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EFFECT OF MAIZE-WHEAT CROPPING SEQUENCE ON SOIL PROPERTIES AND FERTILITY STATUS

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ABSTRACT

A pot experiment was conducted to investigate the effect of different nutrient sources (M_0-no organic; M_1-FYM @ 10 t ha^{-1}; M_2-Pressmud (PM) @ 5 t ha^{-1}; F_0-no fertilizer; F_1 (FYM) -75% of recommended NP; F_2-100% of recommended NP; F_3-75% of recommended NP+S+Zn+ Fe; F_4-100% of recommended NP+S+Zn+Fe; F_5-100% of recommended NP+Foliar spray of 1% multi-micronutrient formulation) with maize-wheat cropping sequence on soil properties in Factorial Complete Randomized design (FCRD) with three replications. The addition of M_1 and M_2 were declined soil pH but increased the content of available N, P, S, Fe, Zn, Cu and Mn in soil. The available P, K and Zn content were higher in M_1 residue than M_2 residue. The F_3 and F_4 treatments were reduced soil pH whereas, reverse trend was noticed in EC after maize harvested. Maximum available S was found in the M_2F_3 (42.81 mg kg^{-1}) and M_2F_4 (46.73 mg kg^{-1}) and maximum DTPA-Zn was in the M_2F_3 (2.89 mg kg^{-1}) and in M_2F_4 (2.55 mg kg^{-1}).

INTRODUCTION

Per capita land resources are shrinking with ever increasing population pressure. This resource is becoming degraded at an increasing rate due to soil salinity/alkalinity, waterlogging and soil pollution. The shrinking of agricultural land and the demand for more food production calls for multiple cropping in a single piece of land. The present day agriculture is to achieve the targeted production to meet the increasing food demand and also sustaining soil productivity. However, soil productivity and crop production is declined with imbalanced and indiscriminate use of nitrogen, phosphorus and potash and withdrawal of organic matter input (Kumar *et al.*, 2008). The plants are obtained nutrients from the native soil pool. Therefore, the nutrient supplying power of many soils has declined steadily under continuous and highly intensive farming. The nutrient removal by crops could be balanced with nutrients recycling through the addition of organic waste and plant residues. The farm yard manure (FYM) and pressmud (PM) have cumulative and residual effects in improving physical, chemical and biological environment of soil and also reducing the need of chemical fertilizers for crop production (Singh *et al.*, 2009). An amount of 25-50% of available nitrogen was obtained from the FYM (Singh *et al.*, 1998) but restricted the nutrient supplying capacity of FYM in winter season (Singh *et al.*, 1983). The application of 20 t pressmud ha^{-1} can saved 25% of the recommended dose of fertilizers and had a significant residual effect of pressmud in the succeeding crops (Jurwarkar *et al.*, 1993). Carbon from organic manure is an important source for active proliferation of organisms and production of organic acids whereas nitrogen source is important for the production of inorganic acids (Kumari and Prakash, 2013). Therefore, integrated nutrient management (INM) has been an increasing necessity for soil health management. INM approach has increased the soil organic C and available nutrients (Sharma *et al.*, 2013, Parmar, 2014); improved the bulk density, porosity, OC and available nutrients (Babar and Dongale, 2013). The application of FYM and pressmud (PM) were decreased soil pH and exchangeable sodium percentage (ESP) (More 1994, Dang and Verma, 1996). On the contrarily, Dutta and Gupta (1983) observed the increase in pH with pressmud (PM) application. Kumar and Mishra (1991) reported no change in the soil pH with application of pressmud. The available Iron (Fe), manganese (Mn), and zinc (Zn) decreased with soil pH. The available copper (Cu) increased with organic carbon content and available Fe decrease with sand content (Chhabra *et al.*, 1996). Shetty (1975) found that the application of organics reduced soil pH due to decomposition of organics. After completion of decomposition, pH tried to shift towards the higher pH. It is not so clear the changes of soil properties and fertility status after addition of organic and inorganic sources of nutrient alone and combination of organic and inorganic source.

Considering these the present investigation was carried out to generate the information on soil fertility under direct and residual effect with different combinations of organic and inorganic source and individual effect on soil fertility using maize-wheat sequence.

