DESERTATION-II REPORT

Efficacy of Fly Ash as a Soil Amendment Under Maize (*zea mays L.)* Cultivation

Submitted to Lovely Professional University in partial fulfilment of the requirements for the degree of

Master of Science
In Agronomy

BY

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Under the Guidance of Dr. Premasis Sukul

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CERTIFICATE-I

This is to certify that the thesis entitled **"Efficacy of Fly ash as a soil amendment under maize (Zea mays L.) Cultivation"** submitted in partial fulfilment of the requirement for the award of the degree of Master of Science in the discipline of Agronomy is a bonafide research work carried out under my supervision and that no part of this thesis has been submitted for any degree or diploma.

(Signature of supervisor)

Dr. Premasis Sukul

Assistant professor

School of Agriculture

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CERTIFICATE -2

This is to certify that the thesis entitled **"Efficacy of Fly ash as a soil Amendment under maize(Zea mays L.)** cultivation" submitted by Ms. Banjurip Lyngdoh (Registration no-11501938) to Lovely Professional University, Phagwara, Punjab in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE(AGRICULTURE)AGRONOMY** has been approved after the oral examination of the same in collaboration with the internal examiner.

Dr. Arun Kumar   Internal examiner

Assistant Professor

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External examiner

Declaration

I, hereby declare that the project work entitled "**Efficacy of Fly ash as a Soil amendment under maize (Zea mays L.) cultivation"** is an authentic record of my work carried out at lovely professional university as requirement of project work for the award of the degree of Master of Science in Agronomy under the guidance of Dr. Premasis Sukul.

I also declare that the material contained in this thesis has not been published earlier in any manner

Signature of student

Acknowledgement

I am ever grateful to god for his blessings and i feel proud to express my profound regards to my mom, brothers, sisters and my friends for their enormous love and support which enables me to carry out this research work and complete this thesis.

It is an immense pleasure for me to express my profound sense of gratitude and indebtedness to my esteem, major advisor Dr Premasis Sukul, Assistant professor, school of Agriculture, Lovely professional university, Punjab for his valuable, affectionate and inspiring guidance and his immense zeal of hard work, never withering patience and constant inspiration and encouragement to me during the course of the present investigation and for preparation of the manuscript. My heartfelt gratitude also goes to Dr.Arun Kumar ,H.O.D,Department of Agronomy,School of Agriculture, Lovely Professional University, Phagwara, Punjab.

I would also like to thank Lovely Professional University for giving me this opportunity to carry out this project work and for providing most of the materials required to carry out the project.

Last but not the least , I would once again thank my mom(Mrs S.Lyngdoh) ,the only person who truly encouraged me during the entire period of study.

Yours faithfully

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Abstract

The experimental trial was entitled “Efficacy of Fly ash as a soil amendment under maize(Zea mays L.)Under maize cultivation was conducted at the experimental trial was conducted at the experimental farm of Lovely Professional university during the year 2016-2017 during Kharif season.

In this experiment conducted on maize(P 3396), it was found that T6 with 100% Fly ash increases the soil properties like pH, EC, organic carbon, Available P and Available K .Whereas on the basis of growth characters ,T2 with 20% Fly ash + 100% RDF increases the plant height, no of leaves /plant, stem girth , no of cobs and yield. Hence less doses of FA is recommended for better growth of the plant.

CHAPTER -1

INTRODUCTION

Maize (Zea mays) is one of the most cultivated and the third important cereal crop species in the India after wheat and rice. It belongs to the grass family Poaceae and is mainly grown for its edible grain. It was first domesticated in Mexico about 10,000 years ago and it is used as livestock feed, as human food, as biofuel and also as raw material in many industries. It can be grown under wide ranges of climate, soil, management practices but mostly in warmer temperate regions and humid sub-tropics. It is one of the staple foods for people in many countries. The USA (United States of America) being the largest producer of maize in the world contributes about 35% of the total production in the world. It also has the highest productivity (about 9.2 t/ha) whereas India has the average productivity (2.3 t/ha). Maize has been developing as one of the important crops that cater to major issues like food and nutritional security, climate change, water scarcity, farming systems, bio-fuel etc. National Centre for Agricultural Economics and Policy Research (NCAP) has recently showed that there is an increasing demand for maize in the industry sector which caters to consumer needs like textiles, paper, glue, alcohol, confectionery, food processing and pharmaceutical industry etc. It has also seen that the demand for maize keeps on increasing with the increasing population. Maize is largely grown in north India with the highest concentration of the crop being found in Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar, Himachal Pradesh, Jammu and Kashmir and Punjab which together account for two-third of the total area and output of the crop. Karnataka and Andhra Pradesh are the major producers of maize in southern part of the country. Madhya Pradesh ranks first in the production of maize in the country, followed by Andhra Pradesh, Karnataka, Rajasthan, Uttar Pradesh and Gujarat. These six states together account for over 67 per cent of the total area and 66 per cent of the total production of maize in the country. India’s Maize production for 2016/17 is expected to rebound to 24.5 million tons, up 1.5 million from last month estimates, according to United States Department of Agriculture (USDA). In 2016, corn production was forecast to be over 15 billion bushels, an increase of 11% over 2014 American production. Based on conditions as of August 2016, the expected yield would be the highest ever for the United States. The area of harvested maize was forecast to be 87 million acres, an increase of 7% over 2015(NASS, USDA 2016).

