Plant Archives Vol. 19 No. 2, 2019 pp. 2193-2200 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

IMPACT OF VERMICOMPOST, FARM YARD MANURE, FLY ASH AND INORGANIC FERTILIZERS ON GROWTH AND YIELD ATTRIBUTING CHARACTERS OF MAIZE (*ZEA MAYS* L.)

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Abstract

A field experiment was conducted to determine the effect of different soil amendments constituting various combinations of inorganic fertilizers, vermicompost, farm yard manure and fly ash on the growth and yield of maize crop. All treatments showed significant positive influence over control in respect of leaf chlorophyll content, plant height, stem girth, number of leaves, number of cobs per plant, number of grains per cob, grain yield and harvest index. While growth and yield attributing characters were studied, it was found that treatment constituting recommended fertilizer dose (T_1, 100% RDF + 100% vermicompost) exhibited maximum positive influence over control, producing a total grain yield of 8.4 t ha^{-1}. However, when harvest index was considered, T_1 and T_4 treatments (20 % FA + 80 % RDF + 80 % VC) were found as the best performer in producing economic yield (49.7%). Therefore, from the findings of the present investigation, combination of 100 % RDF + 100% vermicompost and 20% fly ash + 80% RDF + 80% vermicompost are recommended as the best application input as soil amendment in maize cultivation.

Key words : Vermicompost, Farm yard manure, Fly ash, Growth indices, Yield attributes Maize.

Introduction

Maize (*Zea mays* L.) possesses a significant position as an important economic cereal crop among others. Maize is the India's third most important food crop after wheat and rice (Singh *et al.,* 2003). Maize ranks below wheat and sorghum but considerably above rice considering the nutritional value aspect. Maize grain mainly contains starch as chief components, and other components like protein, oil, fiber, sugar and ash. Farmers are benefitted with maize cultivation due to high price of green cobs and with green stalk that are used as fodder. However, during its cultivation, maize crop requires special attention in respect of its soil nutrient management.

Farm Yard Manure (FYM) is one of the oldest manures used by the farmers to grow plants because of its easy availability and presence of all plant nutrients. Organic manures, like FYM / vermicompost, not only supplies macronutrients and micronutrients to plants but also improves soil health from physical, chemical and biological points of view (Reddy and Reddy, 2003). Vermicompost (VC) is a broken-down product when micro-organisms and earthworm interact in hemophilic process to produce organic soil amendments with less C: N ratio (Ramasamy *et al.,* 2011). VC is eco-friendly and non-toxic to plants (Louraduraj, 2006). In addition to considerable amount of nutrients with huge amount of beneficial microbial population, VC also contains cytokinins, auxins, gibberellins like biological active growth promoting substances. It may be used alone or in combination with other organic and inorganic fertilizers in order to get a good qualitative and quantitative yield (Arancon *et al.,* 2006 and Jack *et al.,* 2011). VC possesses properties like high permeability, good aeration, good drainage, large water holding capacity and high microbial activities. (Arancon *et al.,* 2008)

Fly ash (FA) is a fine grey powder, produced by combusting coal in thermal power station (Vom Berg., 1998). India annually produces 235 million tons (2013) of fly ash which is projected to exceed 1000 million tons by 2031-32 (Kumar and Jha, 2014). It becomes a challenge to dispose this huge amount of FA in an amicable manner.

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However, FA which was considered in previous times as a waste, is now used as a valuable resources in agriculture to improve texture, reduce acdic character of soil, enhance nutrient levels, increase water holding capacity and can be used against pests to protect vegetables. (Rautaray *et al.,* 2003, Jala and Goyal, 2006; Inam, 2007; Kishore *et al.,* 2010). FA is gaining importance in agriculture as it contains many nutrients, especially the secondary (Ca, Mg & S) and the micronutrients (Fe, Mn, Zn & Cu). Therefore, it may be used as nutrient source to plants and also to improve the physicochemical properties of soils. Investigations under Fly Ash Utilization programme (FAUP) in India in varying agro-climatic conditions and different soil crop combinations described a significant more crop yield without any adverse effects on crop as well as soil quality despite of the presence of toxic and heavy metals and radio nuclides in fly ash (Kumar *et al.,* 2005).

Therefore, on this backdrop, attempts are made in the present study to examine the effect of FA alone and in combination with organic and inorganic fertilizers on the growth & yield attributing characters of maize crop, since limited information on such subject is available under Punjab agro-climatic conditions and finally benefit-cost ratio was assessed for different treatments.

Materials and Methods

The field experiment was carried out at the experimental farm of School of Agriculture, Lovely Professional University during Kharif season 2017-2018. The experimental site possessed sub-tropical type of weather conditions which normally favoured the cultivation of maize. Average value of temperature (highest and lowest) and rainfall during the field experimental period of July-October in 2017 have been 17.3 ^{0}C & 35.4 ^{0}C, and 27 mm & 197 mm, respectively. The experiment was laid out in Randomized Block Design with three replications. The treatments included were T_0 [Control: no RDF (recommended dose of fertilizers) and manures], T_1 (100 % RDF + 100 % VC), T_2 (100 % RDF + 100 % FYM), T_3 (100 % FA), T_4 (20 % FA + 80 % RDF + 80 % VC), T_5 (40 % FA + 60 % RDF + 60 % VC), T_6 (60 % FA + 40 % RDF + 40 % VC), T_7 (80 % FA + 20 % RDF + 20 % VC). Recommended dose of fertilizers (RDF) for N, P and K were used as 180, 60 and 40 kg ha^{-1}, respectively. FYM, VC and FA were applied to the field @16, 5 and 20 tonnes ha^{-1}.