MATERIALS AND METHODS

Bulk soil sample was collected from 0-15cm at Golagamdi, Sankheda taluka of Vadodara district. It is located at 21.97ºN latitude and 73.57ºE longitudes with an altitude of 59 m above mean sea level. The area falls under central highland peninsular, hot dry, sub-humid zone with receiving annual rainfall of 1004mm. The soil is clay loam (Typic Chromustert) with 40% clay, 22% silt and 38% sand in the surface layer (0-15 cm). The soil was moderately alkaline (pH 8.23) (1:2.5 soil: water), electrical conductivity (EC) 0.18 dS m^{-1}, 3.8 g kg^{-1} organic carbon, 132 kg ha^{-1} available nitrogen, 27.3 kg ha^{-1}available P_2O_5, 307 kg ha^{-1} available K_2O, 8.6 mg kg^{-1} available sulphur, DTPA extractable Fe (7.51 mg kg^{-1}), Zn (0.96 mg kg^{-1}), Mn (5.68 mg kg^{-1}) and Cu (1.03 mg kg^{-1}).

A pot experiment of maize (var. GM4) -wheat (var. GW 496) sequence was designed in Factorial Complete Randomized design (FCRD) with three replications. The experiment consisted of three sources of organic manure (M_0-no organic; M_1(FYM) @ 10 t ha^{-1}; M_2-Pressmud (PM) @ 5 t ha^{-1}) and six different inorganic fertilizer level (F_0-no fertilizer; F_1-75% of recommended NP; F_2-100% of recommended NP; F_3-75% of recommended NP+S+Zn+ Fe; F_4-100% of recommended NP+S+Zn+Fe; F_5-100% of recommended NP+Foliar spray of 1% multi-micronutrient formulation (Grade I) containing Fe 2%, Mn 0.5%, Zn 4%,Cu 0.3% and B 0.5%). The sources of fertilizers used in F_1 to F_4 were N - urea; P - single super phosphate; S – gypsum @ 150 kg ha^{-1}; Zn - $ZnSO_4$ @ 25 kg ha^{-1}; Fe - 0.25% neutralized $FeSO_4$. The recommended dose of N and P for maize was 60 and 40 $kgha^{-1}$ respectively. Half dose of nitrogen and full dose of P were applied as basal in the soil. The remaining half dose of N was applied in two equal split at tillering and at flowering stage. The sources of Zn and S were also applied as basal as per treatment. Fe was applied as foliar spray at 30, 45 and 60 DAS. Foliar spray @1% of multi-micronutrient formulation in F_5 treatment was applied at 30, 45 and 60DAS. The five maize plants per pot were grown as first crop during *kharif* (rainy) season and harvested at 60 days. The residual effect of organic manures was studied by growing wheat in the rabi season with application of the same fertilizer treatments given in the previous crop except the recommended doses of NP. Half of the recommended N (120 kg N ha^{-1}) and full dose of recommended P (60 kg P_2O_5 ha^{-1}) was applied as a basal dose. The remaining half dose of N was applied in equal two splits at tillering stage (25 DAS) and panicle initiation (50 DAS). The 8 plants of wheat per pot were grown and harvested at 100 days. The chemical properties of FYM and pressmud were analyzed in the laboratory following standard methodologies and are presented in Table 1.

Soil samples from each pot were collected using tube auger for understanding the nutrient status of soil after harvesting maize and wheat. These samples were air dried, ground and passed through 2 mm sieve for chemical analysis. The soil pH (1:2.5) and electrical conductivity (1:2.5) were determined by digital pH meter and conductivity bridge. The soil organic carbon was determined by Walkley and Black (1934). Available

Table 1: The Chemical composition of FYM and pressmud.

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (mg kg^{-1})	Zn(mg kg^{-1})	Cu(mg kg^{-1})	Mn(mg kg^{-1})
FYM	0.98	0.82	0.49	1.9	0.75	0.18	501.7	94.05	24.05	217.0
Pressmud	1.65	2.70	0.49	3.3	1.3	2.46	368.5	130.45	123.15	315.7

Table 2: Direct effect of organics (i.e. FYM and Pressmud) and fertility treatments on soil properties after the harvest of maize.

