

Fly Ash and Organic Amendments on Nutrient Status of Soil Under Maize Cultivation

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ABSTRACT

A field study was conducted to determine effect of fly ash with organic and inorganic amendments on physical and chemical properties of soil on maize crop under Punjab agro-climatic condition during kharif season of 2018 in Randomized Block Design (RBD) with three replications and eight treatments. Different combinations of poultry manure (PM), fly ash (FA) and inorganic fertilizers at their recommended doses (RDF) were used as nutrient sources. It has been demonstrated that all combinations of nutrient sources exhibited significant positive impact over control with respect to available nitrogen, phosphorous, potassium and sulphur. However, the treatment including RDF + PM (T₂, 100% RDF + 100% PM) performed best, followed by (T₃, 10% FA + 90% RDF + 90% PM).

Keywords: - Fly ash, poultry manure, inorganic fertilizers, maize, available N, available P, available K, available S

INTRODUCTION

Maize is one of the major tropical and subtropical cereal crops (Makate, 2010) and it is a key component of global food security as a major part of millions of people's diet (Kamanula *et al.*, 2011). Maize, a C₄ plant, is placed third and next to rice and wheat in world ranking among the cereals. In many countries, it is primarily used as a staple food for domestic consumption. However, over 50% of maize products in India are used as animal feed (Singh *et al.*, 2003). In respect of total area of maize cultivation, the United States possesses the top position among the maize-growing countries, followed by Brazil, China, Mexico and India. In India, maize in 1.15

Maize area accounts for nearly 15.5 Mt of production (Hareeshet *al.*, 2016). Maize is largely used for commercial production of starch, syrup, oil, flaking, gluten, lactic acid or acetone in different textiles, food and fermentation industries.

Fly ash (FA) is obtained as a by-product in thermal power stations during carbon combustion in large amount, when coal is used as a raw material for energy generation. Although FA is disposed of in basins, in deposits or in landfills, disposal of FA is a major concern in many developing countries, and only a small quantity of ash (less than 3% of the total ash production) is used commercially in a country like India (Kumar and Jha, 2014) in the construction, cement and road construction industries. However, it could be used more favorably in agriculture sector also because FA is rich in minerals and contains almost all essential plant nutrients (Porbaha *et al.*, 2000; Vittal 2001, Kaur *et al.*, 2019). In previous studies (Panda and Biswal, 2018; Singh and Sukul, 2019a & 2019b), favorable impact of FA application in soil alone or in combination with other soil amendments was demonstrated. Poultry manure (PM) is regarded as a rich source of N and P and it improves physicochemical and biological properties of soil.

Due to prolonged pressure on the soil, there is a need of the hour to check soil health and its fitness to produce an economic yield. The soil fitness can be evaluated by both the biological indicators as well as physio-chemical methods. Maize, a major nutrient feeder, needs a special attention for its nutrient management. Thus, maize field is usually supplemented with various organic and inorganic nutrient sources. However, it is essential to check the effects of soil amendments on nutrient status of soils under maize cultivation. Therefore, in the present investigation an attempt has been made to generate data on the effect of FA, PM and chemical fertilizers in their various combinations on soil nutrient status, when maize is cultivated.

MATERIALS AND METHODS

A field study was carried out at Lovely Professional University farm during *Kharif* season 2018-2019. Fresh seeds of maize (variety Kanchan 25) were grown taking 8 treatments with 3 replications for each treatment in a randomized block design (RBD). PM as an organic manure and FA were applied to the field at different combinations with chemical fertilizers based on their recommended dose of 180, 60 and 40 kg/ha for N, P and K, respectively and 2.5 and 20 tones/ha for PM and FA, respectively. Eight treatments include T₀ (Control, no application of FA, PM and

RDF), T₁ (100% RDF), T₂ (100% RDF + 100% PM), T₃ (10% FA + 90% RDF + 90% PM), T₄ (20% FA + 80% RDF + 80% PM), T₅ (30% FA + 70% RDF + 70% PM), T₆ (40% FA + 60% RDF + 60% PM), T₇ (50% FA + 50% RDF + 50% PM). The plot size was 5m × 4m with plant to plant and row to row distance of 60cm and 20cm, respectively.

Soils were analyzed for available nitrogen (N), available phosphorous (P), available potassium (K) and available sulphur (S). Available N was estimated by alkaline permanganate method (Subbiah and Asija, 1965), where soil was treated with KMnO₄ and NaOH, evolved ammonia / ammonium hydroxide was absorbed in boric acid and titrated against sulphuric acid. Available P in soil was extracted with 0.5N Sodium bicarbonate solution and was reacted with ammonium molybdate in presence of stannous chloride (Olsen *et al.*, 1954) for colour development. Finally, phosphorus was quantified at 660nm wavelength (Systronics Visible Spectrophotometer 168). Soil available K was extracted using 1N ammonium acetate as an extractant (Muhret *al.*, 1965) and was quantified using a flame photometer (Labtronics Digital Flame Photometer Model LT-66). Available S was estimated by turbidimetric method (Chesnin and yien, 1950). Soil was extracted with mono calcium phosphate solution and extracted solution was treated with barium chloride and gum acacia.

