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Effect of organics and rice-crop establishment methods on yield and nutritional performance of winter-maize

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Abstract
Rice and winter maize are two important crops of Bihar. The conventional method of establishment of paddy crop is by puddling and transplanting. Puddling is a time, labor and water-intensive practice which may benefit rice crop but has detrimental effects on succeeding *rabi* crop in terms of productivity. Therefore, puddling needs to be eliminated by substitution of proper technologies. In this background, the present investigation was carried out in sandy loam calcareous soil of Pusa in Split Plot Design replicated thrice. The main plot treatments consisted six rice crop establishment methods viz. zero tillage, dry seeded, puddled seeded using drum seeder, puddled transplanted, SRI and puddle transplanted + brown manuring while, subplot treatments involved five organic matter enrichment methods viz. mulch (rice straw) @ 10 t/ ha, vermicompost @ 3 t/ ha, 1/3rd rice crop residue incorporation, mulch @ 5 t/ ha + vermicompost @ 1.5 t/ ha, and without organic matter i.e., control. *Dhaincha* was used for brown manuring. Application of organics (mulch, vermicompost, a combination of mulch & vermicompost, and 1/3rd rice crop residue incorporation) significantly increased grain yield and total nutrient uptake. Results clearly point out the benefits of zero tillage and dry seeded rice as compared to puddle transplanted rice on grain yield of winter maize. Application of organic matter in form of paddy straw mulch/ vermicompost/ combination of mulch and vermicompost was of paramount importance for improving productivity of winter maize.

Keywords: Brown manuring, calcareous soil, puddling, winter maize

Introduction
India has the arduous task of feeding almost 17 percent of the global human and 11 percent of the livestock population on only 2.3 percent of the world's land, and the entire burden of producing enough depends upon the first few inches of the earth's crust- soil. It is estimated that by 2025, India would require 350 million tons of food grains to feed its teeming millions. This target has to be met under the constraint of an almost fixed net cultivated area hovering around 140±2 million ha since the 1970s. Ironically, the modern intensive agriculture, which was responsible for a quantum jump in the food grain production and ensured food security has led to overexploitation and degradation of natural resources like soil, water, forest, atmosphere and the genetic base.

In Bihar, out of 93.60 lacs ha of total geographical area, 56.689 lacs ha is net sown area and 6.61 lacs ha under forest. Area sown more than once is 23.27 lacs, ha, and the cropping intensity is 1.41. Rice and winter-maize are two important crops of Bihar covering an area of 3.18 and 0.26 million hectares with average productivity of 2.84 and 6.01 tons per hectare, respectively, during the year 2018-19 (Directorate of statistics and Evaluation, Bihar, 2019). The conventional method of establishment of paddy crop is by puddling and transplanting. Puddled transplanted rice is in practice for two reasons: firstly, to increase water retention by complete destruction of soil aggregates and to control weeds. Puddling is a time, labor and water-intensive practice, which may benefit rice crops but has detrimental effects on succeeding *rabi* crops in terms of productivity. Therefore, puddling needs to be eliminated by substitution of proper technologies. Direct seeded rice may be the right answer to these problems. However, it would require eco-friendly weedicides (which do not persist for long in soil) to control weeds without impairing the soil health. Rabi or winter-maize crops usually suffer from nutritional deficiencies such as phosphorus and zinc due to low soil temperature and resulting in lower productivity. Such problems need to be urgently taken care of. In the light of the above facts, the present investigation was carried out.

Material and Methods

Experimental site and design: The experiment was conducted at 25^0 – 30' N latitude and 85^0 – 40' E longitude in South Kisan Vidhya Peeth Block of Crop Research Centre of Rajendra Agricultural University, Bihar, Pusa (Samastipur) during the *rabi* season. The climate is humid sub-tropical characterized by hot summer, wet monsoon and dry cool winter. The maximum temperature goes up to 45 ^{0}C in May-June and the minimum up to 6 ^{0}C in December-January. It receives a fairly good amount of south-west monsoon with an average annual rainfall of 1270 mm, out of that nearly 1025 mm (80.75%) occurs in the monsoon months. Soil in the experimental site is calcareous, alkaline in reaction [pH (1: 2) 8.3], high in free $CaCO_3$ (34.24%), deficient in organic carbon (0.43%), poor in available N (236.0 kg ha^{-1}), P_2O_5 (19.7 kg ha^{-1}) and K^2O (106.9 kg ha^{-1}) and sufficient in available micronutrient (Zn, Cu, Fe and Mn) content with textural class of sandy loam (sand, silt and clay: 58.7, 28.8 and 11.5%, respectively; Table 1). The experiment was conducted in Split Plot Design with three replications. The main plot treatments consisted six rice crop establishment methods viz. zero tillage, dry seeded, puddled seeded using drum seeder, puddled transplanted, SRI and puddle transplanted + brown manuring while, subplot treatments involved five organic matter enrichment methods viz. mulch (rice straw) @ 10 t/ ha, vermicompost @ 3 t/ ha, 1/3rd rice crop residue incorporation, mulch @ 5 t/ ha + vermicompost @ 1.5 t/ ha, and without organic matter i.e., control. *Dhaincha* was used for brown manuring.

