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RESEARCH PAPER

Soil physico-chemical properties and nutrient balance as influenced by integrated weed and nutrient management in a transitional plain zone of Luni basin of Rajasthan

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Abstract: An experiment was conducted during *Kharif* 2019 and 2020 at Instructional Farm, College of Agriculture, Sumerpur (Rajasthan) to study the impact of integrated methods of weed management and organic nutrient sources on the nutrient balance sheet after harvest of maize (*Zea mays* L.). The experiment comprised 6 weed management and 5 nutrient management practices in a split-plot design with three replications. The treatments stale seedbed + hoeing once at 20 DAS + application of 5 t/ha straw mulch at 30 DAS and weed-free check maintained up to 60 DAS of maize was found significantly effective in increasing the crop productivity but improved the above properties non significantly over rest of treatments. The soil chemical properties *viz*., pH, EC, and available nutrients *viz*., N, P_2O_5, K_2O, Zn, and Fe in soil did not influence significantly by various weed management treatments after harvesting of maize except for organic carbon content. The nutrient balance was negative but the minimum was in weed-free check and stale seedbed + hoeing at 20 DAS + straw mulch at 30 DAS. Among the organic nutrient management treatments, 75% RDN through vermicompost in two splits + seed treatments with *beejamurt* + two sprays of *jeevamurt* did not affect the soil physio-chemical properties *viz*., pH & EC and available nutrients (Fe and Zn) in the soil after harvest of maize was remained unaffected while the available NPK and organic carbon of soil was influenced significantly during the study period. The treatment of 100% RDN through FYM gave the mean maximum values of these parameters while the lowest was recorded in the treatment of 75% RDN through vermicompost + seed treatment with *beejamurt* + two sprays of *jeevamurt* (at 500 l/ha at sowing and 30 DAS). The balance sheet indicated that the minimum net loss of nitrogen was in 100% RDN through vermicompost while minimum net loss of phosphorus and potassium gain were recorded at 100% RDN through FYM at the end of the experiment. The mean soil available nitrogen, phosphorus, and organic carbon were also significantly increased in this treatment.

Keywords: *Beejamurt* · FYM · *Jeevamurt* · Physical soil properties · Stale seedbed · Straw mulch · Vermicompost · Yield

Introduction

Organic farming is being practiced in 187 countries on a 72.3 M ha area showing a 1.6% increase over 2018. In India, the cultivable area under organic certification is only 2.30 M ha, which is around 1.6% of the net cultivated area of the country besides having the maximum number of registered organic producers (13.33 million) during 2019 (FIBL and IFOAM, 2021). Rajasthan has the highest area (4.82 lakh hectares) in organic farming after Madhya Pradesh. The maize occupied a consistent area (8.75 lakh ha) in Rajasthan where it is grown during *Kharif* as rainfed and irrigated during the *Rabi* season with a production of 11.35 lakh tonnes (Vital Agriculture Statistics, 2019–20). The decreasing or stagnating in seed yields has been attributed to imbalances of nutrients and multiple-nutrient

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deficiencies which created a serious threat to the long-term sustainability of crop production (Karunakaran and Behera, 2013). Developing and implementing tillage, mulching, organic nutrients and organic concoction strategies to maintain the quality of soil is of utmost need to enhance the performance and sustainability of an agro-ecosystem. The benefits of using tillage, mulching, organic nutrients, and organic concoction in maintaining soil quality have been increasingly recognized (Shukla *et al*., 2011).

The mineralization through soil microorganisms maintains the long-term sustainability of agricultural eco-systems and are important factors in nutrient cycling. The physico-chemical properties of the soil are greatly altered by organic nutrient management practices and by maintaining mulches on the soil surface. Some researchers have shown that the incorporation of organic manures increased soil-microbial activity and densities of bacteria (Pawar *et al.,* 2012). The most of research indicated increased microbial diversity in soils from organic farming systems compared to conventional farming systems (Shannon *et al.,* 2006). Since information on the effect of organic weed and nutrient management practices on maize is very scanty as it is an exhaustive crop, the present experiment was undertaken to study their effects on nutrient uptake and soil chemical properties in western Rajasthan.

