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Long term effect of integrated nutrient management on growth under maize-wheat cropping system in Chhotanagpur Plateau region

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Abstract
The experiment was carried out during two consecutive years of 2020-22 under the ongoing permanent manurial trial with different nutrient management practices under maize-wheat system since 1983-84 at Birsa Agricultural University, Kanke, and Ranchi to study the long term effect of integrated nutrient management on growth under maize-wheat cropping system. Experiment was laid out in RBD with 12 treatments replicated thrice. RDF for both component crop was @ 100:50:25 N: P_2O_5: K_2O kg/ha. Crop varieties of maize (*kharif*) and wheat (*Rabi*) were Suwan Composite 1 and K 9107, respectively. The experimental soil was loam in texture (42.4% sand, 23.4% silt and 34.2% clay) with slightly acidic (6.5) in reaction having low organic carbon (4.1 g/kg soil) and available nitrogen (255.0 kg/ha), medium in available phosphorous (12.50 kg/ha) and available potash (195.0 kg/ha) consisting 11.13 ppm available iron, 18.65 ppm available manganese and 3.85 ppm available zinc. Results showed that application of 50%N through FYM along with 50% RDF through chemical fertilizer to maize fb 100% RDF through chemical fertilizer to wheat produced maximum and significantly higher plant population (55008plants/ha in maize and 381 plants/m^2 in wheat), leaf area index (3.82 in maize and 2.85 in wheat), dry matter production (1459 g/m^2 and 1395 g/m^2), crop growth rate (14.29 g/m^2/day and 6.57 g/m^2/day in maize and wheat, respectively).

Keywords: Cropping system, farm yard manure, integrated nutrient management, manurial trial and recommended dose of fertilizer

Introduction
Maize (*Zea mays* L.) - wheat (*Triticum aestivum* L.) is the third most important cropping system after rice (*Oryza sativa* L.)-wheat and rice-rice in India, and is grown on about 1.80 million ha each year (Jat *et al*., 2013) [3]. It is also prevalent cropping system adopted in uplands of Jharkhand. Most of the farmers use only urea (N fertilizers) for crop cultivation and this fertilizer use pattern results in multiple nutrient deficiencies as well as promotes soil bankruptcy. Maize and wheat are the main source of world's food energy and also contain significant amounts of proteins, vitamins and minerals, which are essential nutrients for human health. Maize is the third most important food grain crop in India, considered as a most important option for diversifying agriculture in upland areas of India. Maize has high production potential compared to any other cereal crop. Wheat, is another major important staple cereal, supplies the bulk of calories and nutrients in the diets of a large proportion of the world population (Chatzav *et al*., 2010) [2]. Globally, India is the second largest wheat-producing country and contributes about 11.9% to the world wheat production from about 12% of world area (Singh *et al*., 2010). Intensified and multiple cropping systems require judicious application of chemical, organic and bio-fertilizers for yield sustainability and improved soil health (Jat *et al*., 2013) [3]. Organic manures supply nutrients to the current crop and also leave a substantial residual effect on the succeeding crops in different sequential cropping systems. The efficiency of applied chemical fertilizers is also increased when applied along with organic manures. The utilization of well-decomposed farmyard manure (FYM) in soil management practices is a well-known practice for enhancing crop yield, enhancing SOM, promoting microbial activities, promoting friendly soil environmental management (Blair *et al*., 2005 and Kundu *et al*., 2006) [1, 4], increasing the total organic sources supply, and increasing the plant-available macro and micronutrients in soil. Therefore, better management of soil nutrients is required that delivers sustainable agriculture and maintains the necessary increases in food production while minimizing waste, economic loss and environmental impacts.

Various long term research results have shown that neither organic nor mineral fertilizers alone can achieve sustainability in crop production. Rather, integrated use of organic and mineral fertilizers has become more effective in maintaining higher productivity and stability through correction of deficiencies of primary, secondary and micronutrients. Integrated nutrient management (INM) is the feasible solution for sustaining the crop productivities, as nutrient requirements of both the crops are high and have shown superior response towards higher levels of nutrient application (Sharma *et al*., 2020) [5]. Therefore, judicious use of integrated nutrient management is best alternative to supply nutrient to crop needs and improve soil conditions.

