *et al*., 2000) [4, 5].

Materials and Methods

The experiment was carried out at Instructional cum Research Farm of IGKV, Raipur situated at latitude of 21º4' N, longitude of 81º35' E and altitude of 290.2 m above mean sea level. The climate of Raipur region is sub-humid to semi-arid. The source of rainfall is south-west monsoon. The average annual rainfall is 1326 mm (based on 80 years mean), of which mostly concentrated during the period from June to September and very little during October to February. May is the hottest and December is the coolest month of the year. Temperature controls seed germination, tillering, and other plant practices. The soil of experimental field was clayey (*Vertisols*) in texture, locally known as "*Kanhar*" which was low, medium and high in available N, P_2O_5 and K_2O, respectively. Experiment with both the crops *i.e.* rice and wheat was laid out in randomized block design with four replications having ten treatments. The treatments for both the crops were T_1: control, T_2: 50% RDF, T_3: 100% RDF, T_4: 150% RDF, T_5: 100% RDF+$ZnSO_4$ ($ZnSO_4$ Applied only *kharif*). T_6: 100% NP, T_7: 100% N and T_8: 100% RDF+FYM (FYM applied only *kharif*), T_9: 50% RDF+BGA (BGA applied only *kharif*), T_9: 50% RDF+GM (GM Applied only *kharif*).

Result and Discussion

Plant height and number of tillers, m^2

The data on mean plant height of rice revealed that the average plant height increased progressively with increases in crop stage. Data showed that plant height varied significantly at 60 and 90 DAT. The data revealed that the application of T_4: 150% RDF produced the highest plant height and number of tillers at 60 and 90 DAT, respectively. The comparable plant height and number of tillers were also observed under the treatments T_8: 100% RDF+ FYM T_3: 100% RDF, T_5: 100% RDF + $ZnSO_4$, T_6: 100% N and P_2O_5 during both the years and on mean basis. The lowest plant height and number of tillers were recorded under T_1: control during both the years.

The production of tillers in rice mainly takes place from the nodes appeared on the shoot and sequences as primary, secondary and tertiary tillers. In general tillers increased with increasing the crop age up to 60 DAT and reduced thereafter up to maturity due to dyeing of some tillers. The increase in number of tillers under said treatments was mainly due to application of sufficient nutrients. The level of nutrients led to the greater availability and steady supply of plant nutrients during the entire period of crop growth also maintained acceptable growth and encouraged the tiller production and thus above treatments assisted in increasing tillers. The Increased plant height probably helped in increasing the photosynthetic area for photosynthesis in plant, which in turn helped in formation of new tillers. The tiller production at higher levels of nutrient application due to better nutrition of the crop have been also reported by Balasubramanian *et al*. (1991) [8], Prasad and Sharma (2000) [6] and Mari, *et al*. (2004) [7].

Dry matter accumulation g m^{-2}

The data on dry matter accumulation at 60 and 90 DAT and at harvest of rice as influenced by long term inorganic and integrated nutrient management practices of rice in rice-wheat cropping system are presented in table 1-3. The findings revealed that the dry matter accumulation was significantly affected at all the stages of crop growth during both the years and on mean basis due to different treatments.

Among the different treatments, the application of T_4:150% RDF (150: 90: 60: N: P_2O_5: K_2O Kg ha^{-1}) accumulated significantly the highest dry matter at, 60 and 90 DAT and at harvest. This treatment was found to be significantly superior to the treatments of T_1: control, T_2: 50% RDF, T_7: 100% N, T_9: 50% RDF + BGA, T_{10}: 50% RDF +GM at all the stages of crop growth during both the years. The remaining treatments found to be equally effective to that of T_4-150% RDF (150: 90: 60: N: P_2O_5: K_2O Kg ha^{-1}) for producing dry matter at all the stages during both the years and on mean basis. The lowest number of leaves was recorded in T_1: control followed by T_7: 100% N.