Cultural practices

Maize (variety: Kawari 50) seeds were sown on 15 July 2017 by dibbling method, following plant to plant and row to row distance as 20 cm and 60 cm, respectively. Weeds were controlled by hand weeding at 40 days after germination and one spray of atrazine@ 1.25 kg a.i. / ha in 500 L / ha after 12 days of sowing. To control insects, maize seeds were treated with chloropyriphos (3 ml kg^{-1} seed). Afterwards, Nurocombi (chloropyriphos 50% EC + cypermethrin 5% EC) @1 L / ha in 500 L water) was sprayed on crop on 2nd week of August 2017 to avoid termites and other insects. Irrigations were given as per requirement in addition of rainfall. The full dose of DAP, MOP, VC, FYM and FA were applied during the last preparation of field. Urea was applied in 3 split doses.

Before application of any amendment, soil contained 0.63% organic carbon, 7.73 pH, 0.289 dSm^{-1} EC, 117.65 mg kg^{-1} available nitrogen, 7.23 mg kg^{-1} available phosphorous and 128.66 mg kg^{-1} available potassium. VC, FYM and FA contained 0.71%, 0.62%, 0.20% organic carbon, 1.12%, 0.52%, 0.067% total nitrogen, 0.23% 0.21%, 0.097% total phosphorous and 0.73%, 0.53%, 0.184% total potassium, respectively.

Growth and yield parameter

Five plants were selected randomly from each replication of each treatment and tagged. Plant height, leaf numbers and stem girth were recorded on 30, 60 and 90 days after sowing (DAS). Data obtained were subjected to further statistical analysis.

Leaf chlorophyll was extracted in 80% acetone and estimated by spectrophotometer (Systronics Visible Spectrophotometer 168, Bandwidth 2 nm) measuring the optical density at 663 nm and 645 nm (Arnon, 1949).

Five randomly selected plants from the sampling area were used to record the total dry matter accumulation at different growth stages of maize. The plant sample was air dried and then dried in oven at 60 – 70 ^{0}C until a constant weight was achieved. Dry matter accumulation was expressed in gram per plant.

Number of cobs/single plant, cob length, number of grains / cobs, grain and straw yield (after complete drying) from each replication of each treatment were estimated from randomly selected five plants. Mean value was calculated for further statistical analysis. Finally, harvest index (Singh and Stoskopf, 1971) was calculated using the formula:

$$\text{Harvest index (\%)} = \text{Economic yield} \times 100 / \text{Biological yield}$$

Economic analysis

Cost of cultivation was calculated based on local prices for various inputs *viz.* labour, fertilizer, compost and other necessary materials. Gross return was estimated by converting economic yield in accordance with local market price and was expressed in Rupees/

ha. Net return was obtained by subtracting the cost of cultivation from the gross return. Finally, benefit-cost ratio (Gross return/cost of cultivation) was calculated.

Statistical analysis

Duncan Multiple Range Test (DMRT) was applied to identify the most efficient treatment. Anova was done to test the significance of difference for each parameter. Calculation was done at 5 % significant level.

Results and Discussion

Plant height

A significant difference in plants height among the treatments at 30, 60 and 90 DAS were observed (Table 1). All treatments showed a significant increase in plant height as compared to the control plot. Considering all treatments including control, the mean plant height at 30 DAS was found to be in the range of 73.33 – 92.66 cm, which increased in the range of 201.36 – 240.10 cm at 60 DAS and 209.40 – 246.10 cm at 90 DAS. Maximum plant height was obtained in T_1 (92.66 cm) followed by T_4 (89.53 cm), T_2 (88.00 cm), T_5 (86.33 cm), T_7 (84.73 cm), T_6 (83.76 cm), T_3 (80.63 cm) and T_0 (73.33 cm) at 30 DAS. However, at 60 and 90 DAS the increasing trend in plant height was found in the order of $T_1>T_4>T_5>T_2>T_6>T_7>T_3>T_0$. It was found that the per cent increase in plant height in T1 treatment was 26.37, 19.24 and 17.53 at 30, 60 and 90 DAS, respectively. Overall in the present study, a combination of 100% RDF and 100% vermicompost (T_1) exerted highest influence in increasing the plant height, which conforms the earlier findings (Pevvast *et al.,* 2008; Prajapati and Swaroop 2016). In a previous study, it was observed that 25% application of FA increased plant length of cosmos plant, whereas higher percent reduced them significantly (Khan, 2001). In tomato, plant heights were significantly higher in treatment receiving 33% FA w/w while 50% FA w/w was found better to influence growth parameters in palak (Malewar *et al.,* 1999).

Number of leaves plant/plant

Like effect on plant height, a significant difference in number of leaves among the treatments at 30, 60 and 90 DAS were also observed (Table 1). All treatments showed a significant increase in number of leaves as compared to the control plot. Maximum number of leaves was obtained in T_1 (8.50) followed by T_4 (8.37), T_2 (8.20), T_5 (8.17), T_6 (7.83), T_3 (7.73), T_7 (7.67) and T_0 (7.27) at 30 DAS. However, at 60 DAS the increasing trend in number of leaves was found in the order of $T_1>T_4>T_2>T_5>T_6>T_7>T_3>T_0$. Same trend was also found at 90 DAS. The per cent increase in number of leaves in T1 treatment was 16.92, 9.55 and 10.03 at 30, 60 and 90 DAS, respectively. The result showed that application of VC had great effect on number of leaves when it was combined with fertilizer. Although FA did not exert effects like VC but influenced in increasing the leaf number more than that of RDF and FYM combination and the control. Stimulation of plant growth with increase in leaf number, caused by the application of FA and organic amendments was reported earlier (Katiyar *et al.,* 2012; Baharvand *et al.,* 2014; Prajapati and Swaroop, 2016).