Treatment	Soil pH	EC	Ava. N (kg ha^{-1})	Ava. P_2O_5 (kg ha^{-1})	Ava. K_2O (kg ha^{-1})	Ava. S (mg kg^{-1})	DTPA-Fe (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})
Organics (M)										
M_0	7.95	0.27	98.02	37.70	339.56	13.98	8.02	1.29	1.19	4.93
M_1	7.94	0.28	174.82	69.44	336.74	15.86	7.77	1.41	1.05	4.53
M_2	7.86	0.37	207.76	57.15	344.09	27.99	8.20	1.67	1.10	5.43
S. Em (±)	0.017	0.004	3.17	1.21	-	0.44	0.10	0.05	0.03	0.11
C.D. (p=0.05)	0.05	0.01	9.09	3.48	NS	1.27	0.27	0.15	0.08	0.31
Fertility levels (F)										
F_0	7.99	0.25	123.88	55.41	334.50	12.40	7.70	1.06	1.16	5.01
F_1	7.91	0.25	133.28	57.15	336.73	13.79	8.13	0.95	1.03	4.88
F_2	7.92	0.27	150.53	50.71	337.98	16.39	8.05	1.15	1.03	5.17
F_3	7.88	0.32	166.20	55.40	344.22	27.65	8.14	2.22	1.08	5.23
F_4	7.87	0.37	197.57	53.88	344.56	29.95	7.95	2.11	1.04	4.75
F_5	7.91	0.38	189.73	56.02	342.79	15.49	8.02	1.24	1.35	4.75
S. Em (±)	0.024	0.006	4.48	-	-	0.63	-	0.07	0.04	-
C.D. (p=0.05)	0.07	0.02	12.85	NS	NS	1.80	NS	0.21	0.11	NS

* M_0-No organic; M_1-FYM (10 tha^{-1}); M_2-Pressmud (5 tha^{-1}); F_0-No fertilizer; F_1-75% of recommended NP; F_2-100% of recommended NP; F_3-75% of recommended NP+S (150 kg gypsum ha^{-1}) + Zn (25 kg ZnSO4 ha^{-1}) + Fe (0.25% $FeSO_4$); F_4-100% of recommended NP+S (150 kg gypsum ha^{-1})+ Zn (25 kg $ZnSO_4$ ha^{-1})+Fe (0.25% $FeSO_4$); F_5-100% of recommended NP+Foliar spray @1% of multi-micronutrient formulation (Grade I: containing Fe2%,Mn0.5%,Zn4%,Cuo.3% and Bo.5%).

Table 3: Residual effect of organics (i.e. FYM and Pressmud) and fertility treatments on soil properties after the harvest wheat

Treatment	Soil pH	EC	Ava. N (kg ha^{-1})	Ava.P_2O_5 (kg ha^{-1})	Ava.K_2O (kg ha^{-1})	Ava. S (mg kg^{-1})	DTPA-Fe (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})
Organics (M)										
M_0	8.16	0.25	57.80	33.88	322.77	14.42	7.30	1.26	0.97	3.27
M_1	8.21	0.29	196.89	71.49	324.72	15.78	7.13	1.38	1.02	3.55
M_2	8.24	0.37	210.92	49.25	316.09	18.56	7.47	1.31	1.01	3.69
S. Em (±)	0.01	0.005	3.03	1.06	2.19	0.33	-	0.03	0.01	0.05
C.D. (p=0.05)	0.02	0.015	8.69	3.04	6.30	0.95	NS	0.09	0.03	0.15
Fertility levels (F)										
F_0	8.26	0.23	98.82	51.32	320.34	10.56	7.22	1.07	0.99	3.39
F_1	8.21	0.26	155.24	59.57	321.39	12.91	7.22	1.23	1.02	3.63
F_2	8.21	0.28	166.22	49.12	326.33	15.43	7.43	1.13	1.03	3.45
F_3	8.18	0.30	161.31	47.52	320.33	20.79	7.53	1.82	0.98	3.51
F_4	8.19	0.38	177.34	49.02	325.22	20.86	6.95	1.57	0.98	3.39
F_5	8.17	0.37	172.28	52.68	313.53	16.98	7.45	1.08	1.01	3.64
S. Em (±)	0.010	0.007	4.28	1.50	-	0.47	-	0.04	-	-
C.D. (p=0.05)	0.02	0.021	12.29	4.30	NS	1.35	NS	0.12	NS	NS