Effective tillers m^{-1}, panicle length (cm), grains $panicle^{-1}$

Number of effective tillers, panicle length, Grains $panicle^{-1}$ and test weight of rice were observed at harvest (Table. 3). These parameters were significantly influenced by the adaption of different inorganic and integrated nutrient and management practices. Among the treatments, application of T_4-150% RDF (150: 90: 60: N: P_2O_5: K_2O Kg ha^{-1}) produced the highest numbers of effective tillers during both the years (388 and 380) and on mean basis (384), which was statistically at par with the treatments of T_8: 100% RDF + FYM, T_3: 100% RDF, T_5: 100% RDF + $ZnSO_4$ and T_6: 100% N and P during both the year and on mean basis. On the other hand, treatments of T_9: 50% RDF+ BGA (50:30:20:10, N: P_2O_5: K_2O + BGA kg ha^{-1}, T_2: 50% RDF (50:30:20:: N: P_2O_5: K_2O Kg ha^{-1}), T_7: 100% N (100: 0: 0:: N: P_2O_5: K_2O Kg ha^{-1}) and T_1: control (no fertilizer) were found to be significantly inferior to that of T_4-150% RDF (150z: 90: 60: N: P_2O_5: K_2O Kg ha^{-1}).

The increase in effective tiller, panicle length, grains $panicle^{-1}$ under said treatments was mainly due to early emergence of primary and secondary tillers at vegetative stage and supported with proper nutrient supply and translocation of food materials towards reproductive parts, which contributed for panicle bearing tillers, panicle length and number of grains $panicle^{-1}$. The study of Gangwar and Singh (2004) also explained that availability and translocation of food materials to the productive parts of the plants helps for increasing effective tiller, panicle length, grains $panicle^{-1}$ and test weight. The reduction of these parameters mainly under the treatment T_1: control and T_7: 100% N was due to unavailability or imbalance supply of the nutrients. These treatments also gave the higher sterility percentage.

Grain and straw yields (q ha^{-1})

Among various treatments, application of T_4: 150% RDF (150: 90: 60: N: P_2O_5: K_2O Kg ha^{-1}) produced the highest grain yield (69.70, 69.30 and 69.50 qha^{-1}) during both the years and on mean basis. This treatment being at par with the treatment of T_8: 100 RDF+FYM, T_3: 100% RDF, T_5: 100% RDF+ Zn and T_6:100% N and P produced significantly higher grain yield than the others treatments. When application of T_2: 50% RDF was compared with T_9: 50% RDF +BGA and T_{10}: 50% RDF+GM, it has been observed that the treatment of T_{10}: 50% RDF+GM produced significantly higher yield than that of T_2: 50% RDF and T_9: 50% RDF+BGA. Almost similar trend was noticed for straw yield of rice during both the years and on mean basis. The harvest index was not influenced significantly due to various treatments.

Table 1: Plant height (cm) of rice as influenced by long term inorganic and integrated nutrient management practices in rice-wheat cropping system

Treatment	Plant height (cm)						Number of tillers, m^2					
	60 DAT			90 DAT			60 DAT			90 DAT		
	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
T_1: Control	76.29	73.27	74.78	87.06	85.15	86.11	287	269	278	268	264	266
T_2: -50% RDF	81.99	86.05	84.02	98.46	105.64	102.05	467	452	459	458	442	450
T_3: 100% RDF	100.39	98.89	99.64	119.87	118.49	119.18	590	574	581	587	573	580
T_4: 150% RDF	105.94	104.98	105.46	123.42	122.51	122.96	620	598	608	624	614	619
T_5: 100% RDF +$ZnSO_4$	96.19	94.85	95.52	118.93	117.29	118.11	593	578	585	578	570	574
T_6: 100% N and P_2O_5	95.73	92.73	94.23	116.91	115.97	116.44	575	567	571	566	552	559
T_7: 100% N	83.46	80.51	81.98	97.55	95.75	96.65	431	419	425	408	396	402
T_8: 100% RDF +FYM	105.30	104.12	104.71	121.86	120.67	121.26	600	598	599	612	602	607
T_9: 50% RDF +BGA	91.66	85.65	88.65	107.58	104.36	105.97	459	471	465	476	485	481
T_{10}: 50% RDF + GM	93.49	89.46	91.47	109.72	107.47	108.60	492	484	488	507	505	506
S.Em ±	3.77	3.68	3.71	4.94	4.77	4.87	26.61	25.94	26.25	26.52	26.04	26.29
LSD (P=0.05)	10.87	10.68	10.78	14.33	13.84	14.14	77.22	75.28	76.18	76.99	75.56	76.28