Stem girth

Stem girth also showed positive significant response to different treatments over control at different growth stage (Table 1). Maximum stem girth was obtained in T_1 (2.14 cm) followed by T_4 (2.04 cm), T_2 (1.96 cm), T_5 (1.95 cm), T_6 (1.93 cm), T_7 (1.90 cm), T_3 (1.89 cm) and T_0 (1.73 cm) at 30 DAS. However, at 60 DAS the increasing trend in stem girth was found in the order of

Table 1: Effect of fly ash, organic manures and inorganic fertilizers on maize plant height, number of leaves per plant and stem girth.

Treatments	30 DAS	60 DAS	90 DAS
Plant height (cm)			
T_0	$73.33^{f}\pm0.63$	$201.36^{f}\pm3.24$	$209.40^{g}\pm2.42$
T_1	$92.66^{a}\pm0.66$	$240.10^{a}\pm3.85$	$246.10^{a}\pm2.85$
T_2	$88.00^{bc}\pm2.80$	$225.26^{bcd}\pm3.62$	$232.46^{cd}\pm2.71$
T_3	$80.63^{e}\pm0.90$	$210.63^{ef}\pm3.39$	$216.53^{f}\pm2.50$
T_4	$89.53^{ab}\pm0.40$	$235.50^{ab}\pm3.80$	$243.13^{ab}\pm2.83$
T_5	$86.33^{bcd}\pm0.69$	$230.53^{abc}\pm3.71$	$236.60^{bc}\pm2.74$
T_6	$83.76^{de}\pm0.97$	$219.40^{cde}\pm3.53$	$227.16^{de}\pm2.65$
T_7	$84.73^{cd}\pm0.23$	$214.23^{de}\pm3.44$	$222.33^{ef}\pm2.56$
Number of leaves plant^{-1}			
T_0	$7.27^{d}\pm0.06$	$13.20^{e}\pm0.11$	$13.36^{d}\pm0.08$
T_1	$8.50^{a}\pm0.05$	$14.46^{a}\pm0.17$	$14.70^{a}\pm0.05$
T_2	$8.20^{b}\pm0.05$	$14.06^{abc}\pm0.17$	$14.26^{ab}\pm0.17$
T_3	$7.73^{c}\pm0.067$	$13.53^{de}\pm0.17$	$13.66^{cd}\pm0.24$
T_4	$8.37^{ab}\pm0.03$	$14.26^{ab}\pm0.06$	$14.40^{ab}\pm0.11$
T_5	$8.17^{b}\pm0.03$	$13.93^{bcd}\pm0.17$	$14.36^{ab}\pm0.14$
T_6	$7.83^{c}\pm0.12$	$13.86^{bcd}\pm0.13$	$14.06^{bc}\pm0.17$
T_7	$7.67^{c}\pm0.14$	$13.73^{cd}\pm0.66$	$13.96^{bc}\pm0.18$
Stem girth (cm)			
T_0	$1.73^{c}\pm0.04$	$1.77^{b}\pm0.06$	$1.69^{c}\pm0.04$
T_1	$2.14^{a}\pm0.03$	$2.46^{a}\pm0.09$	$2.02^{a}\pm0.03$
T_2	$1.96^{b}\pm0.04$	$2.15^{a}\pm0.12$	$1.84^{abc}\pm0.04$
T_3	$1.89^{b}\pm0.26$	$2.08^{ab}\pm0.08$	$1.78^{bc}\pm0.04$
T_4	$2.04^{ab}\pm0.04$	$2.24^{a}\pm0.12$	$1.95^{ab}\pm0.09$
T_5	$1.95^{b}\pm0.03$	$2.21^{a}\pm0.03$	$1.90^{ab}\pm0.02$
T_6	$1.93^{b}\pm0.01$	$2.21^{a}\pm0.07$	$1.80^{bc}\pm0.07$
T_7	$1.90^{b}\pm0.10$	$2.13^{ab}\pm0.22$	$1.78^{bc}\pm0.05$

The mean followed by different letters are significantly different at $p< 0.05$, according to DMRT (Duncan's Multiple Range Test) for separation of means. Values are mean ± SE.

