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Short Communication

Impact of organic weed and nutrient management practices on soil physico-chemical properties and nutrient balance in Maize (*Zea mays* L.) of western Rajasthan

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Organic farming is being practiced in 187 countries on 72.3 M ha area showed 1.6 percent increase over 2018. In India, the cultivable area under organic certification is only 2.30 M ha, which is around 1.6 percent of net cultivated area of the country besides having maximum number of registered organic producers (13.33 million) during 2019 (FIBL and IFOAM, 2021). In the country, the state of Rajasthan has highest area (4.82 lakh hectares) in organic farming and stood second after Madhya Pradesh. The maize occupied consistent area (8.75 lakh ha) in Rajasthan where it is grown during *kharif* as rainfed and irrigated during *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 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 are 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 a long-term sustainability of agricultural eco-systems and are important factors in nutrient cycling. The physico-chemical properties of the soil greatly altered by organic nutrient management practices and by maintaining mulches on soil surface. Some researchers have shown that incorporation of organic manures increased soil-microbial activity and densities of bacteria (Pawar *et al.,* 2013). 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 effect on 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.

Geographically, the experimental site is situated in the western part of Rajasthan at $25^{0}09'$ N latitude and $73^{0}04'$ 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 the *kharif* 2019 and *kharif* 2020 was 636.9 mm and 473.5 mm, respectively. The experiment was conducted in split plot design where six weed management and three organic nutrient management treatments were replicated thrice.

The gross sub plot size was 18 m^2 while 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^{-1}using recently notified maize cultivar Pratap Hybrid Maize 3 at the seed rate of 25 kg ha^{-1}. The lay out of the experimental site was prepared well in advance to incorporate the recommended quantity of well rotten FYM and vermicompost in respective subplots as per treatment (Table 1), spread and mixed properly and irrigation is provided to prepare stale seedbed. The black polythene of 25 micron was spread and punctured at prescribed distance at the time of 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^{-1}at 30 DAS. The fermented organic products i.e.*jeevamurt*(Aulakh*et al.*, 2013)and *beejamurt*(Shyamsunder and Menon, 2021)was locally prepared and applied @ 500 l ha^{-1} as per treatment at the time of sowing and 30 DAS. The details of experimental units are as follows:

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^{-1}) at 30 DAS,

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

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

W_6-Weedy check

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 spray of *jeevamrut* @ 500 l ha^{-1}at sowing and 30 DAS,

N_3-100% RDN through vermicompost,

N_4-75% RDN through vermicompost as basal + seed treatment with *beejamrut* + two spray of *jeevamrut* @ 500 l ha^{-1}at sowing and 30 DAS and

N_5-75 % RDN through vermicompost (75% as basal + 25% as top dress at 30 DAS) + seed treatment with *beejamrut* + two spray of *jeevamrut* @ 500 l ha^{-1}at sowing and 30 DAS.

Table 1: 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)

Soil samples were taken from each experimental unit up to 30 cm depth and were dried, ground to pass through 2 mm sieve and analyzed for pH, EC, organic carbon (%), available nitrogen, phosphorus, potassium, zinc and iron before and after maize harvest during both years as per methods mentioned in Table 2.

Table 2: Physico-chemical properties of the soil

Soil parameters	2019-20	References
Soil pH (1:2.5 soil: watersuspension)	7.92	Glass electrode pH meter (Richards, 1968)
EC (dS m^{-1} at 25° C)	0.43	Conductivity bridge meter (Richards, 1968)
Organic carbon (%)	0.26	Rapid titration method (Walkley and Black, 1947)
Organic matter (%)	0.45	By factor (1.724)
Available nitrogen (kg ha^{-1})	198.7	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5(kg ha^{-1})	26.6	Olsen's method (Olsen *et al.,* 1954)
Available K_2O(kg ha^{-1})	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)

Effect on soil physico-chemical properties

Two years mean data on various soil physico-chemical properties i.e. pH, EC and organic carbon content in soil after harvest of maize after 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 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 soil. The significantly higher content of organic carbon in application of straw mulch and was at par to stale seedbed+ hoeing twice at 20 & 40 DAS and statistically superior over rest of treatments while 100% RDN through FYM (0.28%) as against the minimum in 75% RDN through vermicompost as basal application + organic concoction (0.26%) and was also statistically at par to rest of all other treatment.The organic manures improved physico-chemical properties of soil and results in better utilization and movement of nutrients towards crop (Onte*et al.,* 2019).

Available Nutrient Status

Available Nitrogen

The data presented in Table 3 reflected that weed management treatments applied to maize failed to affect the available nitrogen status significantly in soil after harvest of crop however, different organic nutrition applied to maize significantly affected the available nitrogen status of soil after harvest of maize and 3.5 percent higher mean available nitrogen in 100% RDN through FYM (194.6 kg ha^{-1}) as against minimum in 75% RDN through vermicompost as basal application organic concoction (188.1 kg ha^{-1}).

Available Phosphorus

The weed management through mulching and tillage applied to maize failed to affect the available phosphorus status in soils after harvest of crop but nutrient management treatments significantly affected the available phosphorus status of soil after harvest of maize and pooled results showed 15.4 percent higher mean available phosphorus was found in 100% RDN through FYM (26.41 kg ha^{-1}) as against minimum in 75% RDN through vermicompost as basal application +organic concoction.

