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Effect of INM on Physico-chemical properties of soil of maize (*Zea mays*) crop in Inceptisol of Central U.P.

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Abstract
A field experiment was conducted at field no. 6 Student's instructural Farm at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during the *Kharif* season 2017 to find out integrated nutrient management effect on maize with ten treatments i.e. T_1 (125% RDN), T_2 (100% RDN), T_3 (100% RDN + 25% N FYM), T_4 (100% RDN + 25% N FYM + S_{30}), T_5 (100% RDN + 25% N FYM + S_{30} + Zn_5), T_6 (75% RDN), T_7 (75% RDN + 25% N FYM), T_8 (75% RDN + 25% N FYM + S_{30}), T_9 (75% RDN + FYM + S_{30} + Zn_5), T_{10} (Control) in RBD with 3 replications. Maize variety Azad Uttam was taken for study. The results revealed that improve the physico-chemical condition of soil after harvesting the crop. The pH, EC, Organic Carbon, Available Sulphur, Available Zinc given non-significant result, when Available Nitrogen, Available Phosphorus, Available Potassium are given significant results in all the treatments.

Keywords: pH, Ec, Organic carbon, Nitrogen, Phosphorus, Potassium.

Introduction
Maize (*Zea mays* L.) is one of the most important cereal crop, next to rice and wheat and is used as a food for human and feed for animals. This crop has been developed into a multi dollar business in countries *viz*. Thiland, Tiwan, Singapore, Malaysia, USA, Canada and Germany, because of its potential as a value added product for export and a good food substitute. Maize is gaining immense importance on account of its potential uses in manufacturing starch, plastics, rayon, adhesive, dye, resins, boot polish etc. and due to this large uses it is rightly called a Miracle crop and also known as 'Queen of cereals' due to its high potential yield. In India, maize is grown in an area of 9.76 million hectares with production of 26.14 million tonnes and productivity of 2629.28 kg ha^{-1} (Government of India, 2017). Maize yield is generally higher in high solar intensities, lower night temperature and lower pest infestation. Optimum plant density leads to better utilization of solar radiation resulting into corn dry matter accumulation and biomass production. Uttar Pradesh is the major producing state contributes 60 percent area and 70 percent of maize production in India.

A judicious combination of organic and chemical fertilizers has been assumed to maintain long term soil fertility and sustain higher levels of productivity (Banwasi *et al.* 2006) [1]. Long term studies being carried out at several locations in different cropping systems indicated that application of all the needed nutrients through chemical fertilizers has deleterious effect on soil fertility leading to unsustainable yields (Shrama *et al.* 2009) [15].

Begum *et al.* (2007) [2] reported that under wheat-mungbean- maize cropping system in sandy clay loam soils, the available nitrogen and phosphorus content of the initial soil (82.4 and 10.4 mg g^{-1}) were decreased in control plot (80.3 and 4.9 mg g^{-1}), where no fertilizer was applied.

Chemical fertilizers with organic manures has been to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production. Crop yield is usually increased by manure application because off the increase nutrient availability and the improvement in the soil structure by providing binding effect of soil aggregates which increase CEC, water holding capacity and phosphate availability of the soil. Besides improving the fertilizers use efficiency and microbial quality of soil, low nitrogen loss due to slow release of nutrients from these organic manures is an additional advantage besides improving soil organic carbon content and decrease in soil pH due to addition of organic manures (Kumar *et al.* 2007) [5].

Jagtap *et al.*, (2007) [3] observed that the addition of FYM along with chemical fertilizers helped in reducing the soil pH and increased the EC of soil under incubation. The release of ammonical nitrogen was higher where the nutrients were applied with FYM.

Lal Bahadur *et al*. (2012) [6] reported that continuous application of organic manures along with inorganic fertilizers was more effective for moderating soil pH and EC as compared to the treatments of no organic manure application.

Pathak *et al.* (2005) [12] documented that application of 50 kg ha^{-1} of urea to each crop in maize- wheat cropping system showed an increase in soil acidity from pH 6.5 to pH 5.79. Application of N, P and K fertilizer in acid soil and nutrient depleted soil resulted change in pH from 5.1 to 5.3 and from 6.2 to 5.8 respectively.

Raman and Suganya (2018) [13] reported that evidently proved 100% RDF + Press mud compost @ 5 t ha^{-1} (T_5) in hybrid maize will be an appropriate Integrated nutrient management practice for achieving sustainable hybrid maize yield with due to care on soil health, fertility and productivity.

Singh *et al*., (2005) [17] reported an improvement in soil fertility status due to selected INM package. INM practices in farmers field soils resulted in an increase in the crop removable of N, P and K and also improved the available nutrient status of soil.