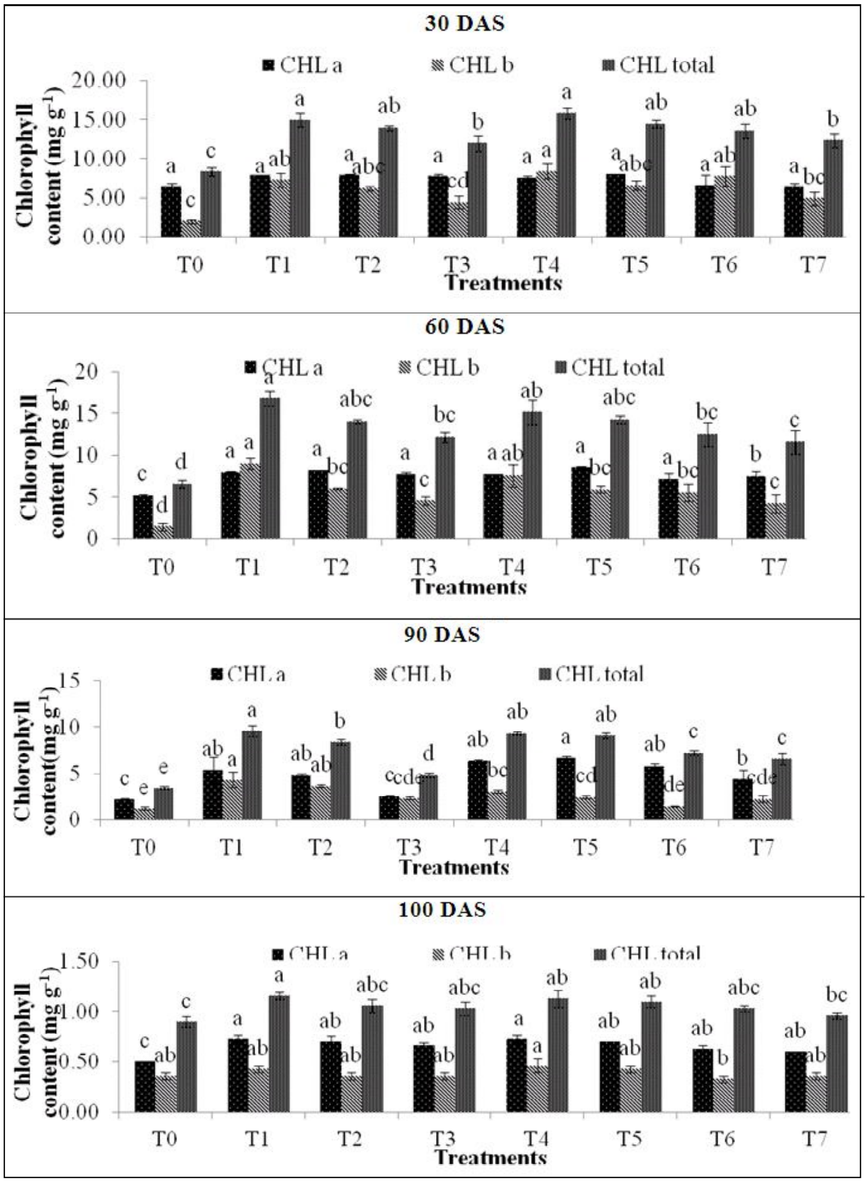

Fig. 1: Effect of fly ash, organic manures and inorganic fertilizers on chlorophyll content in maize leaves.

$T_1>T_4>T_5>T_6>T_2>T_7>T_3>T_0$, while at 90 DAS the increasing trend in stem girth was in the order of $T_1>T_4>T_5>T_2>T_6>T_7>T_3>T_0$. Per cent increase in stem girth in T1 treatment was 23.7, 39.98 and 19.53 at 30, 60and 90 DAS, respectively. The result showed that application of VC had great effect on stem girth when it was combined with fertilizer that conforms earlier findings (Baharvand *et al.,* 2014). Integrated fertilizer management significantly increased stem girth compared to full chemical and full organic amendments. In general, the application of integrated organic and inorganic fertilizer is best option to get maximum growth. However, positive influence of FA was also noticed earlier in wheat at 5% rate of application (Tripathy and Sahu, 1997)

Chlorophyll content

All treatments showed more amount of *chlorophyll a* than *chlorophyll b* at all stages (Fig.1). Except T_1 at 60 DAS, a gradual decrease in total chlorophyll content was noticed in all treatments after 30 DAS. Perhaps, this is due to dilution effect in early stage of growth with a continuous dry matter accumulation and due to degradation of chlorophyll at maturity stage. However, reduction in chlorophyll content also ensures reduction in heat stress on leaves in the upper portion of the canopy that results less water to be needed for cooling and leaving more for grain filling (Hamblin *et al.,* 2014). Besides, chloroplasts are nutrient rich. Reduction in chlorophyll content also means reduction in chloroplast numbers in leaves. Therefore, there is a possibility that nutrients from the chloroplasts are utilized for other metabolic purposes ensuring overall crop growth (Hamblin *et al.,* 2014). At all monitoring stages, T_1 was found to contain highest amount of total chlorophyll, while control treatment (T_0) exhibited with lowest amount; which confirms the effect of various treatments on chlorophyll content. The trend of showing treatment effect on the amount of total chlorophyll was found to be same at 30 & 90 DAS, and 60 & 100 DAS, and the trend followed the order of $T_1>T_4>T_5>T_2>T_6>T_7>T_3>T_0$ and $T_1>T_4>T_5>T_2>T_6>T_3>T_7>T_0$, respectively. Increase in leaf pigment content due to the application of organic manure in various crops was reported earlier (Pandey and Kumari, 2006; Sanwal *et al.,* 2007; Zadda *et al.,* 2008; Naidu *et al.,* 2009; Baharvand *et al.,* 2014). This might be due to the presence of essential nutrients in manure including micronutrients like magnesium and iron in manures, which might be playing an important role in chlorophyll synthesis. Additionally, manure contains plant growth hormones, enhanced levels of soil enzymes and high soil microbial populations. Increase in leaf chlorophyll content was also observed in maize and soybean with the application of FA (Mishra and Shukla, 1986). Perhaps, various elements present in FA after their uptake in plants encourage the pigment synthesis in plant leaves directly, besides its other favourable characteristics that influence the soil physicochemical properties and overall plant growth. However, decreased

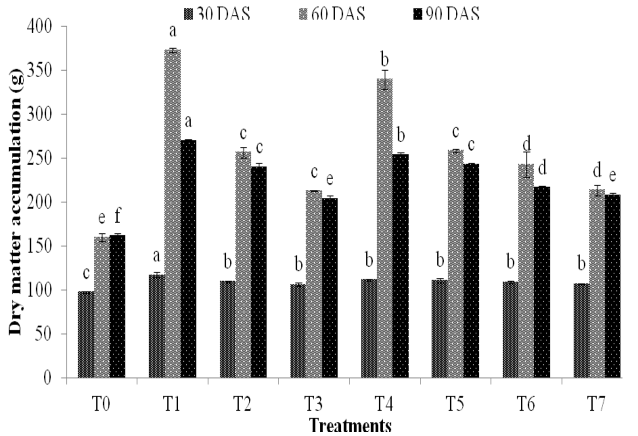

Fig. 2: Effect of fly ash, organic manures and inorganic fertilizers on maize dry matter accumulation in shoot.