Table 4: Plant height (cm) of rice as influenced by long term inorganic and integrated nutrient management practices in rice-wheat cropping system

Treatment	Dry matter accumulation (g m^{-2})								
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T_1: Control	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
T_2: -50% RDF	377	365.6	371.3	377	365.6	371.3	377	365.6	371.3
T_3: 100% RDF	462	450.7	456.35	462	450.7	456.35	462	450.7	456.35
T_4: 150% RDF	677	666.0	671.15	677	666.0	671.15	677	666.0	671.15
T_5: 100% RDF +$ZnSO_4$	688	677.0	682.5	688	677.0	682.5	688	677.0	682.5
T_6: 100%N and P_2O_5	631	620.0	625.5	631	620.0	625.5	631	620.0	625.5
T_7: 100% N	610	599.0	604.5	610	599.0	604.5	610	599.0	604.5
T_8: 100% RDF +FYM	433	422.0	427.5	433	422.0	427.5	433	422.0	427.5
T_9: 50% RDF +BGA	632	621.0	623	632	621.0	623	632	621.0	623
T_{10}: 50% RDF + GM	543	532.0	537.5	543	532.0	537.5	543	532.0	537.5
S.Em ±	513	502.0	507.5	513	502.0	507.5	513	502.0	507.5
LSD (P=0.05)	40.68	40.02	40.35	40.68	40.02	40.35	40.68	40.02	40.35

Table 3: Effective tillers, panicle length, number of grains panicle^{-1}, grain and straw yield of rice as influenced by long term inorganic and integrated nutrient management practices in rice-wheat cropping system

Treatment	Effective tillers m^{-1}			Panicle length (cm)			Number of grains panicle $^{-1}$			Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
T_1: Control	189	167	178	20.11	16.91	18.51	104	97	100.5	24.30	22.25	23.28	44.10	43.14	43.62
T_2: -50% RDF	239	222	230.5	19.94	18.68	19.31	140	131	135.5	45.80	43.75	44.78	58.88	57.05	57.97
T_3: 100% RDF	360	349	354.5	21.36	20.52	20.94	191	184	187.5	66.25	65.00	65.63	86.20	83.95	85.08
T_4: 150% RDF	388	380	384	22.67	21.87	22.27	210	206	208	69.70	69.30	69.50	90.51	87.20	88.86
T_5: 100% RDF + $ZnSO_4$	355	352	353.5	21.23	20.39	20.81	187	180	183.5	65.65	64.35	65.00	84.40	81.15	82.78
T_6: 100% N and P_2O_5	353	352	352.5	21.19	20.07	20.63	182	173	177.5	65.00	63.65	64.33	83.25	78.95	81.10
T_7: 100% N	207	197	202	18.03	17.64	17.835	122	113	117.5	35.35	33.90	34.63	53.55	50.12	51.84
T_8: 100% RDF + FYM	373	368	370.5	22.48	21.54	22.01	203	195	199	68.90	68.50	68.70	88.65	85.78	87.22
T_9: 50% RDF + BGA	254	213	233.5	19.75	18.11	18.93	149	119	134	46.00	42.95	44.48	60.40	56.19	58.30
T_{10}: 50% RDF + GM	273	258	265.5	20.88	19.68	20.28	166	159	162.5	49.20	47.00	48.10	64.15	61.10	62.63
S.Em ±	12.61	12.01	12.31	0.87	0.82	0.85	7.03	6.57	6.80	2.14	1.12	1.07	3.47	3.32	3.40
LSD (P=0.05)	36.61	34.84	35.71	2.52	2.39	2.46	20.39	19.07	19.72	6.22	3.24	3.11	10.11	9.63	9.85

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