Fly ash is produced from combustion of lignite and coal in thermal power plants for electricity generation. The quality of coal determines the quantity and production of ash which contains high proportion of ash that leads to 10-30 percent formation of fly ash (Singh and Siddiqui, 2003). In India, production of fly ash is more than 100 million tonnes annually which is expected to reach 175 million in the future (Jamwal and Nidhi, 2003).Though it has been known for its problematic properties all over the world, several studies proposed that fly ash could be of great use in the use of agriculture .It acts as a soil conditioner that helps in the improvement of properties like physical, chemical and biological properties of degraded soils. It is also a readily and easily available plants micro and macro nutrients (Prem Kishore *et al*. 2010). Being a heterogenous mixture of phases like amorphous and crystalline, it is also known as a ferro-aluminosilicate element. Its size ranges from 0.01 to 100mm.Hydroxides, oxides, carbonates, silicates and sulfates of calcium, aluminum and iron are present in fly ash. A little amount of other metals are also present with its pH ranging from 4.5 to 12.0 (Singh *et al*. 2011). It is also found that fly ash contains essential nutrients such as calcium, potassium and magnesium which have alkaline effect and amending alkaline fly ash is suitable for agriculture as it reduces the soil acidity and also increases the availability of important nutrients. Fly ash plays a major role in agriculture as it promotes plant growth and applying fly ash changes the properties of soil and it may increase or decrease crop yields .It can be used as a fertilizer to complete the deficiencies of several elements and it has also shown successful results in crop production due to its physico-chemical properties and high mineral content. It increases the soil organic carbon content, conductivity, microbial activity, soil porosity and soil WHC (Mahale *et al*. 2012).Fly ash with its various physio-chemical properties like silt particles, low BD, high WHC and pH makes it an important amendment for soils.(Saraswat *et al*.2015). Fly ash helps in the management of various soil borne diseases in various crops like tomato, brinjal etc., example Tomato bacterial wilt and it also helps crops like rice to resist against disease like Rice blast. Recently, a mineralogical study of fly ash was carried out in Punjab, Guru Gobind Singh Super Thermal Power Plant and the soil was collected from Thapar University, Patiala, India. Both the soil and fly ash were tested for their physico-chemical properties. (Kaur *et al*. 2015). On another experiment, fly ash collected from NALCO Captive power plant, Angul, Odisha was used as a soil amendment for growing sunflower crop. It was found that application of 25% fly ash per hectare helps to improve the physical conditions and soil properties and hence increased the crop yield (Pani *et al* .2015).Two reviews have been conducted 20 or 30 years ago (El-Mogazi *et al*. 1988) regarding the effects of fly ash on plants, livestock and environmental responses. At present, various reviews has been conducted on fly ash and its use in agriculture and these reviews shows the increase in the yield and production of a number of crops with the application of fly ash. Hence, Fly ash in spite of being a waste material produced from thermal power plants can be of great use not only in agriculture but also in various purposes like construction of roads, widening of roads, building of bridges, landfills, as a building material etc.

Fly ash contains various macro and micro nutrients which are known to improve the growth and yield of various crops. It acts as a soil conditioner which can improve the fertility of the soil. It is also safe for the environment and due to this reason it can be used as an eco-friendly fertilizer.

As several studies has shown significant increase in the production and yield of of various crops using fly ash, it is appropriate to carry out an experimental trial entitled “Efficacy of Fly ash as a soil amendment under maize (Zea mays L.) Cultivation” with the following objectives:

1) To study the effect of Fly ash on soil chemical properties

2) To study the effect of Fly ash on growth and yield of maize.

CHAPTER-2

REVIEW OF LITERATURE

2.1 Effect of Fly ash on soil quality:

Dube et al. (2014) conducted a study to improve fertilizer value with fly ash composts and it was found that it shows great potential to supply major elements, especially P, in crop production but a major drawback to biological decomposition of fly ash appears to be the reduction of microbial activity, population and diversity and that earthworms and special microbial cocktails such as EM, PSMs and other bio-inoculants are a solution to this problem.

Ram. (2011) at the Central Institute of Mining and Fuel Research (CIMFR), Dhanbad demonstrated FA soil amendment technology (FASAT) and it was shown that the performance of different crops and plant species in cultivable and problematic soils are encouraging, eco-friendly and being adopted by the farmers. FA application includes ash alone and in combination with inorganic/organic amendments. It was found that the combination treatments including bio-solids perform better than FA alone.

Pandey et al.(2010) found that incorporation of FA in soil modifies the physico-chemical, biological and nutritional quality of the soil. Higher dosage of FA incorporation results in heavy metal pollution and hinders the microbial activity. To confirm its safety and quality, practical value of FA in agriculture as an ‘‘eco-friendly and economic’’ fertilizer or soil amendments can be established after repeated field experiments for each type of soil. The study reveals that FA could be effectively used in barren or sterile soil for improving the quality and enhancing fertility status.