* M_0-No organic; M_1-FYM (10 tha^{-1}); M_2-Pressmud (5 tha^{-1}); F_0-No fertilizer; F_1-75% of recommended NP; F_2-100% of recommended NP; F_3-75% of recommended NP+S (150 kg gypsum ha^{-1}) + Zn (25 kg ZnSO4 ha^{-1}) + Fe (0.25% $FeSO_4$); F_4-100% of recommended NP+S (150 kg gypsum ha^{-1})+ Zn (25 kg $ZnSO_4$ ha^{-1})+Fe (0.25% $FeSO_4$); F_5-100% of recommended NP+Foliar spray @1% of multi-micronutrient formulation (Grade I: containing Fe2%,Mn0.5%,Zn4%,Cuo.3% and Bo.5%).

N was estimated by alkaline permanganate method (Subbiah and Asija, 1956) and available phosphorus was determined by Olsen *et al.* (1954). Available K was estimated using neutral 1M NH4OAc as stated by Pratt (1965). Extractable S (0.15% $CaCl_2$) by turbidimetric method (Chaudhary and Cornfield, 1966), 0.005 M DTPA extractable micronutrients by Lindsay and Norvell (1978).

The plant samples were first washed with tap water followed by 0.1 N HCl and subsequently washed by distilled water. Plant samples were air drying and stored in brown paper bag to keep them in oven at 60° to 70°C for drying till the constant weight. The oven dried maize plant samples were ground in SS willey mill and ground to pass through a 0.5 mm sieve for chemical analysis. Nitrogen in plant sample was determined by Modified Kjeldahl's digestion method (Jackson, 1973). One gram of plant samples were digested with HNO_3 : $HClO_4$ (4:1) acid mixture (Jackson, 1973) and in the digest P was measured by vanadomolybdate yellow colour method (Jackson, 1973), K by flame photometer (Tandon, 1993), S by turbidimetric method (Chaudhary and Cornfield, 1966), and Fe, Zn, Cu, Mn by Atomic Absorption Spectrophotometer (AAS Model PE-3110) (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Direct effect of organic and inorganic on soil properties

The result revealed the direct effect of organics M_1 (FYM) and M_2 (PM) on the soil properties. The decrease of soil pH from the initial value in the organically amended with application of M_1 and M_2 could be partly due to formation of various organic acids during mineralization of nutrients from FYM. It was also expected the higher decomposition rate of organic matter due to high temperature during *kharif* season. The M_2 was lowering more soil pH (7.86) in comparison with M_1 (7.95) due to oxidation of sulphur (S) present in M_2 and increasing electrical conductivity (EC) (0.37dSm^{-1}) as comparing to M_1 (0.28 dSm^{-1}). Similar result was also reported by Pasricha *et al.*, 1996. The overall inorganic treatments was also declining the soil pH and increasing EC. The lower pH was recorded in F_4 (7.87) and F_3 (7.88) and higher EC was noticed in F5 (0.38 dSm^{-1}) and F4 (0.37 dSm^{-1}). It might be due to inorganic salts contribution from the application of high doses of NP along with micronutrients.

The available NPS and DTPA extractable Zn were increased with application of M_1 and M_2, however, remain unaltered the available K and decreasing DTPA extractable Fe, Cu and Mn over M_0 in case of M_1 treatment. Additional N might be added from the mineralization of organically bound nitrogen during decomposition of organic matter. Increasing the P availability and maintaining the K availability without external supplementation was due to the offset of fixed P and K by the complex formation with organic ligands. Humic and fulvic acids increase the released of insoluble P and protected the released of K fixed in intermicellar space of clays (Chatterjee *et al.*, 2014). The Zn-fulvic complexation was increased Zn availability (Kumar and Prasad 1989). The application of M_2 was more enriched the plant nutrients as comparing to M_1 (table 2). The addition of pressmud (M_2) was significantly increased the DTPA extractable Fe (8.20 mg kg^{-1}) over M_1 (7.77 mg kg^{-1}). The M_2 was produced through sulphilation process and acting as a quick released fertilizer in the first season. The organic acid release from M_2 decomposition might enhance the available nutrients.