Materials and methods

Geographically, the experimental site is situated in the western part of Rajasthan at 25°09' N latitude and 73°04' E longitude with at an elevation of 297.7 m above mean sea level. The region has a typical semi-arid and sub-tropical climate characterized by mild winter and moderate to high summers, associated with mild relative humidity, especially during the months of July to September. The total rainfall received during the crop season of *Kharif* 2019 and 2020 was 636.9 mm and 473.5 mm, respectively. The experiment was conducted in a split-plot design where six weed management and five organic nutrient management treatments were replicated thrice. The gross sub-plot size was 18 m^2 while the main plot size was 90 m^2. The maize crop was cultivated as per recommended package of practices and supplied 90 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha using the recently notified maize cultivar Pratap Hybrid Maize 3 at the seed rate of 25 kg/ha. The layout of the experimental site was prepared well in advance to incorporate the recommended quantity of well rotten FYM and vermicompost in respective sub-plots as per treatment (Table 1), spread and mixed properly and irrigation was provided to prepare a stale seedbed. The black polythene of 25 microns was spread and punctured at the prescribed distance at the time of the sowing of maize. The intercultural practices were performed as per treatments at 20 and 40 DAS while the straw was spreaded at the rate of 5 t/ha at 30 DAS. The fermented organic products i.e. *jeevamurt* (Aulakh *et al*., 2013) and *beejamurt* (Shyamsunder and Menon, 2021) were locally prepared and applied @ 500 l/ha as per treatment at the time of sowing and 30 DAS. The details of the experimental units are as follows:

A. Weed management through tillage and mulch

W_1 - Stale seedbed (SS) + two hoeing at 20 & 40 DAS,

W_2 - SS + hoeing with power weeder at 20 DAS + hoeing once manually at 40 DAS,

W_3 - SS + hoeing once manually at 20 DAS + straw mulch (5 t/ha) at 30 DAS,

W_4 - SS + black plastic mulch at sowing (25 microns),

W_5 - Weed free check (up to 60 DAS) and

W_6 - Weedy check

B. Nutrient management through organics sources and concoction

N_1 - 100% recommended dose of nitrogen (RDN) through FYM,

N_2 - 75% RDN through FYM + seed treatment with *beejamrut* + two sprays of *jeevamrut* @ 500 l/ha at sowing and 30 DAS,

N_3 - 100% RDN through vermicompost,

N_4 - 75% RDN through vermicompost as basal + seed treatment with *beejamrut* + two sprays of *jeevamrut* @ 500 l/ha at sowing and 30 DAS and

N_5 - 75% RDN through vermicompost (75% as basal + 25% as a top dress at 30 DAS) + seed treatment with *beejamrut* + two sprays of *jeevamrut* @ 500 l/ha at sowing and 30 DAS.

Soil samples were taken from each experimental unit up to 30 cm depth and were dried, ground to pass through a 2 mm sieve, and analyzed for pH, EC, organic carbon (%), available nitrogen, phosphorus, potassium, zinc, and

Table 1. The average composition of organic inputs used for experimental purpose

Particulars	Vermicompost	FYM	Method employed
Available N (%)	1.53	0.48	Modified Kjeldahl method (Jackson, 1973)
Available P_2O_5 (%)	0.43	0.23	Vanadomolybdate yellow color method (Jackson, 1973)
Available K_2O (%)	2.09	0.51	Wet oxidation method (Jackson, 1973)