Subehia *et al.*, (2005) [18] reported that organic carbon content increased in all the treatments as compared to its initial value with the application of P and FYM together.

Tarinder *et al.* (2008) [19] observed that while working with maize based cropping sequence, used NPK and FYM found the highest soil organic carbon content in the treatment receiving FYM along with inorganic fertilizers.

Vikas *et al.* (2007) [21] reported that organic carbon and available N content showed increase of 3.0 g kg^{-1} soil and 31 kg ha^{-1} in FYM treated plots.

Walia and Kler (2005) [22] noted that the OC content of the soil significantly improved under organic nutrient management treatments ranging between 0.8% to 0.96% as compared to alone inorganic nutrient management (0.52%). Similarly, the available N, P and K contents of the soil in the organic nutrient management also showed remarkable improvement over alone inorganic nutrient management.

Materials and Methods

The experiment was conducted on Maize during *kharif* season of 2017 under natural condition at field no. 6 Student's Instructural Farm at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The soil of the experimental field was alluvial in origin. Soil sample (0-15cm) depths were initially drawn from randomly selected parts of the field before sowing. The quantity of soil sample was reduced to about 500gm through quartering technique. The soil sample was then subjected to mechanical and chemical analysis in order to determine the textural class and fertility status the soils were sampled to a depth of 0-30 cm of the soil, air-dried and sieved (2 mm) for soil analyses.Some physical and chemical properties of soils are given in Table 1.

Table 1: Some properties of the <2mm fraction of the top 30 cm of soil used for the site.

S.No.	Particulars	Values
A.	**Mechanical separates**	
1.	Sand (%)	59.6
2.	Silt (%)	17.4
3.	Clay (%)	23.00
4.	Textural Class	Sandy loam
B.	**Physico-chemical properties**	
5.	pH (1:2.5)	8.2
6.	EC (1:2.5) (dS/m at 25^0C)	0.20
7.	Organic Carbon (%)	0.36
8.	Available Nitrogen (kg/ha)	190.00
9.	Available Phosphorus (kg/ha)	13.50
10.	Available Potassium (kg/ha)	182
11.	Available Sulphur (kg/ha)	15.80
12.	Available Zinc (ppm)	0.56
13.	Particle Density (Mg/m^3)	2.54
14.	Bulk Density (Mg/m^3)	1.30
15.	Pore Space (%)	46.0

Maize variety Azad Uttam was taken for study. In the present experiment 10 treatments T_1 (125% RDN), T_2 (100% RDN), T_3 (100% RDN + 25% N FYM), T_4 (100% RDN + 25% N FYM + S_{30}), T_5 (100% RDN + 25% N FYM + S_{30} + Zn_5), T_6 (75% RDN), T_7 (75% RDN + 25% N FYM), T_8 (75% RDN + 25% N FYM + S_{30}), T_9 (75% RDN + FYM + S_{30} + Zn_5), T_{10} (Control)were laid out in Randomized Block Design(RBD) with three replications having plot size 5 x 4 meter square. Doses of fertilizers are applied @ 120 Kg N, 60 Kg P_2O_5, 40 Kg K_2O/ha 30 Kg S/ha, 5 Kg Zn/ha and Organic manure 60 tonne/ha through Urea, D.A.P and Murate of Potash, Elemental sulphur, Zinc oxide and Farm Yard Manure. Sowing is done @ 20 kg seed ha^{-1} maize variety Azad Uttam was used and sown on 22 June 2017. Row to row and plant to plant distance remain 60 and 20 respectively. Seed were sown about 5-6 cm depth

Field Preparation: The experimental field was ploughed once with soil turning plough fallowed by two cross harrowing. After each operation, planking was done to level the field and to obtain the fine tilth. Finally layout was done and plots were demarked with small sticks and rope with the help of mannual labour in each block.

Application of fertilizers: The crop was fertilized as per treatment. The recommended dose of nutrient i.e. N, P, and K was applied @ 120: 60: 40 kg ha^{-1} respectively.

Time and method of fertilizer: Half does N_2 and total phosphorus, potash, zinc and sulphur were applied as basal dressing. Remaining dose of nitrogen was applied through top dressing after knee-high stage. Well decompose FYM applied @ 60 t ha^{-1} 15 day after sowing.

Seed Treatment: To ensure the seeds free from seed borne diseases, seeds were treated with thiram 75% WDP (1.5g/kg of seed).

Seed and sowing: 20 kg seed ha^{-1} maize variety Azad Uttam was used and sown on 22 June 2017. Row to row and plant to plant distance remain 60 and 20 respectively. Seed were sown about 5-6 cm depth.

Intercultural operations: Weeding and hoeing were done with khurpi and hand hoe after germination.

Irrigation: Tube-well was the source of irrigation. Irrigation was provided in the crop as and when required.