Yanusa.(2012) found that by evaluating the edaphic (pH, sodicity, salinity, and elemental composition of the soil) and climatic factors (especially rainfall and its distribution), along with detailed characterization of the fly ash, routine use of this industrial by-product in agronomic management can be optimized. This is achievable with strategies in which the type and amount of fly ash to apply is mutually compatible with soil/crop type. Such a strategic approach should optimize agronomic benefits in terms of the quality and safety of the produce and of the environment, at competitive cost. It was concluded that with appropriate strategies, utilization of coal fly ash in agriculture will be an important avenue in providing sustainable end use for the ever-escalating accumulation of the fly ash around the world.

Gupta.(2012)found that Fly ash can be used as an amendment in soil. It can improve soils physical and chemical properties, reduce pest damage on crops and increase crop yields. The amount and method of fly ash application to soil depend on the type of soil, the crop grown and fly ash characteristics. Besides positive effects fly ash may contain also toxic metals and radionuclides. Therefore use of fly ash should be done with care, notably by taking into account the uptake of metals by plants.

Singh.(2014)stated that the method of FA application and what level of application is appropriate for any one soil depends on the following factors: type of soil treated, crop grown, the prevailing agro climatic condition and the character of the FA used. Although utilizing FA in agricultural soils may help address solid waste disposal problems and may enhance agricultural production, its use has potential adverse effects also. In particular, using it in agriculture may enhance amounts of radionuclides and heavy metals that reach soils, and may therefore increase organism exposures in some instances.

Chaudhary et al.(2013) conducted a study in which FA was amended to field soil at six rates (0, 5, 10, 20, 40, and 70 % w/w) on which J. curcas was grown. After 8 months of growth, the height of jatropha plants was significantly increased at 5 and 10 % FA-amended soil, whereas, biomass significantly increased at 5, 10, and 20 % FA-amended soil compared to control soil (0 % FA). Leaf nutrients uptake, followed by stems and roots uptake were highly affected by fly ash amendment to soil. Most of nutrients accumulation were increased up to 20 % fly ash and decreased thereafter. The results of available nutrient analysis of soil revealed that availability of nitrogen, potassium, sulfur, copper, iron, manganese, and zinc declined significantly at higher levels of fly ash amendments, whereas, availability of phosphorus increased at these levels. However, pH, organic carbon, and available boron were not influenced significantly by fly ash amendment to soil. Microbial biomass C, N, and ratio of microbial-C to organic C were significantly reduced at 20 % fly ash and higher amounts. This study revealed that J. curcas plants could gainfully utilize the nutrients available in fly ash by subsequently amending soil .

Ndoro. (2008) conducted an incubation experiment and it found that addition of fly ash and Calmasil have shown to increase the pH of two acidic soils used in the study . It was found that the treatment with Calmasil in the Avalon soil abtained the desired pH range.There was decrease in Extractable Al and Mn on application of FA and Calmasil to levels comparable to lime in the incubated soils. The base cations of both the soils were also found to increase with addition of fly ash and Calmasil. Incorporation of fly ash more than 200% OLR in the Avalon soil were found to have caused injury to ryegrass.Hence, usage of fly ash and Calmasil at lesser rates has been found to have great agronomic potential in neutralizing soil acidity.

Gupta et al.(2007) conducted a study on Phaseolus vulgaris grown on FA amended soil and found that the EC, CEC, Organic carbon and organic matter decreased with the application of Fly ash whereas the DTPA levels increased with increase application of Fly ash upto 25%.

Mishra et al.(2007) conducted a study on Oriza sativa and found that there was improvement in the physical properties, CEC, EC, WHC and content of silt due to application of Fly ash .Growth and yield was found to increase due to increase in K, P and Fe contents in soil by FA .

Lee et al.(2006) conducted a study on rice and found that pH was increased with the application of FA.It also increased the amount of available P which is needed for growth of the crop.It can also be used as an alternative for essential Si for paddy.

Wong et al.(1989) conducted a study on sandy loam and sandy soil where Brassica parachinensis and B.chinensis were grown.It was found that the electrical conductivity and pH of both soils were increased, in which more increased was seen in sandy soil. It was further found that low FA @ 3% improved the seedling growth of both crops whereas FA@12-30% has adverse effects on growth.

Pani et al.(2015) conducted a study in which fly ash collected from NALCO Captive power plant, Angul, Odisha was used as a soil amendment for growing sunflower crop. It was found that application of 25% fly ash per hectare improves the physical conditions and properties of soil and hence increased the yield of crop.

Antonkiewicz.(2007) found that incorporation of ash in the soil significantly affected an increase in Mg, Ca, K and Na concentrations, whereas there was decrease in P content in maize in comparison to the control. . Ash doses @ 200 and 600 t /ha also showed increase in potassium. However calcium, sodium and phosphorus was not on the optimal level in maize.