Materials and Methods

A field experiment was conducted at Agronomical farm of Birsa Agricultural University, Kanke, and Ranchi during *kharif* and *Rabi* seasons of two consecutive years, 2020-22. The present experiment is a long term being conducted since *Kharif* 1983 with maize-wheat cropping system. The experimental soil was loam in texture (42.4% sand, 23.4% silt and 34.2% clay) with slightly acidic (6.5) in reaction having low organic carbon (4.1 g/kg soil) and available nitrogen (255.0 kg/ha), medium in available phosphorous (12.50 kg/ha) and available potash (195.0 kg/ha) consisting 11.13 ppm available iron, 18.65 ppm available manganese and 3.85 ppm available zinc. Experiment was laid out in RBD with 12 treatments replicated thrice. RDF for both component crop was @ 100:50:25 N: P_2O_5: K_2O kg/ha. Suwan Composit-1 maize and "K 9107" wheat was the test crop variety. Altogether 12 treatments in maize-wheat cropping system were T_1: $N_0P_0K_0$ to maize fb $N_0P_0K_0$ to wheat; T_2: 50% RDF to maize fb50% RDF to wheat; T_3: 50% RDF to maize fb100% RDF to wheat; T_4: 75% RDF to maize fb75% RDF to wheat; T_5: 100% RDF to maize fb100% RDF to wheat; T_6: 50%N through FYM+ 50% RDF through chemical to maize fb 100% RDF through chemical to wheat; T_7:25%N through FYM+ 75% RDF through chemical to maize fb75% RDF through chemical to wheat; T_8: 50%N through cut paddy straw+ 50% RDF through chemical to maize fb 100% RDF through chemical to wheat; T_9: 25%N through cut paddy straw+ 75% RDF through chemical to maize fb75% RDF through chemical to wheat; T_{10}: 50%N through green k*aranj* leaves + 50% RDF through chemical to maize fb100% RDF through chemical to wheat; T_{11}: 25%N through green k*aranj* leaves + 75% RDF through chemical to maize fb75% RDF through chemical to wheat and T_{12}: Farmer's Practice– urea @ 50kg /ha to both crops laid out in randomized block design and replicated thrice. Recommended dose of fertilizer for both component crops were @ 100 kg N, 50 Kg P_2O_5 and 25 kg K_2O /ha. Integrated use of manure (FYM, cut paddy straw and green karanj leaf) along with chemicals at different rate of substitution, farmers' practice of fertilizer use and the control. Residual effect of organic manure application was tested in *rabi* wheat crop along with different levels of inorganic fertilizers. FYM, paddy straw and *karanj* green leaves having 0.5, 0.5 and 2.0 percent N on oven dry basis were 3 organic sources of nutrients (50%N through FYM @10 ton, 50%N through cut paddy straw @10 ton and 50%N through green karanj leaves @2.5 ton). For substitution of inorganic fertilizers by organic sources, the calculation was done on the basis of N-concentration in organic manure and contents of P and K were ignored. Organic manure was incorporated in the soil well in advance prior to sowing of *kharif* maize only. Application of fertilizers at the time of sowing of crops were followed. The optimum dose of fertilizers for both the crops was N, P_2O_5 and k_20:100:50:25 kg/ha. Wheat was grown as test crop at different rate (50%, 75% and 100%) of chemical fertilizers only after harvest of maize. In farmers' practice urea @ 50kg/ha is applied which is equivalent to 23 kg N/ha.

Results and Discussion

Maize

Plant population per hectare

Perusal of pooled data presented in Table-1 revealed that influence of nutrient management practices was not significant at harvest for plant population per hectare. However, plant population varied from 53817 to 55008 plants per hectare at maturity. The highest (55008) was observed in treatment T_6 at harvest and the lowest (53817) in the control followed by farmers' practice (53718).

Leaf area index (LAI)

Leaf area index of maize gradually increased with age of maize crop. The statistical analysis of the pooled data revealed that level of inorganic fertilizers and its integration with organic sources *viz*., FYM, cut paddy straw and green karanj leaves significantly influenced the LAI of maize at each stage of crop. Treatment T_6 (50 percent N nutrient substitution through FYM) exhibited higher leaf area index of maize and it was statistically *at par* with treatments T_3 to T_{11} at 90 DAS. Lowest leaf area index was observed in control ($N_0P_0K_0$) and it was comparable with farmers' practice (@ 50 kg urea/ha. Among integrated series (T_6 to T_{11}), the lowest LAI was observed in treatment T_{11} where 25% N through green karanj leaves was applied along with 75% through chemical fertilizers. Variation in leaf area index (LAI) was 2.37 to 3.82 at 90 DAS.