Table 1: Chemical properties of soil

Sl. No.	Soil characteristics	Values
1.	pH (1:2, soil : water)	8.3
2.	E.C (dSm^{-1})	1.88
3.	Organic carbon (%)	0.43
4.	Free $CaCO_3$ (%)	34.24
5.	Available N (Kg ha^{-1})	236.00
6.	Available P_2O_5 (kg ha^{-1})	19.7
7.	Available K_2O (kg ha^{-1})	106.92
8.	Available S (kg ha^{-1})	26.7
9	Available Zn (ppm)	0.802
10	Available Fe (ppm)	17.1
11	Available Cu (ppm)	1.02
12	Available Mn (ppm)	6.13
13.	Soil textural class	Sandy loam
	(a) Sand (%)	58.71
	(b) Silt (%)	28.82
	(c) Clay (%)	11.50

Plant growth parameters and total nutrient content

Plant height, plant girth, cob yield, stone yield, grain yield and stubble yield were recorded. Chlorophyll content was also recorded with the help of Chlorophyll SPAD-502 Plus.

The plant samples were washed in acidified solution followed by distilled water and oven-dried at 70 ^{0}C and then finally ground with the help of "Willey Mill". The ground plant and grain samples were digested and total N, P, K and S content were estimated with the help of procedure as outlined by Jackson (1973). For the estimation of micronutrients the ground grain, stubble and stone of maize were digested in diacid mixture of HNO_3: $HClO_4$ (9:4) and the total Zn, Fe, Cu, and Mn were determined in diacid digest by Atomic Absorption Spectrophotometer.

Statistical analysis

The data generated from the present investigation were subjected to statistical analysis using the statistical package SPSS (14.0) and Microsoft Excel. The least significant difference (LSD) at the 5 percent level was used for testing the significant difference among the treatment means.

Results and Discussion

Plant height and girth of winter-maize

Data on height and girth of winter-maize presented in Table 2 data revealed that the plant height and girth were significantly influenced both due to main plot and sub plot treatments. The plant height measured at harvest varied from 172 to 193 cm. Among the main plot treatments, zero tillage i.e. A_1 (ZT) excelled all other treatments with respect to plant height (193 cm) and girth (23.2 mm). Whereas, among sub plot treatments, mulching (M), vermicompost (Vc) and mulch with vermicompost (M + Vc) were statistically at par with respect to plant height and girth and significantly superior to control. Under subplot treatments, the highest values of plant height (203 cm) and girth (22.9 mm) were recorded in the plot receiving mulching B_1 (M). The increment in plant height due to the application of M, Vc, and M + Vc, were by 43.9%, 40.4% & 41.8%. The results are in agreement with those of Ogbona *et al.* (2012). The results obtained showed that the application of organic matter improved soil physical properties, increased chlorophyll content, and available nutrients (N, P, K, Zn, Fe, Cu & Mn) and thus enhanced growth parameters.

Cob length, diameter, and weight

Data related to cob length, diameter and weight of winter-maize are presented in Table 2. Among the main plot treatments the highest value of cob length (32.4 cm), diameter (9.0 cm) and weight (100q/ ha) was recorded in treatment A_1 (ZT), while the lowest values of cob length (30.8 cm) & diameter (8.6 cm) were recorded in A_4 (PT) and cob weight (89 q/ ha) in A_3 (PDS) & A_5 (SRI) treatments. Almost a similar trend was observed in plant height and girth of winter-maize. Among the subplot treatments, data on cob length, diameter and weight for B_1 (M), B_2 (Vc) and B_4 (M + Vc) treatments were found to be statistically at par and significantly superior to control. The interaction effect was found to be non-significant. A field study carried out by Miyamaru *et al.* (2012) [6] since 1986 to examine the effects of the long term application of organic matter on the soil properties reported that corn yield was 11 & 7% higher on soils to which had been added as green manure and compost respectively.