Kene *et al* .(1991) revealed that the properties of fly ash from Thermal power plant, Koradi, Nagpur. He concluded that, it had lower bulk density (1.39 g cm^{-3}), water solubility (0.25), EC (0.35 dSm^{-1}). It is poor in contents of NPK, but contains 350 ppm B, 120 ppm Mo, 75 ppm Cu and 100ppm Zn at pH 7.5.

Shinde *et al.* (1995) collected fly ash from Thermal Power Station, Ekalahara, District Nashik and revealed that the fly ash contained bulk of particles (81.2%) in size of 0.002 -0.02 mm. The bulk density was Mgm^{-3}, it was slightly alkaline in reaction (pH 8.2) with low Ec (0.2 dSm^{-1}). It had low cation exchange capacity. The total elemental analysis showed low P (0.45 %) amd K (0.05%).

Deshmukh *et al.* (2000) studied that the addition of fly ash may decrease the bulk density and maximum water holding capacity of the soil, while no marked effects on Ec and pH, cation exchange capacity and lime content was observed. The available NPK and micro – nutrients like Cu, Zn, Fe, and Mn and exchangeable Ca and Mg were increased with fly ash application.

2.2 Effect of Fly ash on growth of crops:

Kumar et al.(2013) conducted a study and found Fly ash has improved the physical properties of soil and hence changes the texture of the soil and hence has altered the water holding capacity(WHC), bulk density(BD), porosity and hydraulic conductivity which has a direct impact on the plant growth, nutrient source and biological properties of the soil. Fly ash @10% acts as a suitable rooting media for Leucaena leucocephala .

Truter et al.(2013)used Class F fly ash as a cover soil on the growth of various grasses and has shown significant increase in the grasses and it also acts as a soil ameliorant .

Mahoharan et al.(2008) found that Fly ash increased the growth and of Canola (Brassica napus) without any detrimental effects on the groundwater or soil .

Ravichandran et al.(2011) found that FA application on some cereal crops and plantation crops have shown significant increase in yields with the application of fly ash @ 50mt and it also improved the nutrient uptake and physical properties of the soil especially the water holding capacity and soil fertility status .

Tripathi et al.(2004) conducted an experiment on Cassia siamea, garden soil, where 100% fly ash and fly ash amended by cowdung, pressmud and garden soil 1:1 w/w was used ,it was found that although fly-ash contains high amount of metals but the metal uptake was more in the plants grown in fly-ash+press-mud mixture and inspite of high metal availability in fly-ash and press-mud mixture, plant growth was good.

Chattopadhyay.(2006) found that mixture of vermicomposted FA and CD (1:1) at 10 ton per hectare in potato cultivation shows that it was able to compensate 80% of the recommended NPK fertiliser, along with farm yard manure application, without compromising the crop yield.

Lal et al.(2014) conducted an experiment on rice variety MTU-1010 and found that the application of different treatment FA combinations increased paddy yield compared to 100% GRD. It was shown that the control treatment failed to produce the yield in degraded land and among the treatments,75% GRD +60t FAha-1+5t FYMha-1 gave highest paddy yield (42.6 q ha-1) than all other treatments.

Parab et al.(2015)conducted an experiment on onion yield,and it was found that the application of FA has reduced the water holding capacity to 50% in comparison to control and also improved the availability of Ca, Cu, Zn, Mn and Fe in soil. The study revealed that 50 Mg/ha dose of FA with 50% CF and Azotobacter is best suited for onion production by reducing the requirement of chemical fertilizers and can be utilized as an eco friendly and economic alternative for onion production.

Katiyar et al.(2012) conducted an experiment on palak and mung beans ,and it was shown that application of FA showed great effect on germination percentage of seeds of both the crops (85% for palak and 95% for mung bean).

Swift et al.(2008)found that Fly ash based products (FAP1 and FAP2) enhanced the growth of maize when applied at the rate of 1.25-5 % w/w and also increased the nutrient uptake of micro-nutrients like copper, zinc and manganese .

Chandraka et al.(2015)conducted an experiment on maize ,and it was shown that one time application of fly ash @ 40 t/ha alone or with FYM increased the clay and silt content and water holding capacity by 8 - 1 2 % both in surface and sub-surface soil. Integration of fly ash+ lime

+FYM resulted in higher pH (5.45) and higher Ca accumulation (3.7 %) in surface soil and application of lime to each crop significantly increased the maize yield by 27 % over control.

Mishra et al.(2014) found that 50:50 of FA+SOIL gave best yield of maize crop in terms of germination percentage & biometric parameters and the level of chlorophyll was found to be 13% more, carotene 3% more and NRA 10% more in Azotobacter treated crops as compared to the control which was treated and in the present study , it was observed that the use of fly ash with soil as carrier for Azotobacter biofertilizer emerged as safe alternative and hence this would also lead to reducing the problem of environmental pollution .