Harvesting: The crop was harvested at proper stage of maturity as determined by visual observations. Half meter length on either end of each plot and two border rose from each side as border were first removed from the field to avoid error. The crop in net plot was harvested for calculation on yield data. Produce was tied in bundles and weighted for biomass yield. Threshing of produce of each net crop was done by manually.

Soil Analysis

Mechanical Separates: Soil separates analyzed by International pipette method as described by the Piper (1966).

pH: pH of the soil determined by using soil water suspension (1:2.5) with the help of digital pH meter.

EC: EC also determined using soil water suspension (1:2.5) with help of conductivity meter (Jackson, 1967).

Organic Carbon: Organic Carbon was determined by Walkley and Black's rapid titration method as described by Jackson (1967).

Available Nitrogen: It was determined by Alkaline Potassium Permagnate Method described by Subbiah and Asija (1956).

Available Phosphorus: It is determined by Olsen's method using 0.5 M NaHCO3 (Olsen *et al*. 1954).

Available Potassium: Potassium is determined by using Neutral Normal Ammonium Acetate (pH 7.0) by Flame Photometer.

Available Sulphur: Available Sulphur was determined by turbidimetric method (Chesnin and Yien, 1950) after extraction with 0.15% $CaCl_2$ solution.

Available Zinc: Available Zn is determined by Atomic Absorption Spectrophotometer with the help of DTPA extractant (Lindsey and Norvell, 1978).

Statistical Analysis: The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. The data obtained during the study were subjected to statistical analysis using the methods advocated by Chandel (1990).

Results

Impact of INM on soil properties

After harvest of the crop soil samples were collected in each treatment and analysis for physiochemical properties of the soil.

Effect on soil pH

Data in regard to soil pH given in table 4.17 and fig. 4.17 showed narrower and non-significant variation within all the treatments. It is also visualized from the data that pH value in all the treatment were decreased in comparison to its initial value. Maximum decrease in soil pH (8.14) was recorded with T_5 (100 % RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by (8.15) with T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}). It is also obvious from the data that integration of FYM showed higher decrease in soil pH when applied with 100% RDN and 75% RDN treatments.

Table 2: Impact of Integrated Nutrient Management on physical properties of soil.

S.No.	Treatment	pH	EC (dsm^{-1})	O. C. (%)
1.	T_1	8.17	0.19	0.366
2.	T_2	8.18	0.19	0.363
3.	T_3	8.16	0.21	0.372
4.	T_4	8.15	0.21	0.375
5.	T_5	8.14	0.21	0.376
6.	T_6	8.18	0.19	0.358
7.	T_7	8.17	0.20	0.361
8.	T_8	8.16	0.21	0.368
9.	T_9	8.15	0.21	0.373
10.	T_{10}	8.20	.020	0.352
S. E. $\pm$		0.002	0.003	0.021
C. D. (at 5 %)		0.005	0.009	0.062

Effect on EC

It is visualized from the data given in table 4.17 and fig. 4.17 showed narrower and non-significant variation in EC values within all the treatments. Integration of FYM showed slight increase in EC value in comparison to its initial value while application of inorganic fertilizers showed slight decrease in EC value in comparison to its initial value.

Effect on soil organic carbon

Data in regard to OC content (%) in soil given in table 4.17 and fig. 4.17 revealed that build up of organic carbon in all the treatments except control over its initial value. It is also visualized from the data that integration of organic manure showed higher increase in organic carbon% in comparison to inorganic fertilizers treatments. Maximum OC content 0.376 % was observed with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by 0.373% with T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum 0.352% at control (T_{10}) variation in organic carbon % within 75% RDN, 100% RDN and 125% RDN was found narrower and non-significant.

Effect on available nitrogen

It is apparent from the data given in table 4.18 and fig. 4.18 showed slight increase in available status of N in all the treatments over to its initial value, except control and 75% RDN. Maximum available status of N 178.6 kg ha^{-1}was recorded with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn) followed by 177.17 kg ha^{-1} with T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum 167.20 kg ha^{-1} at control (T_{10}). It was also observed that integration of organic manure found more effective for increase the available status of N in soil in comparison to inorganic fertilizer treatments. Variation in available status of N within 100% RDN and 125% RDN was found significant.

Table 3: Impact of Integrated Nutrient Management on chemical properties.