Table 2: Yield attributing characters of winter–maize as influenced by organics and rice-crop establishment methods

Main Plot Treatments	Plant Height (cm)	Plant Girth (cm)	Cob Length (cm)	Cob diameter (cm)	Cob weight (q/ha)
A_1 (ZT)	193	23.2	32.4	9.0	100
A_2 (DS)	191	22.8	32.0	8.9	99
A_3 (PDS)	172	21.2	31.3	8.7	89
A_4 (PT)	174	21.4	30.8	8.6	90
A_5 (SRI)	173	21.3	31.4	8.7	89
A_6 (PT + BM)	179	22.4	31.9	8.9	93
SEm±	3	0.4	0.4	0.1	2
CD	11	1.3	NS	NS	6
Sub Plot Treatments					
B1 (M)	203	24.9	32.8	9.1	105
B2 (Vc)	198	24.3	33.1	9.2	102
B3 (1/3 CR)	160	19.4	31.4	8.7	83
B4 (M + Vc)	200	24.6	33.0	9.2	103
B5 (Control)	141	17.0	27.8	7.7	74
SEm±	3	0.6	0.6	0.2	2
CD	11	1.6	1.6	0.5	7

Chlorophyll content (SPAD value)

Chlorophyll content (SPAD value) of winter-maize leaves as influenced by rice-crop establishment methods and organics has been portrayed in Table 3. The data clearly explained that chlorophyll content was significantly influenced by the main plot and subplot treatments. Chlorophyll content of winter maize varied from 43.7 to 47.8 (SPAD Value) due to rice-crop establishment methods and the highest value of (47.8) was obtained in zero tillage (ZT), at par with A_2 (DS), and the minimum was recorded under A_3 (PDS) i.e. (43.7). Under subplot treatments, chlorophyll content significantly increased in all the treatments with the incorporation of organics applied in the form of mulching/ vermicompost/ mulch + vermicompost/ 1/3rd of crop residue. The interaction effect was recorded statistically non-significant. Maximum chlorophyll content (51.0) was recorded with B_1 (M) which was at par with B_2 (49.8) and B_4 (50.5) and the minimum chlorophyll content (34.4) with B_5 (control). The order of chlorophyll content under subplot treatments was:

B_1 (51.0) = B_4 (50.5) = B_2 (49.8) > B_3 1/3rd (39.6) > B_5 (34.4)

Application of organic matter enriched the soil in different nutrients and improved overall soil physical conditions which may be attributed to higher chlorophyll content in these plots. The results are comparable with the findings of Gosavi *et al.* (2009) [3]. It is one of the most important yield contributing characters of the plant, which is directly related to the rate of photosynthesis.

Table 3: Chlorophyll content and yield (Grain, stover, and stone) of winter–maize as influenced by organics and rice-crop establishment methods

Main Plot Treatments	Chlorophyll content (SPAD value)	Grain yield (q/ha)	Stover yield (q/ha)	Stone yield (q/ha)
A_1 (ZT)	47.8	60.5	99	10.3
A_2 (DS)	46.9	59.4	97	10.3
A_3 (PDS)	43.7	55.3	90	9.3
A_4 (PT)	44.1	55.8	88	9.4
A_5 (SRI)	43.8	55.4	88	9.5
A_6 (PT + BM)	44.0	58.5	91	9.6
SEm±	0.9	1.1	1.8	0.2
CD	2.7	3.5	6.0	0.6
Sub Plot Treatments				
B1 (M)	51.0	65.0	105	10.9
B2 (Vc)	49.8	63.5	101	10.8
B3 (1/3 CR)	39.6	50.5	81	8.4
B4 (M + Vc)	50.5	64.1	102	10.2
B5 (Control)	34.4	44.3	72	8.4
SEm±	1.1	1.5	2.3	0.2
CD	3.2	4.1	7.0	0.7

Grain, stover and stone yield

The yield data on grain, stover, and stone of winter-maize as influenced by rice-crop establishment methods and organics have been presented in Table 3. Data on grain, stover and stone yield showed significant variations due to different treatments. The data showed that grain yield of winter-maize varied from 55.3 to 60.5 q/ ha due to rice-crop establishment methods. The highest grain yield of 60.5 q/ ha was registered in A_1 (ZT), statistically at par with A_2 (DS) and A_6 (PT + BM), and the lowest grain yield of 55.3 q/ ha was registered in A_3 (PDS). In a long term study conducted (1991 to 2000) under rice-wheat cropping system in vetisols at Jabalpur, in M.P results indicate that puddling during rice deteriorated the soil physical environment for subsequent wheat crops compared to under direct-seeded paddy plots. A significantly higher yield of wheat was recorded in direct-seeded as compared to transplanted paddy plots and the overall productivity of the system was higher under reduced tillage conditions i.e. direct-seeded paddy followed by zero till wheat (Sharma and Tomar, 2002) [8]. Similar results were reported by workers viz. Sharma and Tomar, 2002 [8] in various soils and climate conditions.