Bhaisare *et al.* (2000) reported that significantly highest yield on grain and straw of green gram along with highest content and uptake of nutrients were recorded with the increasing levels of fly ash upto 10 t ha^{-1}. Further increase in its application did not show any advantage. The highest contents of crude protein and test weight were recorded by same levels of fly ash.

Ashoken *et al.* (1995) conducted experiments in glass containers to study the interaction between pond ash with black cotton soil. The results revealed that application of fly ash with 25%, increased yield from 15 to 25 per cent as compared to controlled one.

Warambhe *et al.* (1992) from the application of 5 to 15 t fly ash per hectare reported that substantial increase in the crop growth and seed cotton yield. He reported that, beneficial effect of fly ash application was attributed to its content of plant nutrients in regards to trace elements.

Inam et al.(2015) observed that fly ash applied at the rate of 15 t ha-1 along with N40P15K20, proved optimum for spinach while in the case of methi, N20P30K40 + FA10 was sufficient. Therefore, both vegetables can safely be grown with 10 to 15 t ha-1 of fly ash and a comparatively lower quantity of NPK.

Khan et al.(1996) found that at 100% fly ash, yield (weight of fruits/plant) of tomato was considerably reduced. The most economic level of fly ash incorporation was 40%, which improved the yield and market value of tomato fruits (mean weight) by 81 and 30%, respectively.

Singh et al.(2003) conducted an experiment on three cultivars of rice and found that plants grown in 100% fly ash suffered higher reductions in growth and yield than plants grown in pure soil or in 20% or 40% fly ash. In general, plant growth was best in Pusa Basmati followed by Pant-4 and Pant-10, while yield was higher in Pant-4 followed by Pant-10 and Pusa Basmati.

Fail et al .(1977) conducted a study on soybean and found that the addition of fly ash was effective as an acid soil neutralizer and substantially enhanced the growth and development of all experimental plants. The parameters used in growth analyses were plant height, dry weight, root/shoot ratios, nodulation, pod production, and nitrogen fixing capacity for legumes.

Sale et al.(1996) conducted an experiment on barley and found that the addition of 6.25 and 12.5% fly ash increased both plant height and grain yield while 25% fly ash produced similar plant heights and grain yields as the 0% fly ash treatment.

CHAPTER-3

MATERIALS AND METHODS

A field experimental trial entitled "Efficacy of Fly ash as a soil Amendment under Maize (*Zea mays L*.) Cultivation" was carried out at the experimental farm of Lovely Professional University, Jalandhar, Punjab during Rabi season of 2016-2017. In this chapter, a complete detail of the work carried out is described. The details include description of location of the experimental trial, materials used, methods adopted, climatic condition, treatments, layout and design of experiment, land preparation, sowing method, land preparation and collection of data. These are described below under the following sub-headings:

3.1 DESCRIPTION OF EXPERIMENTAL TRIAL:

3.1.1 Location and experimental site:

The proposed research work was carried out at the experimental farm of Lovely Professional University, Phagwara (Punjab) .The farm is situated at 31 º15.491'N, 75º 42. 476'E and 252m above mean sea level.

3.1.2 Climate and weather conditions:

The experimental site has a sub-tropical type of weather condition with cool winters and hot summers. The site receives an annual rainfall of 1919.5m. The lowest temperature from 6-10ºC is seen during winters (December to January). The highest temperature during these months goes upto 27°C.It has been seen recently that during summer, the temperature goes upto 42°C.

The maximum temperature during November during the start of this investigation goes upto 22°C with a minimum precipitation. The maximum growth performed by the crop was seen during the months of November and December .Although there was decrease in the growth of the crop in the month of January and first two weeks of February ,the crop was able to withstand the cold condition .The increase in crop's growth was again noticed later.