Statistical analysis

OPSTAT software, developed by CCS HAU, Hisar, India, was used to identify the most efficient treatment. Anova was made to examine the test of significance of difference for each parameter.

RESULTS AND DISCUSSION

Initial nutrient status of soil, FA and PM

Available nutrient present in soil, FA and PM at the initial stage of the experiment before application of any amendment to soil were estimated and presented in Table 1.

1. Table 1. Initial nutrient status of soil, FA and PM

Particulars	Soil (kg/ha)	FA (%)	PM (%)
Available N	256.4	0.057	1.12
Available P	13.28	0.087	0.23
Available K	275	0.174	0.73
Available S	10.8	0.024	0.19

Available nitrogen

FA and PM with different levels of RDF significantly increased available N in soil at 30, 60 and 90 DAS as compared to control (Table 2). Among the treatments, application of 100% RDF + 100% PM (T2) recorded maximum available nitrogen in soil 336.4, 327.6, 315.6 kg/ha at 30, 60 and 90 DAS, respectively; while corresponding data for control plot were found to be 270.1, 254.5 and 251.6 kg/ha. Maximum available N in soil was obtained in T2 (336.4 kg/ha) followed by T3 (330.3 kg/ha), T4 (324.2 kg/ha), T5 (317.6 kg/ha), T1 (304.4 kg/ha), T6 (291.1 kg/ha), T7 (272.5 kg/ha) and T0 (270.1 kg/ha) at 30 DAS. Similar trend was found at 60 and 90 DAS. The present results showed that application of PM in addition to chemical fertilizers exhibited best performance in increasing available N in soil. Apart from supplying nutrients, PM also improves soil physical conditions and microbial activities which encourage the N mineralization and nitrification processes (Kingery *et al.*, 1993; Adenawoola and Adejoro, 2005; Rasool *et al.*, 2008). FA also in combination with other amendments at different concentrations led to increase the level of soil available N. However, the effect decreases with increasing concentration of FA and decreasing concentration of PM and RDF. In all treatments, at 60 and 90 DAS available N content was found to be decreased which might be due to leaching loss and plant uptake.

Table 2. Effect of FA, PM and inorganic fertilizers on Available N (kg/ha)

Treatments	30 DAS	60 DAS	90 DAS
T0	270.1	254.5	251.6
T1	304.4	292.1	291.3
T2	336.4	327.6	315.6
T3	330.3	318.6	311.2
T4	324.2	315.4	301.2
T5	317.6	305.4	297.5
T6	291.1	288.1	283.5
T7	272.5	274.6	268.1
C.D.	4.03	2.71	2.39
SE(m)	1.32	0.89	0.78
SE(d)	1.86	1.25	1.10
C.V.	0.75	0.53	0.46

Available phosphorous

The data related to available P at 30, 60 and 90 DAS influenced by application of FA, PM with different levels of RDF are depicted in Table 3. All treatments showed statistically significant positive effect to increase available P level in soil over control. However, the highest available P content was recorded in T₂ (100% RDF + 100% PM) treatment (27.6 kg/ha) against control T₀ (14.5 kg/ha) at 30 days. The treatment T₂ was found significantly superior to T₃ (10% FA + 80 % PM + 80 % RDF) followed by T₄ (20% FA + 90 % PM + 90 % RDF), T₅ (30 % FA + 70 % PM + 70 % RDF) = T₁ (100% RDF), T₆ (40% FA + 60 % PM + 60 % RDF) and T₇ (50% FA + 50 % PM + 50% RDF), stating that combined application of organic and inorganic fertilizer provided better result over control because PM and RDF both are rich source of nitrogen and phosphorous. (Ullah *et al.*, 2008; Cavigelli and Thien 2004). Basically phosphorous is immobile nutrient in soil and diffusion is the major process for controlling its movement. Application of organic manure in soil increases the soil moisture content, which may lead to improve the phosphorous availability in soil (Botanget *al.*, 2006). Organic manure during decomposition

increases carbonic acid driven phosphorus bioavailability (Marschner, 1995; Mengel and Kirkby, 2001). PM encourages microbial activity which helps to transform unavailable form of phosphorus to available form. In the present study, a slight increase in pH was observed (data not provided) due to application of FA, thus restricting the formation of insoluble phosphate salts of Fe and Al and promoting availability of phosphorus (Lee *et al.*, 2006). With passage of time, at 60 and 90 DAS amount of available phosphorus decreased which might be due to crop removal and leaching loss.