Table 2. Initial chemical properties of the soil

Soil parameters	2019–20	References
Soil pH (1:2.5 soil: water suspension)	7.92	Glass electrode pH meter (Richards, 1968)
EC (dS/m at 25^o C)	0.43	Conductivity bridge meter (Richards, 1968)
Organic carbon (%)	0.26	Rapid titration method (Walkley and Black, 1934)
Organic matter (%)	0.45	By factor (1.724)
Available nitrogen (kg/ha)	198.7	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg/ha)	26.6	Olsen's method (Olsen *et al.*, 1954)
Available K_2O (kg/ha)	260.0	Flame photometer (Richards,1968)
Available Zn (ppm)	0.42	DTPA-extract with AAS (Lindsay and Norvell, 1978)
Available Fe (ppm)	4.10	DTPA-extract with AAS (Lindsay and Norvell, 1978)

iron before and after maize harvest during both years as per methods mentioned in Table 2.

Results and discussion

Effect on soil chemical properties

Two years' mean data on various soil chemical properties i.e. pH, EC, and organic carbon content in the soil after harvest of maize under different weed management and organic nutrient management practices are presented in Table 3. The various weed management and organic nutrient management treatments applied to maize were found to non-significantly affected the value of pH and EC of soils after harvest of maize in individual as well as in pooled analysis however significantly the available organic carbon status of the soil. The significantly higher organic carbon was found with the application of straw mulch and was at par to stale seedbed + hoeing twice at 20 & 40 DAS and statistically superior over the rest of the treatments while 100% RDN through FYM (0.28%) as against the minimum in 75% RDN through vermicompost as basal application + organic concoction [75% RDN VC (2 splits) + STM + JM (T)] (0.26%) and was also statistically at par to rest of all other treatment. Organic manures improved the physico-chemical properties of soil and results in better utilization and movement of nutrients towards crop (Onte *et al.,* 2019).

Available nutrient status

The data presented in Table 3 reflected that weed management treatments applied to maize failed to affect the soil available N, P, and K status significantly after the harvest of the crop. However, different organic nutrition applied to maize significantly affected the available nutrients in the soil. The available N, P, and K were 3.5, 15.4, and 2.9% higher than 100% RDN through FYM as against a minimum of 75% RDN through vermicompost as basal application organic concoction [75% RDN VC + ST BM + JM (T)].

The various weed management and nutrient management treatments failed to exert any significant effect on the available Zn and Fe status of soil after the harvest of maize (Table 3). This might be ascribed to the fact that the recommended dose of organic manures applied to soil maintained nutrient supply and fertility of the soil due to slow mineralization of organic manures particularly FYM resulting in significant differences in post-harvest soil properties. Organic concoction performed better for improving the biochemical properties of soil by enhancing microorganism population through increased root exudates, and biomass and ultimately provides carbon and energy to the soil microbes resulting in the proliferation of microbial population and increased nutrients in soil pool (Singh *et al*., 2019). The organic concoction plays an important role through its regulatory

Table 3. Effect of organic weed and organic nutrient management practices on soil properties after maize harvest (pooled data of two years)

Treatment	pH	EC (dS/m)	Organic carbon (%)	Available nutrients N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Fe (ppm)	Zn (ppm)
*Weed management**								
SS + HT at 20 & 40 DAS	7.92	0.43	0.28	190.8	24.5	295.6	4.10	0.42
SS + H with power weeder at 20 DAS + HO at 40 DAS	7.82	0.43	0.27	190.8	24.6	296.5	4.04	0.43
SS + Hoeing once at 20 DAS + Straw mulch at 30 DAS	7.80	0.43	0.29	193.8	25.0	296.2	4.05	0.43
SS + Plastic mulch at sowing	7.73	0.42	0.27	194.1	24.6	295.9	4.02	0.42
Weedy check	7.66	0.42	0.26	189.3	24.2	295.4	3.96	0.41
Weed free check up to 60 DAS	7.74	0.42	0.27	195.0	25.1	297.2	3.95	0.43
SEm (±)	0.06	0.01	0.00	2.32	0.25	1.3	0.04	0.01
CD (P=0.05)	NS	NS	0.01	NS	NS	NS	NS	NS
*Nutrient management***								
100% RDN FYM	7.82	0.43	0.28	194.6	26.4	301.1	3.96	0.42
75% RDN FYM + ST BM + JM (T)	7.81	0.42	0.27	193.7	25.1	298.7	4.02	0.42
100% RDN VC	7.72	0.42	0.27	193.7	24.4	295.5	4.01	0.43
75% RDN VC + ST BM + JM (T)	7.71	0.42	0.27	188.1	22.9	292.5	4.05	0.42
75% RDN VC (2 splits) + ST .M + JM (T)	7.82	0.42	0.26	190.9	24.4	292.8	4.05	0.43
SEm (±)	0.04	0.00	0.00	1.33	0.16	1.06	0.03	0.01
CD (P=0.05)	NS	NS	0.01	3.74	0.45	2.97	NS	NS