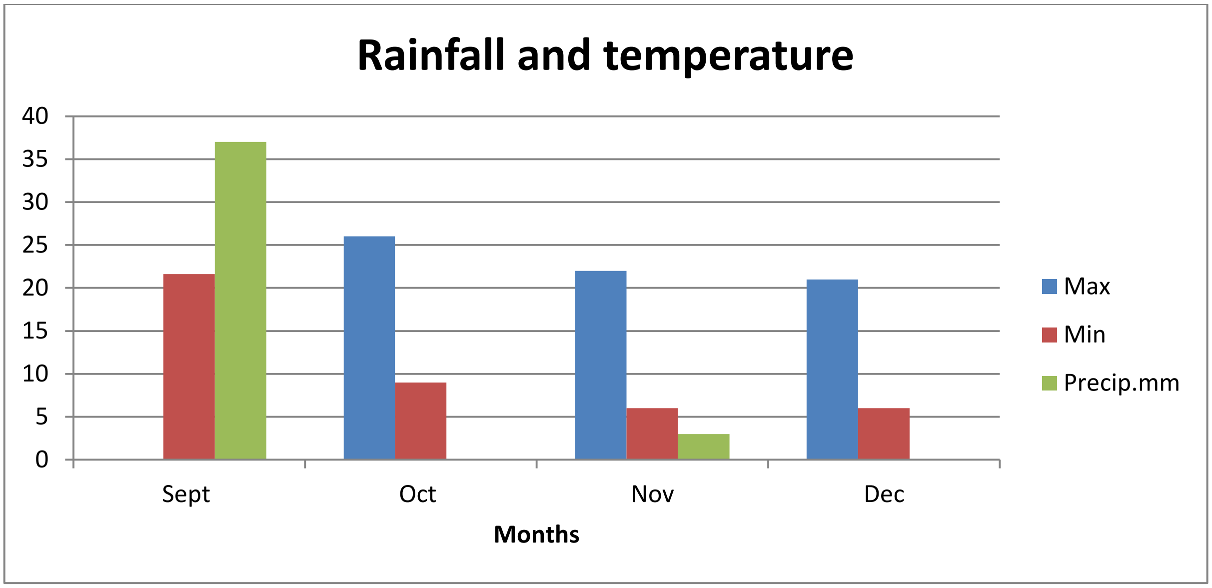


Figure 3.1 Monthly weather report from September 2016 to December 2016

3.1.3 Soil characteristics:

The experimental trial was conducted at the experimental farm of Lovely Professional University, Phagwara, Punjab. The soil sample from the field was collected randomly and was further analyzed for physiochemical properties. The soil was found to be sandy clay loam with pH value of 7.6 to 7.8.

1) pH:

The pH of the soil was measured with the help of a pH meter. 5g of soil was taken and transferred to a 150ml beaker, 25ml of distilled water was added to the beaker. It was then stirred and allowed to settle for 5 minutes. The solution was then measured using pH meter.

2) Electrical conductivity (EC):

The EC of the soil was measured with the help of a EC meter. 5g of soil was taken and transferred to a 150ml beaker, 25ml of distilled water was added to the beaker. It was then stirred and allowed to settle for 5 minutes. The solution was then measured using EC meter.

3) Soil texture:

The mechanical composition of the experimental site i.e. Proportion of sand, silt and clay was determined by Hydrometer method (Bouyoucos, 1962). The texture of the soil was determined according to Textural triangle proposed by USDA (Brady and Weil, 2002).

4) Organic carbon:

The organic carbon content in soil was measured by using Walkley and Black method. First weight 2g of soil in a 250 ml conical flask and then add 10 ml of 1N k_2 Cr_2 O_7solution, mix it properly. After that, 20 ml concentrated H_2So_4 is added. The flask is allowed to stand for sometimes to cool. Then add 2g of sodium fluoride power, 100ml distilled water and shake vigorously. Then 10 drops of diphenyl amine indictor is added which gave violet colour to suspension. The content is titrated with ferrous ammonium sulphate solution. The end point is when the colour of titrate changed from violet to light green. Then the volume of ferrous ammonium sulphate solution. Jackson (1967).

5) Nitrogen:

First weigh 5 gm. of soil sample on a filter paper. Put it into a kjeldahl distillation flask, and then moisten the sample with 25 ml of k_mNO_4 and 25 ml of NaOH solution with 10ml distilled water and quickly fit the cork. After this, take 25ml of the prepared boric acid solution in a conical flask, add about 3 drops of methyl red indicator and dip the end of delivery tube into the conical flask. Switch on the heater/hot plate to distil ammonia gas. Heat the content for about 10 minutes and then collect the distillate. At last, titrate the solution in the conical flask against 0.1N H_2SO_4 and when color changes from pink to yellow, note down the reading Subbiah et al (1956).

6)Available Phosphorus:

The available phosphorous in soil was determined by Olsen's method. First,Weight 1g of soil in 150ml conical flask. Then a pinch of charcoal and 20 ml of 0.5 N $NaOHCO_3$ is added. Shake the flask for half an hour on electric shaker and filter the suspension through whatsman's No. 1 filter paper. Similarly, a blank solution was prepared, pipette 5 ml of extract in a 25 ml. volumetric flask.5ml of 0. 5 N H2SO4 is added and shake it until CO_2evaluation disappears. Then 4 ml of Ascorbic acid was added to it and along with distilled water and mix contents of the flask by measuring the intensity of blue colour development at 760 micro meter wave length in colorimeter. Olsen *et al*. (1967).

6) Available Potassium:

The available potassium in soil was determined by flame photometer. First take 5g of soil in 150ml conical flask. 25 ml of ammonium acetate solution is added and shake the content for five minutes. Filter the contents through whatsman's No.1 filter paper and then Pipette out 5 ml of the filtrate in a 25 ml volumetric flask. Feed the extract to flame photometer and take the readings with solution (0, 2, 4, 6, 8, 10 ppm) of K and note down the readings. Mervin *et al*. (1950).

Soil samples were collected before sowing and and analysed for some of their physical and chemical properties.

Table 3.1- Some physical and chemical properties of soil

Characteristic	content
Texture	sandy loam
Organic carbon	
N	
P	
K	

3.1.4 Sources of nutrients:

Urea was used as a source of nutrient for nitrogen along with Fly ash. Whereas the Fly ash used is alkaline in nature.

3.2 CROPPING HISTORY:

During the past 14 years, maize-wheat rotation was practiced o the experimental site. Maize was during 2016-2017 during this course of investigation.