Available Potassium

Similar to nitrogen and phosphorus, the availability of potassium in soil was not affected significantly under various weed management through mulch and tillage but different nutrient management treatments significantly affected the available potassium status of soil after harvest of maize. The pooled results showed 2.9 percent higher mean available potassium in soils was found in 100% RDN through FYM (301.05 kg ha^{-1}) as against minimum in 75% RDN through vermicompost as basal application + organic concoction (292.54 kg ha^{-1}) and was significantly superior to rest of all other treatments.

Available Zinc and Iron

The various weed management treatments and nutrient management treatments applied to maize non-significantly affected the available Zn and Fe status of soil after harvest of maize during both years and in pooled analysis. 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 slow mineralization of organic manures particularly FYM resulted 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, biomass and ultimately provides carbon and energy to the soil microbes resulting into proliferation of microbial population and increased nutrients in soil pool (Singh *et al.*, 2019).The organic concoction play important role through their regulatory and bio-stimulatory effect on plant growth and development besides supplying small amount of nutrients at critical growth stages as foliar spray (Kumar *et al.,* 2005).

Nutrient Balance Sheet

Data on balance sheet of various nutrients in soils during maize cultivation under different weed management and nutrient management practices 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 the years. Though, the net nitrogen and phosphorus loss was lowest under treatment weed free check after completion of experiment i.e. *kharif* 2020 (-0.46 and-2.69 kg ha^{-1}, respectively) followed by stale seedbed+ hoeing once at

Table3: Effect of organic weed and organic nutrient management practices on soil properties after maize harvest (Pooled of two years)

Treatments	pH	EC (dSm^{-1})	Organiccarbon (%)	Available Nutrients				
				N ($kg\ ha^{-1}$)	P_2O_5 ($kg\ ha^{-1}$)	K_2O($kg\ ha^{-1}$)	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
S.Em.±	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 B.M + J.M (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 B.M + J.M (T)	7.71	0.42	0.27	188.1	22.9	292.5	4.05	0.42
75% RDN VC (2 splits) + ST B.M + J.M (T)	7.82	0.42	0.26	190.9	24.4	292.8	4.05	0.43
S.Em.±	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

*Staleseedbed (SS), two hoeing (HT), Days after sowing (DAS), hoeingonce (HO),

**Recommended dose of nitrogen (RDN), Seedtreatmentwith*beejamrut*(ST) and twosprayof*jeevamrut*@500lha^{-1}atsowingand 30DAS J.M. (T), FYM (Farm Yard Manure, Vermicompost (VC), 2 split (75%asbasal+25%astopdressat30DAS) .

Table 4: Effect of different treatments on nitrogen (kg ha^{-1})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
Weedmanagement															
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 B.M + J.M (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 B.M + J.M (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 + J.M (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_5kg ha^{-1})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
Weedmanagement															
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 B.M + J.M (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 B.M + J.M (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 + J.M (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^{-1})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
Weedmanagement															
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 B.M + J.M (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 B.M + J.M (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 + J.M (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

20 DAS+ straw mulch at 30 DAS as against maximum in weedy check -6.35 and -2.78 kg ha^{-1}, respectively). Among the nutrient management treatments, the maximum net losses of nitrogen was occurred in treatment 75% RDN through vermicompost as basal application + organic concoction (-7.74 and -4.66 kg ha^{-1}, respectively) as against the minimum losses was in 100% RDN through FYM (-1.77 and -1.13kg ha^{-1}, respectively). Unlike to nitrogen and phosphorus, the actual potassium balance in soil was positive in weed management through mulching and tillage during both the years. Though, the actual potassium balance (gain) in soil was highest under treatment weed free check (16.15 kg ha^{-1}) 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^{-1}). The minimum net gain of potassium was recorded in treatment 75% RDN through vermicompost as basal application organic concoction (11.49 kg ha^{-1}) while the treatment 100% RDN through FYM recorded maximum gain (20.02 kg ha^{-1}). The application of vermicompost and FYM recorded more growth and yield attributes might be due to expected higher nutrient balance with organic sources. Such results were reported by Meena *et al.* (2011).The organic matter used as mulch and organic manures as nutrient source restore humus status of the soil ecosystem to holds its fertility and productivity resulted into net gain of nutrients as compared to rest of treatments. These organics also maintain the nutrients for longer period and realizing higher nutrient status in soil after harvest of 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 (JeyaselvinInbaraj, 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 found beneficial in terms of increasing yield besides improving soil status. The application of organic mulch and FYM helped to maintain the health of soil as compared to rest of treatments either applied as weed management or nutrient management.

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Author contributions

Conceptualization of experimentation (LKJ, MPV, HPP & AC); Designing of the experiments (LKJ, MPV, HPP & AC); Experimental materials (LKJ, MPV, HPP & AC); Execution of field experiments and data collection (LKJ, MPV, HPP & AC); Analysis of data and interpretation (LKJ, MPV, HPP & AC); Preparation of the manuscript (all authors).

Conflict of interest

The authors declare no conflict of interest.

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