Dry matter production

Dry matter production of maize gradually increased with age of crop. Maximum acceleration in it was observed from 30 to 60 days after sowing, thereafter the rate of increase was marginal. Pooled data revealed that level of inorganic fertilizers and its integration with organic sources *viz*., FYM, paddy straw and karanj leaves significantly influenced dry matter production of maize at each stage of crop growth. The highest dry matter production was observed in treatment T_6 which were *at par* with T_7 and T_5 at harvest. The lowest dry matter production was observed in T_1 (control) plot which was comparable with T_{12} (farmers' practice). Effect of all the INM practices (T_6 to T_{11}) was observed statistically similar, however, 50% organic + 50% inorganic sources produced higher dry matter than 25% organic + 75% inorganic sources. Variation in dry matter production was 367.07 to 1458.97 g/m^2 at harvest, respectively.

Crop Growth Rate (CGR)

Crop growth rate was recorded maximum during 60-90 DAS. It was higher than the preceding and succeeding growth phases. Treatment T_6 getting recommended dose of nutrients through organic and inorganic source FYM in 50:50 proportion recorded highest crop growth rate at all the stages. It was statistically *at par* with T_7 at 90DAS-harvest stage. Variation in CGR was 2.73 to 14.29 g/m^2/day during 90 DAS harvest.

Wheat

Plant population per metre square

Plant populations per metre square (pooled data) in wheat have been presented in Table-2. It is evident from the table that plant population per metre square differed significantly at maturity of plant growth due to levels of inorganic fertilizers. Data also revealed that level of application of inorganic fertilizers and organic sources in *kharif* crop, significantly influenced plant population per metre square at harvest of wheat crop in *Rabi*. Highest number of plants per metre square was recorded treatment T_6, which was statistically *at par* with treatments T_5, T_7, T_8 and T_{10} at maturity. Plant population per metre square at maturity varied from 187 to 381 plants.

Leaf area index

Pooled data for leaf area index in wheat at 90 DAS as influenced by different treatments, have been presented in Table-2. It is evident from the table that LAI differed significantly at all the stages of plant growth due to levels of inorganic fertilizers. Leaf area index of wheat gradually increased with aging of crop and thereafter it declined. Data also revealed that level of application of inorganic fertilizers and organic sources in *kharif* crop, significantly influenced the LAI at all the stages in *Rabi* crop of wheat. Treatment T_6 getting 100% RDF (in plot of 50% N through FYM and 50%N through inorganic fertilizers during *kharif*) exhibited highest leaf area index of wheat at maturity growth stages during *rabi* season and it was statistically *at par* with the treatments T_7, T_5, T_8 and T_{10}. Variation in leaf area index (LAI) was 1.11 to 2.85 at 90 DAS, respectively.

Dry matter production

Dry matter production of wheat gradually increased with aging of crop. Maximum acceleration in growth of plants was observed from 90 DAS to harvest after sowing. Thereafter, increment rate was slow. Perusal of the data (Table-2) revealed that level of inorganic fertilizers and its integration with organic sources applied in *kharif* crop, significantly influenced dry matter production at all the stages of succeeding wheat crop in *Rabi*. The highest dry matter production was observed in treatment T_6 getting 100% RDF (in plot of 50% N through FYM and 50%N through inorganic fertilizers during *kharif*) at harvest during *Rabi* season. T_6 was *at par* with T_7 at harvest stage. The lowest dry matter production was observed in control (T_1) which comparable with farmers' practice (T_{12}). The variation in dry matter production was 311.63 to 1394.60 g/m^2 at harvest.

Crop growth rate (CGR)

CGR differed significantly at all the stages of plant growth due to levels of inorganic fertilizers. It is evident that level of inorganic fertilizers and its integration with organic sources applied in *kharif* crop, significantly influenced CGR of succeeding wheat at all the stages of crop growth in *Rabi*. Crop growth rate (CGR) was found to be higher during 60 to 90 DAS. It was lower in preceding and succeeding growth phases. The treatment (T_6) getting 100% RDF to wheat (after having received FYM in the preceding crop to supplement 50 percent N + 50 percent (inorganic) RDF exhibited the highest crop growth rate during 90 DAS– harvest. It was significantly superior to all the treatments at 90 DAS to harvest. The lowest CGR was observed in control being *at par* with farmers' practice. Variation in CGR was 1.68 to 6.57 g/m^2/day during 90 DAS to harvest, respectively.