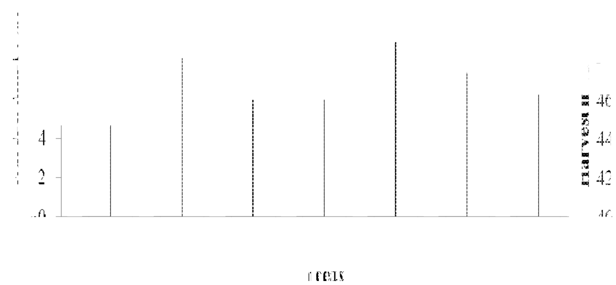

Fig. 3: Effect of various soil amendments on Maize harvest index.

amount of total chlorophyll and carotenoid content with increasing concentrations of FA was noticed in rice (Panda *et al.,* 2015), which was explained by the inhibition of the pigment synthesis by heavy metals present in FA (Krupa and Baszynski, 1995), But low dose of FA (20%) increased chlorophyll content and photosynthetic rate in rice (Panda *et al.,* 2015) and in *Jatropha curcus* (Mohan, 2011).

Shoot Dry matter content

The data related to dry matter content in maize shoots as influenced by the application of FA and other sources of nutrients were depicted in Fig. 2. The dry matter accumulation was significantly influenced by the application FA and organic and inorganic sources of nutrients. Considering all treatments including control, the mean dry matter content at 30 DAS was found to be in the range of 97.53 – 117.07 g, which increased in the range of 159.80 – 373.33 g at 60 DAS and 161.53 – 270.0 g at 90 DAS. Maximum dry matter accumulation was obtained in T_1 (117.07 g), followed by T_4 (111.33 g), T_5 (110.86 g), T_2 (109.40 g), T_6 (108.73 g), T_7 (106.93 g), T_3 (105.93 g) and T_0 (97.53 g) at 30 DAS. The same increasing trend in dry matter content was found at 30, 60 and 90 DAS, which was in the order of $T_1>T_4>T_5>T_2>T_6>T_7>T_3>T_0$. Overall, the result obtained with 100% RDF + 100% VC showed the highest influence in increasing the dry weight, which conforms the earlier findings (Prajapati and Swaroop, 2016). Present investigation also revealed that dry matter accumulation was also influenced by the different levels of FA. Effects were more at lower concentration of FA with chemical fertilizer and other organic amendments. This may be attributed to different chemical constituents of FA promoting plant growth and improving the soil properties (Sarkar *et al.,* 2013). Detrimental effects observed at high dose of FA on plants might be due to a shift in the chemical equilibrium of the soil. High level of FA induced high alkaline pH and increased the level of soluble elements and salts at the rhizosphere soil that might be injurious to crop growth. Higher soil pH leads to a loss of applied and indigenous soil N (Gupta *et al.,* 2002)

Number of cobs/plants

It was found that on an average most of plants produced one fully developed cob and one immature cob. In some case, there were two fully developed cobs. T_1 (100% RDF + 100% vermicompost) resulted in highest number of cobs per plant (1.40), exhibiting 40% increase over control (Table 2). The treatments T_0 (control), T_3 (100% Fly ash), T_6 (60% Fly ash + 40% RDF + 40% vermicompost) and T_7 (80% Fly ash + 20% RDF + 20% vermicompost) were very much alike to each other, producing same number of cobs (1 cob per plant). However, mean value of number of cobs per plant in T_2, T_4 and T_5 were 1.16, 1.33 and 1.20, respectively. This confirms that lower concentration of FA in combination with RDF and VC exerted a positive effect on producing a greater number of cobs per plant.

Number of grains/cobs

Number of grains per cob may also be considered as

Table 2: Effect of fly ash, organic manures and inorganic fertilizers on number of cobs per plants, number of grains per cobs, 100 grains weight and grain yield in maize at harvesting.

Treatment	No. of cobs/plants	No. of grains/cobs	100 grains weight (g)	Grain yield (t/ha)
T_0	$1.0^{c} \pm 0.00$	$278.66^{d} \pm 17.31$	$26.0^{e} \pm 0.00$	$4.20^{f} \pm 0.11$
T_1	$1.40^{a} \pm 0.00$	$372.86^{a} \pm 14.52$	$38.66^{a} \pm 1.33$	$8.40^{a} \pm 0.20$
T_2	$1.16^{b} \pm 0.03$	$329.86^{bc} \pm 11.92$	$32.0^{bcd} \pm 1.15$	$6.20^{bc} \pm 0.15$
T_3	$1.0^{c} \pm 0.00$	$309.73^{cd} \pm 2.90$	$28.66^{de} \pm 2.66$	$5.23^{e} \pm 0.12$
T_4	$1.33^{a} \pm 0.06$	$370.0^{ab} \pm 8.17$	$34.0^{b} \pm 1.15$	$7.93^{a} \pm 0.20$
T_5	$1.20^{b} \pm 0.05$	$340.93^{abc} \pm 9.57$	$33.33^{bc} \pm 0.66$	$6.70^{b} \pm 0.17$
T_6	$1.0^{c} \pm 0.00$	$323.26^{c} \pm 6.32$	$31.33^{bcd} \pm 0.66$	$6.0^{cd} \pm 0.25$
T_7	$1.0^{c} \pm 0.00$	$320.13^{c} \pm 21.76$	$29.33^{cde} \pm 1.76$	$5.43^{de} \pm 0.27$

The mean followed by different letters are significantly different at $p< 0.05$, according to DMRT (Duncan's Multiple Range Test) for separation of means. Values are mean ± SE.