*Stale seed bed (SS), two hoeing (HT), Days after sowing (DAS), hoeing once (HO),
** Recommended dose of nitrogen (RDN), Seed treatment with *beejamrut* (ST) and two spray of *jeevamrut* @ 500 l/ha at sowing and 30 DAS JM (T), FYM (Farm yard manure, Vermicompost (VC), 2 splits (75% as basal + 25% as a top dress at 30 DAS).

and bio-stimulatory effect on plant growth and development besides supplying a small amount of nutrients at critical growth stages as a foliar spray (Kumar *et al.*, 2005).

Nutrient balance sheet

The balance sheet of various nutrients in soils are presented in Tables 4–6. The results showed that the net nitrogen and phosphorus balance in soil remained negative in all weed management as well as in organic nutrition treatments during both years. Though, the net nitrogen and phosphorus loss were lowest under treatment weed-free check after completion of the experiment i.e., *Kharif* 2020 (-0.50 and -2.70 kg/ha, respectively) followed by stale seedbed + hoeing once at 20 DAS + straw mulch at 30 DAS as against maximum in weedy check -6.40 and -3.30 kg/ha, respectively). Among the nutrient management treatments, the maximum net losses of nitrogen were occurred in the treatment of 75% RDN through vermicompost as basal application + organic concoction [75% RDN VC + ST BM + JM (T)] (-7.70 and -4.70 kg/ha, respectively) as against the minimum losses was in 100% RDN through FYM (-1.77 and -1.13 kg/ha, respectively). Unlike to nitrogen and phosphorus, the actual potassium balance in soil was positive in weed management through mulching and tillage during both years. Though, the actual potassium balance (gain) in soil was highest under treatment weed-free check up to 60 DAS (16.15 kg/ha) followed by stale seedbed + hoeing once at 20 DAS + straw mulch at 30 DAS as against the minimum net gain in weedy check (13.81 kg/ha). The minimum net gain of potassium was recorded in the treatment of 75% RDN through vermicompost as basal application organic concoction [75% RDN VC + ST BM + JM (T)] (11.49 kg/ha) while the treatment of 100% RDN through FYM recorded a maximum gain (20.02 kg/ha). The application of vermicompost and FYM recorded more growth and yield attributes might be due to the expected higher nutrient balance with organic sources. Similar results were reported by Meena *et al.* (2011). The organic matter used as mulch and organic manures as a nutrient source restore humus status of the soil ecosystem to hold its fertility and productivity resulting into a net gain of

Table 4. Effect of different treatments on nitrogen (kg/ha) balance after harvest of maize