3.3 TREATMENT DETAILS AND EXPERIMENTAL DESIGN:

3.3.1 Treatment details:

Crop : Maize

Variety : P 3396(Rabi)

Total number of treatments : 7

Replications : 3

Total number of plots : 21

Plot area : 3m×2m= 6m^2

Design : RBD (Randomized block design)

Period of work : 2016-2017

Seed rate : 8 kg/ acre

Irrigation : Lifesaving irrigation

3.3.2 Treatments:

T1 Control: 0% Fly ash + 0% RDF

T2: 20% Fly ash + 80% RDF

T3: 40% Fly ash + 60% RDF

T4: 60% Fly ash + 40% RDF

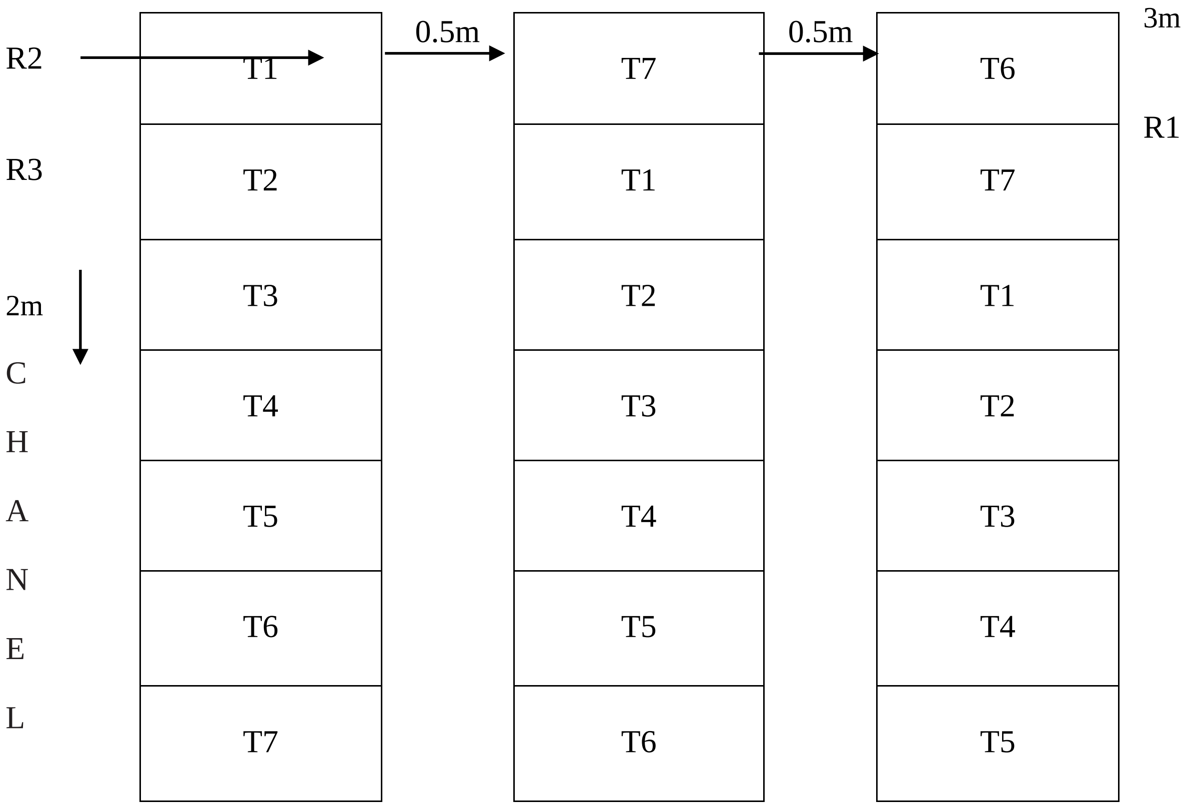
T5: 80% Fly ash + 20% RDF

T6: 100% Fly ash + 0% RDF

T7: 100% RDF

3.3.3 Experimental layout:

The experiment was carried out using Randomized Block Design with three replications and seven treatments.



3.4 DETAILS

3.4.1 Variety:

Hybrid P 3396 was used for this experiment. It is a long duration hybrid with a crop period of 100 days.

3.4.2 Seed rate and sowing:

P 3396 was used hand sown with recommended spacing on 5th November 2016 with a seed rate of 8kg/acre. The seeds were sown at a depth of about 3cm from the top of the ridge and covered with soil.

3.4.3 Planting material used for planting:

P3396 can be planted during Kharif and Rabi season and it has a unique plant structure that makes it to respond to higher populations. It also has very good standability.

3.4.4 Season:

The experiment was conducted during Rabi season of 2016-2017.The crop was sown on 5 th November, 2016 and harvested on 20th, 21st February, 2017.

3.4.5 Weed management:

Atrazine 0.5kg/ha was used two days after sowing through foot sprayer with a flat fan nozzle and 600l /ha of water. The first hand weeding was done 30 DAS followed by 45 DAS and whenever required .Weeding was done with a khurpi.