Application of fertilizers also increased the availability of N, K, S, and DTPA extractable Zn and lowering DTPA extractable Cu (table 2). The initial low organic carbon (3.8 g kg^{-1}) content in the soil might lead to the lowering of Cu content. The available Cu was increased with clay content and organic carbon content (Chhabra *et al.*, 1996). The broken edge surface of clay attains positive charge and will attract organic anions. After adsorption by clay, the organic compounds become positively charged with accepting protons from H^+-saturated clay and water polarized by a cation donate a proton to the organic compound. The positive charge organic compound might be replaced inorganic cations on exchange positions or in interlayer surfaces of clay (Mortland, 1970 and Tan *et al.* 1971). The none significant difference of DTPA extractable Fe with different fertility treatments might be due to Fe^{3+} displacement by Zn^{2+} from Zn-EDTA at pH 6-7. The Zn-EDTA was form a stable chelate mixture at pH 6-7(Lindsay, 1974; Lindsay and Norvell, 1969). The F_3 and F_4 treatments were noted the highest K (344.22 and 344.56 kg ha^{-1}), S (27.65 and 29.95 mg kg^{-1}) and Zn (2.22 and 2.11 mg kg^{-1}) availability. The foliar application of Fe (0.25% $FeSO_4$) was not contributing the Fe availability in soil. Overall effect of F_3 on soil fertility status was better than other treatments. It was much cleared form the finding that the application of F_3 treatment could save some energy for maintain the sustainable soil heath.

Residual effect of organic and inorganic on soil properties

The data revealed the residual effect of organics (FYM and PM) on the soil properties. The residual effect of M_1 and M_2 would increase soil pH and EC from the initial value. It might be due to the release of bases form the decomposition of organic matter. The pH was increased due to increased base retention capacity (Laxminarayana and Patiram, 2006). The soil pH was tried to shift towards alkaline reaction due to the buffering action of soil and also conversion of some organic acids into bicarbonate and carbonates with time. The residual effect of M_2 was found to be significant in increasing the soil pH (8.24) and EC (0.37 dSm^{-1}) than the pH (8.21) and EC (0.29 dSm^{-1}) M_1.

It was noted that high amount of availability of N (210.92kg ha^{-1}), S (18.56 mg kg^{-1}), DTPA extractable Fe (7.47 mg kg^{-1}) and Mn (3.69 mg kg^{-1}) in M_2 residue while the application of FYM the residue of P (71.49 kg ha^{-1}), K (324.72 kg ha^{-1}), DTPA extractable Zn (1.38 mg kg^{-1}) and Cu (1.02 mg kg^{-1}) in the FYM were noted (table 3). The available Mn was increased with organic treatments (Chhabra *et al.*, 1996). The Cu availability was enhanced after wheat harvested as a result of breakdown of organic residues. Cu has higher affinity for forming organo-metalocomplexes than other metals. M_1 residues was continued the beneficial effect in the subsequent crop. It was because of slower decomposition rate and higher quantity application in comparison with M_2. Higher availability of P (71.49 kg ha^{-1}) in M_1 residue might be due to mineralization of organic phosphorus under the influence of organic acids. The production of organic acids had a solubilizing effect on soil phosphorus and organic anions retard the fixation of P in soil (Sandhu and Meelu, 1974).

The availability of plant nutrient for the subsequent crop was declined except N availability with addition of the similar doses of inorganic nutrition. The nutrient availability status of soil with application of inorganic sources in organic residual trial was found lower PKS and DTPA extractable micronutrients (table 3). The availability of P was reduced due to fixation in alkaline above 8 pH (Bhan and Tripathi, 1973).The increased availability of N might be due to supplementation from mineralization of organically bounded N. Slightly reduction of K was due to crop removal and not supplementation of K, considering soil content high amount of K. From the finding it was clearly revealed the need for K supplementation for maintaining the soil health. Phosphorus application was significantly built up total N, P and K availability in the soil. The non-exchangeable or fixed-K forms were released with microbiological activities (Sandhu and Meelu, 1974). The DTPA extractable Fe was found none significant and decreasing due to crop removal and the complexation with organic legends besides the effect of alkaline pH during wheat (Chhabra *et al.*, 1996). The application of fertilizer alone could no longer support the soil fertility. However, the residue of organic matter could improve further depletion of plant nutrient.

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