Treatment	Initial status (A)		Added (B)	Uptake by weeds (C)		Uptake by crop (D)		Expected balance (E) E=A+B-C-D		Actual balance (F)		Apparent gain (G) G= F–E		Net gain (H) H=F–A	
	2019	2020		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Weed management															
SS + HT at 20 &40 DAS	198.7	197.3	76.5	5.7	5.0	92.0	96.0	188.9	182.8	189.6	192.1	0.7	9.3	-9.1	-5.2
SS + H with power weeder at 20 DAS + HO at 40 DAS	198.7	197.3	76.5	6.1	5.4	89.7	94.3	191.6	184.9	189.8	191.9	-1.8	7.0	-8.9	-5.4
SS + Hoeing once at 20 DAS + Straw mulch at 30 DAS	198.7	197.3	76.5	4.4	3.6	94.9	100.2	184.7	177.2	192.1	195.4	7.4	18.2	-6.6	-1.9
SS + Plastic mulch at sowing	198.7	197.3	76.5	0.0	0.0	91.7	95.1	183.5	178.7	192.9	195.4	9.4	16.7	-5.8	-2.0
Weedy check	198.7	197.3	76.5	38.8	37.2	66.1	70.5	247.9	240.5	187.7	191.0	-60.2	-49.5	-11.0	-6.4
Weed-free check up to 60 DAS	198.7	197.3	76.5	3.8	3.1	98.7	103.2	180.3	173.7	193.3	196.8	13.0	23.1	-5.4	-0.5
Nutrient management															
100% RDN FYM	198.7	197.3	90.0	12.4	11.4	81.9	85.7	219.1	213.1	193.6	195.5	25.5	17.5	-5.1	-1.8
75% RDN FYM + ST BM + JM (T)	198.7	197.3	67.5	11.8	10.9	85.2	90.4	192.8	185.3	192.2	195.1	0.6	-9.8	-6.5	-2.2
100% RDN VC	198.7	197.3	90.0	12.0	11.1	88.8	93.5	211.9	204.9	192.4	195.9	19.5	8.9	-6.3	-1.4
75% RDN VC + ST BM + JM (T)	198.7	197.3	67.5	11.5	10.6	91.5	95.7	186.2	179.7	186.7	189.6	-0.5	-9.8	-12.0	-7.7
75% RDN VC (2 splits) + ST B.M + JM (T)	198.7	197.3	67.5	11.1	10.2	96.8	100.8	180.5	174.2	189.5	192.4	-9.0	-18.1	-9.2	-4.9

Table 5. Effect of different treatments on phosphorus (P_2O_5 kg/ha) balance after harvest of maize

Treatment	Initial status (A)		Added (B)	Uptake by weeds (C)		Uptake by crop (D)		Expected balance (E) E=A+B-C-D		Actual balance (F)		Apparent gain (G) G= F–E		Net gain (H) H=F–A	
	2019	2020		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Weed management															
SS + HT at 20 & 40 DAS	26.6	27.8	27.6	1.3	1.1	17.1	18.5	38.4	38	24.1	24.8	-14.3	-13.2	-2.5	-3.0
SS + H with power weeder at 20 DAS + HO at 40 DAS	26.6	27.8	27.6	1.4	1.2	16.5	18.1	39.1	38.5	24.3	24.8	-14.8	-13.7	-2.3	-3.0
SS + Hoeing once at 20 DAS + Straw mulch at 30 DAS	26.6	27.8	27.6	1.0	0.9	17.9	19.5	37.3	36.8	24.9	25.0	-12.4	-11.8	-1.7	-2.8
SS + Plastic mulch at sowing	26.6	27.8	27.6	0.0	0.0	17.1	18.2	37.1	37.2	24.3	24.9	-12.8	-12.3	-2.3	-3.0
Weedy check	26.6	27.8	27.6	9.8	9.2	12.4	13.4	51.6	51.2	23.6	24.8	-28	-26.4	-3.0	-3.0
Weed-free check up to 60 DAS	26.6	27.8	27.6	0.8	0.6	18.6	20.1	36.4	35.9	25.0	25.1	-11.4	-10.8	-1.6	-2.7
Nutrient management															
100% RDN FYM	26.6	27.8	43.0	3.0	2.7	15.2	16.6	57.5	57.0	26.2	26.7	31.3	30.3	-0.4	-1.1
75% RDN FYM + ST BM + JM (T)	26.6	27.8	32.3	2.8	2.6	15.9	17.4	45.9	45.3	24.8	25.3	21.1	20.0	-1.8	-2.5
100% RDN VC	26.6	27.8	25.0	3.0	2.7	16.7	18.0	37.9	37.5	24.2	24.7	13.8	12.8	-2.4	-3.1
75% RDN VC + ST BM + JM (T)	26.6	27.8	18.8	2.7	2.5	17.2	18.5	31.0	30.6	22.6	23.1	8.3	7.5	-4.0	-4.7
75% RDN VC (2 splits) + ST B.M + JM (T)	26.6	27.8	18.8	2.7	2.4	18.1	19.4	29.9	29.6	24.1	24.6	5.8	5.0	-2.5	-3.2