Table 3. Effect of FA, PM and inorganic fertilizers on Available Phosphorous (kg/ha)*

Treatments	30 DAS	60 DAS	90 DAS
T0	14.5	13.7	11.8
T1	22.4	18.3	15.2
T2	27.6	24.3	20.4
T3	26.5	22.4	19.3
T4	25.3	20.4	18.3
T5	22.4	18.7	16.4
T6	18.6	17.3	14.4
T7	17.5	15.3	12.5
C.D.	2.22	1.57	1.64
SE(m)	0.73	0.51	0.54
SE(d)	1.03	0.72	0.76
C.V.	5.75	4.71	5.78

Available Potassium

Influence of PM, FA and RDF at their various levels on available potassium in soil was found significant at 30, 60 and 90 DAS over control (Table 4) Among the treatments, application of 100% RDF + 100% PM (T₂) recorded significantly maximum available potassium in soil 346.2, 342.1 and 337.2 kg/ha at 30, 60 and 90 DAS, respectively; while corresponding data for control treatment were found to be 291.8, 278.5 and 271.4 kg/ha. Maximum available potassium in soil was obtained in T₂ (346.2 kg/ha) followed by T₃ (338.2 kg/ha), T₁ (310.6 kg/ha), T₄ (329.7

kg/ha), T₅ (318.9 kg/ha), T₆ (298.5 kg/ha), T₇ (293.9 kg/ha) and T₀ (291.8 kg/ha) at 30 DAS. The trend was same at 60 and 90 DAS. The present results showed that application of PM exhibited significant effect on available potassium in soil when it was combined with chemical fertilizers. The higher availability of potassium in soil may be due to beneficial effect of organic manures on the reduction of potassium fixation and releasing more available potassium. The increase in availability of potassium with application of FA, organic manure and fertilizer was mainly because of their own K content. More availability of K content in soil amended with FA, manures and fertilizers was also observed earlier (Sarkar *et al.*, 2013; Das *et al.*, 2013; Nasabet *al.*, 2015). However, higher concentration of FA decreased available potassium content which confirmed that the combined application of low dose of FA along with PM and RDF was the best soil amendment for obtaining higher K availability in soil (Sarkar *et al.*, 2013; Panda *et al.*, 2015). All treatments including control showed a decrease in available K content in soil during 60 and 90 DAS. This lowering tendency might be due to the result of crop removal and leaching loss.

Table 4 .Effect of FA, PM and inorganic fertilizers on Available Potassium (kg/ha)*

Treatments	30 DAS	60 DAS	90 DAS
T0	291.8	278.5	271.4
T1	310.6	301.3	285.1
T2	346.2	342.1	337.2
T3	338.2	330.3	325.7
T4	329.7	319.1	311.2
T5	318.9	315.5	297.1
T6	298.5	289.3	281.1
T7	293.9	285.2	273.1
C.D.	4.72	2.73	2.21
SE(m)	1.54	0.89	0.72
SE(d)	2.18	1.26	1.02
C.V.	0.85	0.50	0.42

Available Sulphur

The data in Table 5 Showed significant effect of treatments on available S over the control plot. Highest sulphur content was found in T₂, over control at 30, 60 and 90 DAS. The increasing trend in available sulphur was found to be in the order of T₂> T₃>T₄> T₆>T₅>T₁>T₇>T₀. In general, application of organic manure along with inorganic fertilizers exhibits better result in improving soil properties and as well as the nutrient uptake by plants (Bahraniet *al.*, 2007; Ullah *et al.*, 2008; Ndukweet *al.*, 2014). The increase in sulphur content due to organic manures and RDF application might be due to its direct addition and mineralization of sulphur during the decomposition of organic matter. But surprisingly, higher dose of FA decreased sulphur content. It might be due to the interaction of FA and the microbial activities. In a separate experiment (data not provided here), it was evidenced that higher dose of FA inhibited microbial biomass. Thus, transformation of unavailable form of sulphur to its available form might be reduced in presence of larger quantity of FA. Lower organic carbon content of the soil and continuous removal of sulphur by crops would be the possible reason for low Sulphur content at 60 and 90 DAS. The result was well in agreement with previous studies (Tiwari *et al.*, 2008).

Table 5. Effect of FA, PM and inorganic fertilizers on Available Sulphur (kg/ha)

Treatments	30 DAS	60 DAS	90 DAS
T0	11.14	10.25	7.77
T1	14.53	12.18	10.22
T2	19.24	16.54	13.65
T3	17.61	14.49	11.89
T4	17.19	14.66	11.46
T5	14.99	12.63	10.72
T6	13.35	11.59	9.20
T7	12.31	11.26	9.00
C.D.	2.63	1.56	1.32
SE(m)	0.86	0.51	0.43
SE(d)	1.21	0.72	0.61

C.V.	9.88	6.89	7.14
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CONCLUSION

This study revealed that soil nutrient status, in respect of available N, P, K and S, was significantly enhanced by application of complementary dose of organic and inorganic fertilizers (100% RDF + 100% PM). Application of lower dose of FA proved to be better than higher dose. The present study makes it clear that substitution of organic and inorganic fertilizers (10% each) by FA (10%) provides nearly same results as evidenced by the treatment involving 100% PM and 100% RDF. Therefore, application of FA at low dose in combination with organic manure and chemical fertilizers may improve soil available nutrient status, apart from partial solution of FA disposal problem.

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