S. No.	Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
1.	T_1	173.85	14.00	184
2.	T_2	172.42	13.80	183
3.	T_3	176.70	14.20	184
4.	T_4	178.12	14.50	185
5.	T_5	178.60	14.80	186
6.	T_6	170.05	13.40	180
7.	T_7	171.49	13.60	182
8.	T_8	174.81	14.00	183
9.	T_9	177.17	14.30	185
10.	T_{10}	167.20	13.30	178
S. E. ±		0.194	0.258	0.120
C. D. (at 5 %)		0.581	0.773	0.358

Effect on available Phosphorus

Data in regard to available status to P given in table 4.18 and fig. 4.18 showed slight increase in available status of P in all the treatments except control in comparison to its initial value. Available status of P within all the treatments varied from 13.32 to 14.8 kg ha-1. Integration of organic manure showed higher increase in available status of P in comparison to inorganic fertilizer.

Effect on available Potassium

Data in respect to available status of K given in table 4.18 and fig. 4.18 showed slight increase in available status of K in all the treatments except control and 75% RDN over its initial value. Maximum increase in available status of K was recorded 186 kg ha^{-1} with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by 185 kg ha^{-1} with T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum 178 kg ha^{-1} at control (T_{10}). Like-wise available status of N and P variation in available status of K in all the treatment was observed narrower and non-significant. Addition of organic manure showed higher increase in available status of K in comparison to inorganic fertilizer treatments.

Effect on available Sulphur

The data pertaining to available status of S given in table 4.19 and fig 4.19 showed non-significant influenced in available status of S by the application of different treatments except control. Like-wise N, P, K available status of S also varied minimum control and maximum under T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}). The data further revealed that application of S either alone or in combination with organic manure showed higher increase in available status of S over its initial value in comparison to other treatments.

Table 4: Impact of Integrated Nutrient Management on soil chemical properties.

S.No.	Treatments	Available S (kg ha^{-1})	Available Zn (g ha^{-1})
1.	T_1	16.00	0.564
2.	T_2	15.86	0.562
3.	T_3	15.98	0.568
4.	T_4	16.14	0.570
5.	T_5	16.22	0.57
6.	T_6	15.82	0.558
7.	T_7	15.92	0.561
8.	T_8	16.10	0.564
9.	T_9	16.18	0.572
10.	T_{10}	15.70	0.552
S. E. ±		0.007	0.007
C. D. (at 5 %)		0.022	0.020

Effect on available Zinc

Data in regard to available status of Zn given in table 4.19 and fig 4.19 showed non-significant variation in available status of Zn in all the treatments in comparison to its initial value. Integration of Zn showed higher increase in available status of Zn with 100% and 75% RDN. It is also visualized from the data that all the treatments showed slight increase in available status of Zn except control and 75% RDN variation in available status of Zn within 100% RDN and 125% RDN was also found non-significant.

Discussion

Impact of INM on soil properties

In order to evaluate the physiochemical properties of the soil *i.e*. pH, EC organic carbon, available N, P, K, S and Zn were investigated in soil after harvest of the crop and results are describe below:

Soil pH

Data in regard to soil pH given in table 4.17 and fig. 4.17 showed slight decrease in soil pH was recorded in all the treatments as compared to its initial value. Maximum decrease in soil pH value was recorded with the combined application of organic fertilizer treatments and inorganic fertilizers followed by inorganic fertilizer treatments. This may be due to the release of organic acid during decomposition of organic manure in the soil. This results are in close conformity with the findings of Madakemohekar *et al.* (2013) [7] and Mishra *et al*. (2008) [10]

Soil EC

Data in respect to soil EC are presented in table 4.17 and fig. 4.17 revealed that combined application of organic manure and inorganic manure showed slight increase in EC values while addition of inorganic manure alone showed slight decrease in EC values in comparison to its initial value, which is obviously due to decomposition of organic matter in the soil. These results are in close conformity with the findings of Sarwar *et al.* (2008) [14].

Soil organic carbon

Data in regard to soil OC given in table 4.17 and fig. 4.17 revealed that OC content in soil increased slightly in all the treatments over its initial value. Maximum increase in OC content in soil was observed with integration of organic treatments followed by inorganic treatments. It may be due to the decomposition and mineralization of organic matter by narrow C:N ratio. These findings are in line to the findings of

Varalakshmi *et al.* (2005) [20], Vikas *et al.* (2007) [21], Tarinder *et al.* (2008) [19] and Adeniyan *et al.* (2011).

Available N, P, K, S and Zn ion soil

Data in regard to available status of N, P, K, S and Zn are present in table 4.18 to table 4.19 and fig. 4.18 to fig. 4.19 revealed that available status of all the nutrient was slightly increased in all the treatment in comparison to its initial value, except control and 75% RDN. Maximum increase in available status of N, P, K, S and Zn was noted with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum at control (T_{10}). These finding are related with the finding of Karki *et al*. (2005) [4], Shashidhar *et al.* (2009) [16], Mann *et al.* (2006) [9], Mahala *et al.* (2006) [8] and Negassa *et al.,* (2007) [11].

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