Table 1: Long term effect of Integrated Nutrient Management on growth of maize under maize-wheat cropping system (Pooled data of 2020-21 and 2021-22)

Treatments		Maize			
***Kharif* (Maize)**	***Rabi* (Wheat)**	**Plant population/m^2 at maturity**	**Leaf Area Index at 90 DAS**	**Dry matter production (g/m^2) at harvest**	**CGR(g/m^2/day) at 90 DAS maturity**
T_1 $N_0P_0K_0$	$N_0P_0K_0$	53817	2.37	367.07	2.73
T_2 50%RDF	50%RDF	54410	3.35	789.72	3.85
$T_3$50%RDF	100%RDF	54512	3.49	858.46	3.91
T_4 75%RDF	75%RDF	54413	3.53	872.07	4.30
T_5 100%RDF	100%RDF	54810	3.77	1309.92	10.67
T_6 50%N (FYM) + 50% RDF	100%RDF	55008	3.82	1458.97	14.29
T_7 25%N (FYM) + 75% RDF	75%RDF	54909	3.79	1388.43	13.27
T_8 50%N (CPS) + 50% RDF	100%RDF	54611	3.72	1145.08	9.63
T_9 25%N (CPS) + 75% RDF	75%RDF	54611	3.65	995.92	6.92
T_{10}50%N (GKL) + 50% RDF	100%RDF	54810	3.69	1121.94	8.84
T_{11}25%N (GKL) + 75% RDF	75%RDF	54313	3.58	933.17	4.57
T_{12} Farmer's practice (urea @ 50kg/ha)	Farmer's practice (urea @ 50kg/ha)	53718	2.90	510.85	3.67
SEm±		1676.41	0.15	45.79	0.45
CD at 5%		NS	0.43	134.30	1.33
CV (%)		5.33	7.31	8.10	10.88

DAS: - Days after sowing; CPS: - Cut paddy straw; GKL: - Green karanj leaves FYM - Farm yard manure

Table 2: Long term effect of Integrated Nutrient Management on growth of wheat under maize-wheat cropping system (Pooled data of 2020-21 and 2021-22)

Treatments		Wheat			
***Kharif* (Maize)**	***Rabi* (Wheat)**	**Plant population/m^2 at maturity**	**Leaf Area Index at 90 DAS**	**Dry matter production (g/m^2) at harvest**	**CGR(g/m^2/day) at 90 DAS - maturity**
T_1 $N_0P_0K_0$	$N_0P_0K_0$	187	1.11	311.63	1.68
T_2 50%RDF	50%RDF	309	2.12	913.44	2.85
$T_3$50%RDF	100%RDF	324	2.58	1055.25	3.14
T_4 75%RDF	75%RDF	335	2.64	1047.45	3.81
T_5 100%RDF	100%RDF	364	2.80	1263.22	4.78
T_6 50%N (FYM) + 50% RDF	100%RDF	381	2.85	1394.60	6.57
T_7 25%N (FYM) + 75% RDF	75%RDF	374	2.83	1315.62	5.12
T_8 50%N (CPS) + 50% RDF	100%RDF	357	2.78	1246.99	4.26
T_9 25%N (CPS) + 75% RDF	75%RDF	340	2.75	1143.35	3.63
T_{10}50%N (GKL) + 50% RDF	100%RDF	353	2.76	1199.35	3.62
T_{11}25%N (GKL) + 75% RDF	75%RDF	337	2.73	1097.04	3.43
T_{12} Farmer's practice (urea @ 50kg/ha)	Farmer's practice (urea @ 50kg/ha)	187	1.61	532.45	2.53
SEm±		9.78	0.10	45.76	0.23
CD at 5%		28.69	0.30	134.23	0.66
CV (%)		5.28	7.17	8.42	10.35

DAS: - Days after sowing; CPS: - Cut paddy straw; GKL: - Green karanj leaves FYM - Farm yard manure

Conclusion

On the basis of above results, it may be concluded that substitution upto 50% N through FYM + 50% RDF in *kharif* and 100% RDF in *rabi* in maize–wheat cropping system was found best for higher growth of maize and wheat cultivation in chhotanagpur plateau region of Jharkhand.

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