Table 3: Economical aspect of Maize cultivation.

Treatments	Yield (t/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_0	4.20	57504	58800	1296	1.02
T_1	8.40	86544	117600	31056	1.36
T_2	6.20	79824	86800	6976	1.09
T_3	5.23	72104	73220	1116	1.02
T_4	7.93	83654	111020	27366	1.33
T_5	6.70	80765	93800	13035	1.16
T_6	6.0	77876	84000	6124	1.08
T_7	5.43	74993	76020	1027	1.01

another contributing factor toward yield, since number of grains in the cobs vary with different inputs and cultural practices adopted for growing the crop. In the present investigation, all treatments showed increased number of grains over the control table 2 although they vary within themselves. The number of grains per cob ranged from 278.66 – 372.86. The highest cob grains were recorded in T_1 (372.86), followed by T_4 (370.0), T_5 (340.93), T_2 (329.86), T_6 (323.26), T_7 (320.13), T_3 (309.73) and T_0 (278.66). This might be due to favourable conditions for crop growth and higher nutrient uptake by plants under various treatments over control (Ramasamy *et al.,* 2011). It was found that the percent increase in number of grains in T_1 treatment was 33.8 as compared to control. Number of grains per cob was also found to be influenced by the lower concentration of FA. T_4 out of all FA treatments, which constituted 20% FA in addition to 80% RDF and 80% VC, exhibited highest positive result.

100 grain weight (g)

The weight of 100 grains, test weight of the seed, has been depicted in Table 2. All the treatments produced significantly higher test weight over control that ranged from 26.0 – 38.66 g. The highest test weights were recorded in T_1 (38.66 g), followed by T_4 (34.0 g), T_5 (33.33 g), T_2 (32.0 g), T_6 (31.33 g), T_7 (29.33), T_3 (28.66), and T_0 (26.0 g). Per cent increase in test weight over control ranged from 10.23 – 48.69% in different treatments. It revealed the higher efficiency of the application of RDF with vermicompost to influence 100-grain weigh, conforming previous findings (Prajapati and Swaroop, 2016), followed by the combined application of FA, RDF and VC.

Total grain yield (t/ha)

Total grain yield of maize ranged from 4.20 – 8.40 t/ha table 2 depending on the effect of different treatments. The highest grain yield were recorded in T_1 (8.40 t/ha), followed by T_4 (7.93 t/ha), T_5 (6.70 t/ha), T_2 (6.20 t/ha), T_6 (6.0 t/ha), T_7 (5.43 t/ha), T_3 (5.23 t/ha) and T_0 (4.20 t/ha). Increase in total yield is the reflection of improvement on other yield attributing characters like increased cob length, number of grains per cob and number of cobs per plant. In a separate experiment (unpublished) it has been observed that applications of RDF/organic manure/FA improved the physical conditions and nutrient status of the soil, and enhanced plants nutrient uptake during maize cultivation. With increase uptake of nutrients, the number of grains per cob increased resulting in maximum grain yield at maturity. In general, to get higher yield the application of organic and inorganic fertilizer is best option (Baharvand *et al.,* 2014; Prajapati and Swaroop, 2016). However, previous studies also revealed that FA application in soil also increased total yield significantly in chilly, eggplant and tomato. (Khan and Ghadirpour, 1999), in mung bean (Singh and Agrawal, 2010), in rice (Dwivedi *et al.,* 2007) and conforms our present investigation. FA exerts its effect on the yield of a crop because it improves the growth and metabolic rate and increases the photosynthetic pigments content (Mishra and Shukla, 1986). Present investigation also revealed the effects of various treatments in increasing the chlorophyll content over the control treatment (Fig. 1).

Harvest index (%)

The application of FA, organic and inorganic fertilizers, alone or in combination, significantly influenced

Table 4: Cost of inputs used in experiment.

Sr. No.	Particulates	Price	Inputs (Rs/ha)	Total cost
1.	Seed	300 Rs/kg	25 kg/ha	7500
2.	Fertilizers			
a.	Urea	584 Rs/q	180 N kg/ha	2400
b.	DAP	2184 Rs/q	60 P kg/ha	2830
c.	MOP	1110 Rs/q	40 K kg/ha	1066
3.	Plant protection chemicals			
a.	Nurocombi	758 Rs/L	1 L/ha	758
4.	Weedicide			
a.	Atrazine	280 Rs/kg	1.25 kg/ha	350
5.	Organic manures			
a.	Vermicompost	400 Rs/q	5 t/ha	20000
b.	FYM	83 Rs/q	16 t/ha	13280
c.	Fly ash	73 Rs/q	20 t/ha	14600
6.	Land rent (hectare)			31250
7.	Tractor work			2500
8.	Men labour (13 men, 8 hours day^{-1}, 300 $head^{-1}$)			3900
9.	Harvest labour (4500 $Rs.acre^{-1}$)			11250

Table 5: Variable cost of maize production (Rs/ha).