Table 6. Effect of different treatments on potassium (K_2O kg/ha) balance after harvest of maize

Treatment	Initial status (A)		Added (B)	Uptake by weeds (C)		Uptake by crop (D)		Expected balance (E) E=A+B-C-D		Actual balance (F)		Apparent gain (G) G= F–E		Net gain (H) H=F–A	
	2019	2020		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Weed management															
SS+ HT at 20 & 40 DAS	260.0	283.0	95.1	5.29	4.63	91.2	95.9	269.2	286.8	293.7	297.6	24.5	10.8	33.7	14.6
SS + H with power weeder at 20 DAS + HO at 40 DAS	260.0	283.0	95.1	5.74	5.08	89.9	95.3	270.9	287.9	295.0	297.9	24.1	10.0	35.0	14.9
SS + Hoeing once at 20 DAS + Straw mulch at 30 DAS	260.0	283.0	95.1	4.4	3.8	90.8	96.1	268.7	285.8	293.8	298.7	25.1	12.9	33.8	15.7
SS + Plastic mulch at sowing	260.0	283.0	95.1	0	0	88.7	93.7	266.4	284.4	294.0	297.9	27.6	13.5	34.0	14.9
Weedy check	260.0	283.0	95.1	42.7	41.1	73.9	78.7	323.9	340.5	293.9	296.8	-30.0	-43.7	33.9	13.8
Weed-free check up to 60 DAS	260.0	283.0	95.1	3.29	2.67	93.8	98.6	264.6	282.2	295.2	299.2	30.6	17.0	35.2	16.2
Nutrient management															
100% RDN FYM	260.0	283.0	96.0	13.02	12.18	81.8	87.4	287.2	303.8	299.1	303.0	-11.9	0.7	39.1	20.0
75% RDN FYM + ST BM + JM (T)	260.0	283.0	72.0	12.11	11.28	86.2	91.9	258.0	274.4	296.8	300.7	-38.8	-26.3	36.8	17.7
100% RDN VC	260.0	283.0	123.0	12.91	12.06	88.7	93.5	307.2	324.5	294.0	297.0	13.2	27.6	34.0	14.0
75% RDN VC + ST BM + JM (T)	260.0	283.0	92.3	11.77	10.97	90.0	94.9	274.1	291.4	290.6	294.5	-16.5	-3.1	30.6	11.5
75% RDN VC (2 splits) + ST B.M + JM (T)	260.0	283.0	92.3	11.61	10.8	93.5	97.5	270.4	288.6	290.8	294.7	-20.4	-6.1	30.8	11.7

nutrients as compared to the rest of the treatments. These organics also maintain the nutrients for a longer period and realize higher nutrient status in the soil after the harvest of the crop. The residual soil nutrient status was maintained with organic nutrient management practices because they enable greater uptake of nutrients by crop, the balance with slow mineralization from the organic sources, which maintained or enhanced the soil nutrient status (Jeyaselvin Inbaraj, 1995). With judicious application of organic matter, the leaching and fixation of nutrients could be reduced and moreover sustain soil fertility and yield.

Conclusion

The organic weed management through tillage and mulching significantly increased the yield as against their respective checks. The crop feed through organic nutrients along with fermented organic products was found beneficial in terms of increasing yield besides improving soil status. The application of organic mulch and FYM helped to maintain the health of the soil as compared to the rest of the treatments either applied as weed management or nutrient management.

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