Grain yield of winter-maize increased significantly with the addition of organic matter in the form of vermicompost, mulching, and a combination of the two under subplot treatments. Grain yield varied from 44.3 to 65.0 q/ ha. Among subplot treatments, the maximum grain yield of 65q/ ha was obtained with B_1 (M), which was at par with B_2 (Vc) and B_4 (M + Vc). Percent increase in grain yield due to application of mulch (B_1), vermicompost (B_2), and combination of the two (B_4) over control (B_5) plot was 46.7, 43.3, and 44.6%, respectively.

Likewise, the highest stover and stone yield were recorded in A_1 (ZT), which at par with A_2 (DS) and significantly superior to A_3 (PDS). Among subplot treatments, B_1 (M), B_2 (Vc), and B_4 (M + V_c) were statistically at par and significantly superior to B_5 (control). Thus, similar trends of data on stover and stone yield were observed as in grain yield. The interaction effect was found to be non-significant. The results suggested that organic source can improve the plant growth attributes, chlorophyll content, soil moisture availability, water-stable aggregates and nutrient availability and were finally reflected in increased grain, stover and stone yield of the crop. Similar results were reported by Gosavi *et al* (2009) [3], Jalali *et al.* (2011) [4] and Ogbonna *et al.* (2011) [7]. Organic matter is a key component in the build upon maintenance of a high quality of soil.

Total major nutrients and Sulphur uptake

The total N uptake by winter-maize as influenced by rice-crop establishment methods and organics has been presented in Table 4. The observations recorded for this trait showed significant variations among different treatments. The data explained that total N uptake by winter-maize varied significantly in the range of 150 and 170 kg/ ha due to different rice-crop establishment methods. The highest N uptake (170 kg/ ha) was registered in A_1 (ZT), statistically at par with A_2 (DS), while the lowest (150 kg/ ha) was registered in A_3 (PDS). The total N uptake by winter-maize increased significantly with the addition of organic matter in the form of vermicompost, mulching and combination of two under subplot treatments over control. The total N uptake varied from 120 to 180 kg/ ha due to subplot treatments. Among subplot treatments, highest total N uptake (180 kg/ ha) was obtained with B_1 (M), which was found statistically at par with B_2 (Vc) and B_4 (M + Vc) and significantly superior to control. The interaction effect was found to be non-significant. A similar trend was observed for total P, K and S uptake.

Nutrients uptake by winter-maize crop in treatments involving rice crop establishment methods of zero tillage (ZT) and dry seeded (DS), which require minimum or no soil disturbance recorded higher values as compared to treatments involving puddling and the reason may be assigned to the fact that ZT and DS treatments maintained better soil conditions and thereby improved nutrient availability which in turn resulted in higher crop yield and therefore higher nutrients uptake. Addition of organic matter either in the form of mulch or vermicompost or crop residue upon decomposition releases different nutrients and also releases CO2 which dissolves free $CaCO_3$ and thus nutrients fixed therein are released to improve the available nutrient status of the soil resulting in better supply and uptake of the nutrients by plants. Further use of organic mulches during the winter season has been reported to improve the hydrothermal regime of soils, which favor nutrient availability. (Ghildyal and Gupta, 1991; Tripathi and Tomar, 2002) [2, 9].

Table 4: Major nutrients and Sulphur uptake by winter–maize as influenced by organics and rice-crop establishment methods

Main Plot Treatments	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total K uptake (kg/ha)	Total S uptake (kg/ha)
A_1 (ZT)	170	48	128	41.3
A_2 (DS)	168	47	125	40.5
A_3 (PDS)	151	42	113	36.5
A_4 (PT)	150	43	111	36.5
A_5 (SRI)	152	43	113	36.8
A_6 (PT + BM)	163	45	120	39.6
SEm±	1.6	0.4	1.3	0.4
CD	5.0	1.0	4.0	1.3
Sub Plot Treatments				
B1 (M)	180	50	134	43.5
B2 (Vc)	174	50	132	43.1
B3 (1/3 CR)	142	39	103	33.5
B4 (M + Vc)	180	50	133	43.6
B5 (Control)	120	34	89	29.0
SEm±	2.1	0.5	1.6	0.5
CD	6.0	2.0	5.0	1.5