Treatment	Particulars	Cost (Rs/ha)
T_0	General cost of cultivation	57504
	Cost of fertilizers	-
	Total	57504
T_1	General cost of cultivation	57504
	Cost of fertilizers	29040
	Total	86544
T_2	General cost of cultivation	57504
	Cost of fertilizers	22320
	Total	79824
T_3	General cost of cultivation	57504
	Cost of fertilizers	14600
	Total	72104
T_4	General cost of cultivation	57504
	Cost of fertilizers	26150
	Total	83654
T_5	General cost of cultivation	57504
	Cost of fertilizers	23261
	Total	80765
T_6	General cost of cultivation	57504
	Cost of fertilizers	20372
	Total	77876
T_7	General cost of cultivation	57504
	Cost of fertilizers	17489
	Total	74993

the harvest index (Fig. 3) of maize. All soil amendment treatments produced significantly higher harvest index over control. Harvest index of maize ranged from 44.66 – 49.76% in different treatments. The highest harvest index was recorded in T_4 (49.76 %), followed by T_1 (49.70 %), T^5 (48.90), T_2 (48.06 %), T_6 (47.36 %), T_7 (46.23 %), T_3 (45.93 %), and T_0 (44.66 %). The effects of T_4 and T_1 were considered statistically same. Per cent increase in harvest index in T_4 treatment was 11.42%, taking control harvest index as a base value. The maximum harvest index, observed in T_4, might be attributed to the use of proper combination of inorganic and organic fertilizers along with FA that improves the physicochemical properties of the soil and thus, increased nutrient status in the soil, and nutrient uptake by the plants at desired level.

Economical view

The data on net returns revealed that application of RDF + vermicompost at 5.0 t/ha recorded higher net returns of Rs. 31056 followed by 20% fly ash + 80% RDF + 80% vermicompost (Rs. 27366, Table 3). Lower net returns of Rs.1406 was associated with treatment receiving 80% fly ash + 20% vermicompost + 20% RDF. The net returns in the treatments T_4, T_5 and T_2 were Rs.27745, Rs.13414 and Rs.7355 while the net returns in the treatments T_6, T_7 and T_3 were Rs.6503, Rs.1495 and Rs.1027, respectively. In general, the treatments with 80% fly ash + 20% vermicompost + 20% RDF recorded conspicuously lower net returns than rest of the treatments. The higher cost benefit ratio of 1.36 was recorded in the treatment with 100% vermicompost + 100% RDF (T_1) and it was followed by 20% fly ash + 80% RDF + 80% vermicompost (1.33). In general, the treatments in (T_0, T_3 and T_7) recorded lower cost benefit ratio than rest of the treatments. The raw data utilized for calculation of cost of cultivation and other parameters are presented in Table 4 and 5.

Conclusion

Although all treatments of soil amendments showed significant positive influence over control treatment in respect of growth & yield attributing characters, T_1 (100 % RDF + 100 % vermicompost), T_4 (20 % fly ash + 80 % RDF + 80 % vermicompost) and T_2 (100 % RDF + 100 % FYM) performed comparatively better. Besides, when harvest index was considered, T_1 and T_4 treatments were found as the best performer in producing economic yield. The harvest index is a measure of productive efficiency. Therefore, from the findings of the present investigation, combination of 100 % RDF + 100% vermicompost (T_1) and 20% FA + 80% VC + 80% RDF (T_4) are recommended as the best application input as soil amendment in maize cultivation.

References

Arancon, N.Q., C.A. Edwards, A. Babenko, J. Cannon, P. Galvis and J.D. Metzger (2008). Influences of vermicomposts, produced by earthworms and microorganisms from cattle manure, food waste and paper waste, on the germination, growth and flowering of petunias in the greenhouse. *App. Soil Eco.,* **39:** 91-99.

Arancon, N.Q., C.A. Edwards, S. Lee and R. Byrne (2006). Effects of humic acids from vermicomposts on plant growth. *Euro. J. Soil Bio.,* **42:** S65-S69.

Arnon, D. (1949). Estimation of Total chlorophyll. *Plant. Physiol.,* **24:** 1-15.

Baharvand, Z.A., H. Zahedi and M. Rafiee (2014). Effect of Vermicompost and Chemical Fertilizers on Growth Parameter of three Corn Cultivars. *Appl. Sci. Agric.,* **9:** 22-26.

Dwivedi, S. F. E. B., R.D. Tripathi, S. Srivastava, S. Mishra, M. K. Shukla, K.K. Tiwari, R. Singh and U. N. Rai (2007). Growth performance and biochemical responses of three rice (*Oryza sativa* L.) cultivars grown in fly-ash amended soil. *Chemosphere,* **67:** 140-151.

Gupta, D.K., U.N. Rai;, R.D. Tripathi and M. Inouhe (2002). Impacts of fly-ash on soil and plant responses. *J. Plant Res.,* **115:** 401-409.

Hamblin, J., K. Stefanova and T.T. Angessa (2014). Variation in chlorophyll content per unit leaf area in spring wheat and implications for selection in segregating material. *PLoS One,* **9:** e92529.

Inam, A. (2007). Use of flyash in turnip (*Brassica rapa* L.) cultivation. *Pollut. Res.,* **26:** 39.

Jack, A.L., A. Rangarajan, S.W. Culman, T. Sooksa-Nguan and J. E. Thies (2011). Choice of organic amendments in tomato transplants has lasting effects on bacterial rhizosphere communities and crop performance in the field. *Appl. Soil Ecol.,* **48:** 94-101.

Jala, S. and D. Goyal (2006). Fly ash as a soil ameliorant for improving crop production-a review. *Bioresour. Technol.,* **97:** 1136-1147.

Katiyar, D., A. Singh, P. Malaviya, D. Pant, P. Singh, G. Abraham and S.K. Singh (2012). Impact of Fly-Ash-amended soil on growth and yield of crop plants. *Int. J. Environ. Waste Manag.,* **10:** 150-162.

Khan, M.R. and M.H. Ghadirpour (1999). Effects of field application of fly ash on the growth and yield of chilli, eggplant and tomato in the presence and absence of root-knot nematode. *Zeitschrift Pflanzenkrankh. Pflanzenschutz. / J. Plant. Dis. Protec.*,**106:** 624-632.