Total uptake of micronutrients (Zn, Cu, Fe & Mn)

Data on total Zn uptake by winter-maize, presented in Table 5, varied from 323 to 370 g/ ha and 260 to 388 g/ ha due to rice-crop establishment methods and organics, respectively. Among rice-crop establishment methods the effect of A1 (ZT) was more pronounced followed by A2 (DS) and A6 (PT + BM). The highest total Zn uptake of 370 g/ ha by winter–maize was obtained at treatment A1 (ZT) and the lowest total Zn uptake of 323 g/ ha was obtained in treatment A4 (PT). A similar trend was observed for Cu, Fe and Mn. Among the organic matter enrichment, maximum total Zn uptake (388 g/ ha) was recorded with B_1 (M), which was at par with B_2 (383 g/ ha) and B_4 (387 g/ ha) whereas, minimum (260 g/ ha) under B_5 (control). Among organic sources the effect of mulching vermicompost and mulch with vermicompost was found superior which might be due to the fact that organic matter in soil might have enhanced the uptake of applied as well as native zinc by the crop through its influence on solubility and availability in soil. The results are in conformity with the findings of Walia *et al.*, (2010).

Table 5: Micronutrients uptake by winter–maize as influenced by organics and rice-crop establishment methods

Main Plot Treatments	Total Zn uptake (g/ha)	Total Cu uptake (g/ha)	Total Fe uptake (g/ha)	Total Mn uptake (g/ha)
A_1 (ZT)	370	124	2166	260
A_2 (DS)	362	120	2108	253
A_3 (PDS)	326	109	1907	229
A_4 (PT)	323	107	1869	225
A_5 (SRI)	328	109	1902	228
A_6 (PT + BM)	350	116	2023	243
SEm±	3	1.0	24	2.6
CD	10	4.0	77	8.0
Sub Plot Treatments				
B1 (M)	388	129	2259	271
B2 (Vc)	383	127	2225	267
B3 (1/3 CR)	298	99	1736	208
B4 (M + Vc)	387	129	2252	270
B5 (Control)	260	86	1506	181
SEm±	4	2.0	31	3.3
CD	12	5.0	89	10.0

Conclusion
It may be prudent to to adopt zero tillage method of rice crop establishment with a view to boost the yield of the ensuing winter-maize crop. Further that application of organic matter/ manure such as paddy straw @ 10 t/ha in the form of mulch or verimicompost @ 3 t/ ha or combination of the two (paddy straw @ 5 t/ ha in the form of mulch+vermicopost@ 1.5t/ha) along with 100% recommended dose of fertilizers in winter-maize would be of great significance from the view point of substantial yield increment.

References
1. Directorate of Statistics and Evaluation, Bihar, Patna, 2019.
2. Ghildyal BP, Gupta RP. Effect of application of crop residues, FYM and gypsum on water stable aggregates in different soils. Soil Structure Problems and management, 1991, 22.
3. Gosavi SP, Chavan SA, Bhagat SB. Effect of mulches, fertilizer and levels of FYM on yield attributes and yield of *rabi* sweet corn (*Zea mays* saccharata). Journal of Soils and Crops. 2009; 19:84-87.
4. Jalali AH, Bahrani MJ, Karimian N. Effect of crop residue management, 2011.
5. Application of compost and nitrogen fertilizer on grain yield and its components in maize cv. DC370. Iranian Journal of Crop Sciences. 2011; 13:336-351
6. Miyamaru N, Iha S, Gima Y, Kameya S, Toyota K. Effects of long-term application of green manure and compost on the physical, chemical and biological properties of Jahgaru soil in Okinawa. Japanese Journal of Soil Science and Plant Nutrition. 2012; 83:280-287.
7. Ogbonna DN, Isirimah NO, Princewill E. Effect of organic waste compost and microbial activity on the growth of maize in the utisoils in Port Harcourt, Nigeria. African Journal of Biotechnology. 2012; 11:12546-12554.
8. Sharma SK, Tomar SS. Rice-wheat cropping system production technology through minimum tillage in Vertisols. Abs. In Proceedings of 67th Annual Convention of ISSS on Development in Soil Science 2002 held at JNKVV, Jabalpur, MP. India during Nov. 11-15, 2002, 9-10.
9. Tripathi RP, Tomar VS. Soil air and soil temperature. In: Fundamentals of soil Science, 2002, 111-125. Indian Society of Soil Sciences, New Delhi, India