Khan, M.R. (2001). Use of fly ash in the cultivation of ornamental plants for domestic purpose. In: Proceeding of the IAEM National Conference on Recent Advances in Waste Management, S.N. Upadhyay, B.N. Rai and P.K. Mishra (eds.), Brzark Information System Pvt. Ltd., Varanasi, 85-89.

Kishor, P., A.K. Ghosh and D. Kumar (2010). Use of fly ash in agriculture: A way to improve soil fertility and its productivity. *Asian. J. Agric. Res.,* **4:** 1-14.

Krupa, Z. and T. Baszynski (1995). Some aspects of heavy metals toxicity towards photosynthetic apparatus-direct and indirect effects on light and dark reactions. *Acta Physiol. Plantarum.,* **2:** 177-190.

Kumar, V. and G.K. Jha (2014). Use of fly ash in agriculture: Indian scenario. 27–29 May 2014. Agricultural Center, Bet Dagan, Israel.

Kumar, V., M. Mathur and S.S. Sinha (2005). A case study: manifold increase in fly ash utilization in India. *Fly Ash India 2005*, New Delhi, 8.

Louraduraj, A.C. (2006). Identification of optimum quantity of vermicompost for maize under different levels of fertilization. *J. Ecobiol.,* 18: 23-27.

Malewar, G.U., P.B. Adsul, S. Ismail (1999). Growth parameters in tomato and spinach as influenced by fly ash, soil and their combination. *J. Soils Crops.,* **9:** 30-33.

Mishra, L.C. and K.N. Shukla (1986). Effects of fly ash deposition on growth, metabolism and dry matter production of maize and soybean. *Environ. Pollut. Series A: Eco. Bio.,* **42:** 1-13.

Mohan, S. (2011). Growth of biodiesel plant in fly ash: a sustainable approach response of Jatropha curcus, a biodiesel plant in fly ash amended soil with respect to pigment content and photosynthetic rate. *Proc. Environ. Sci.,* **8:** 421-425.

Naidu, D.K., B.M. Radder, P.L. Patil, N.S. Hebsur and S.C. Alagundagi (2009). Effect of integrated nutrient management on nutrient uptake and residual fertility of chilli (Cv. byadgi dabbi) in a vertisol. *Karnat. J. Agri. Sci.,* **22:** 306-309.

Panda, S.S., L.P. Mishra, S.D. Muduli, B.D. Nayak and N.K. Dhal (2015). The effect of fly ash on vegetative growth and photosynthetic pigment concentrations of rice and maize. *Biologija*., **61:** 94-100.

Pandey, R. and C. Kumari (2006). Effect of Fly ash on Chlorophyll in Rice Leaf. *Environ. Ecol.,* **24:** 665.

Peyvast, G.H., J.A. Olfati, S. Madeni and A. Forghani (2008). Effect of vermicompost on the growth and yield of spinach (Spinacia oleracea L.). *J. Food Agri. Environ.,* **6:** 110-113.

Prajapati, V.K. and N. Swaroop (2016). Effect of different dose of NPK and Vermicompost on growth and yield attributes of maize. *Int. J. Multi. Res. Develop.,* **3:** 217-219.

Ramasamy, P.K., K. Baskar and S. Ignacimuthu (2011). Influence of vermicompost on kernel yield of maize (*Zea Mays* L.). *Elixir Int. J. Agric.,* **36:** 119-3121.

Rautaray, S.K., B.C. Ghosh and B.N. Mittra (2003). Effect of fly ash, organic wastes and chemical fertilizers on yield, nutrient uptake, heavy metal content and residual fertility in a rice–mustard cropping sequence under acid lateritic soils. *Bioresour. Technol.,* **90:** 275-283.

Reddy, Y.R. and G.H. Reddy (2003). Principle of Agronomy. 3rd Ed. Kalyani Publishers; Ludhiana, (India), 203-253.

Sanwal, S.K., K. Laxminarayana, R.K. Yadav, N. Rai, D.S. Yadav and M. Bhuyan (2007). Effect of organic manures on soil fertility, growth, physiology, yield and quality of turmeric. *Indian J. Hort.,* **64:** 444-449.

Sarkar, A., A. Singh and S.B. Agrawal (2013). Utilization of fly ash as soil amendments in agricultural fields of North-Eastern Gangetic Plains of India: Potential benefits and risks assessments. *Bull. Nat. Inst. Ecol.,* **23:** 9-20.

Singh, A. and S.B Agrawal (2010). Response of mung bean cultivars to fly ash: growth and yield. *Ecotoxicol. Environ. Saf.,* **73:** 1950-1958.

Singh, I.D. and N.C. Stoskopf (1971). Harvest Index in Cereals. *Agron. J.,* **6:** 224-226.

Singh, R.N., R. Sutaliya, R. Ghatak and S.K. Sarangi (2003). Effect of higher application of nitrogen and potassium over recommended level on growth, yield and yield attributes of late sown winter maize (*Zea mays* L.). *Crop Res. - Hisar,* **26:** 71-74.

Tripathy, A. and R.K. Sahu (1997). Effect of coal fly ash on growth and yield of wheat. *J. Environ. Biol.,* **18:** 131-135.

Vom Berg, W. (1998). Utilization of fly ash in Europe. In *Proceedings of International Conference on Fly Ash Disposal and Utilization,* (ICFDU'98), Central Board of Irrigation and Power, New Delhi, India, **1:** 20-22.

Zadda, K., R. Ragjendran and C. Vijayaraghavan (2008). Induced systemic resistance to major insect pests of brinjal through organic farming. *Crop Res.-Hisar,* **34:** 125-129.