3.4.6 Thinning:

Inorder to maintain plant to plant distance, thinning was done at 35 DAS.

3.4.7 Irrigation:

First irrigation was given one day after sowing, second irrigation on 25^{th}DAS, and 3rd irrigation on 60^{th} DAS and fourth on 85^{th} DAS.

3.4.8 Harvesting:

The crop was harvested when the leaves and stalks are somewhat green but the husk cover became brown and dried. The crop was harvested on 110,111 DAS.

3.5 TREATMENT EVALUATION:

3.5.1 Soil parameters:

Soil samples from each treatment were collected on 30, 60 and 90 DAS. The soil samples were sundried, sieved and taken to the lab for analysis of pH, EC, OC, P and K.

The methods used for analysis are as follows:

1) **pH meter for pH:**

The pH of the soil was measured with the help of a pH meter. 5g of soil was taken and transferred to a 150ml beaker, 25ml of distilled water was added to the beaker. It was then stirred and allowed to settle for 5 minutes. The solution was then measured using pH meter.

2) **EC meter for EC:**

The EC of the soil was measured with the help of a EC meter. 5g of soil was taken and transferred to a 150ml beaker, 25ml of distilled water was added to the beaker. It was then stirred and allowed to settle for 5 minutes. The solution was then measured using EC meter.

3) **Organic carbon:**

The organic carbon content in soil was measured by using Walkley and Black method. First weight 2g of soil in a 250 ml conical flask and then add 10 ml of 1N k_2 Cr_2 O_7solution, mix it properly. After that, 20 ml concentrated H_2So_4 is added. The flask is allowed to stand for sometimes to cool. Then add 2g of sodium fluoride power, 100ml distilled water and shake vigorously. Then 10 drops of diphenyl amine indictor is added which gave violet colour to suspension. The content is titrated with ferrous ammonium sulphate solution. The end point is when the colour of titrate changed from violet to light green. Then the volume of ferrous ammonium sulphate solution. Jackson (1967).

OC= $(B-S)/2\times0.003\times100/2$

4) **Available Phosphorus:**

The available phosphorous in soil was determined by Olsen's method. First,Weight 1g of soil in 150ml conical flask. Then a pinch of charcoal and 20 ml of 0.5 N $NaOHCO_3$ is added. Shake the flask for half an hour on electric shaker and filter the suspension through whatsman's No. 1 filter paper. Similarly, a blank solution was prepared, pipette 5 ml of extract in a 25 ml. volumetric flask.5ml of 0. 5 N H2SO4 is added and shake it until CO_2evaluation disappears. Then 4 ml of Ascorbic acid was added to it and along with distilled water and mix contents of the flask by measuring the intensity of blue colour development at 760 micro meter wave length in colorimeter. Olsen *et al*. (1967).

5) **Available Potassium:**

The available potassium in soil was determined by flame photometer. First take 5g of soil in 150ml conical flask. 25 ml of ammonium acetate solution is added and shake the content for five minutes. Filter the contents through whatsman's No.1 filter paper and then Pipette out 5 ml of the filtrate in a 25 ml volumetric flask. Feed the extract to flame photometer and take the readings with solution (0, 2, 4, 6, 8, 10 ppm) of K and note down the readings. Mervin *et al*. (1950).

3.5.2 Growth parameters:

1) Plant height at 30, 60 and 90 DAS:

Five plants were randomly selected and tagged from each treatment, the height of each plant was measured from ground level to top of the shoot at 30, 60 and 90 DAS.The mean height was then calculated and expressed in cm.

2) Number of leaves/plant at 30, 60 and 90 DAS:

The five randomly tagged plants from each treatment were counted for their number of leaves. Average was taken and expressed as number of leaves/plant.

3) Number of cobs/plant at 30, 60 and 90 DAS:

The numbers of cobs from the five tagged plants were counted at harvest and the mean value per plant was taken.

4) Stem girth at 30, 60 and 90 DAS:

The stem girth was measured from the five randomly tagged plants from each treatment at 30, 60 and 90 DAS and average was taken.

5) Yield:

Yield from each five tagged plants were recorded after harvesting and expressed in kg/ha.

Figure 3.2 Application of Fly ash and RDF(urea)

Figure 3.3 Field visit two weeks after sowing

Figure 3.4 Hand weeding

Figure 3.5 Crop after hand weeding

Figure 3.6 Sun drying and sieving of soil for analysis

Figure 3.7 Analyzing soil samples in laboratory

3.6 Statistical analysis:

Data were assessed by Duncan's multiple range tests with a probability $p<0.05$.Difference between mean values were evaluated by one way analysis of variance (ANOVA) using the software SPSS 16. Critical difference between different variables was calculated to estimate significance treatment mean under the F-test of one way ANOVA.

CHAPTER-4

RESULTS AND DISCUSSION

In this chapter, the results of the experimental trial entitled **"Efficacy of Fly ash as a soil Amendment under Maize (*Zea mays L.)* Cultivation"** conducted at the Experimental farm of Lovely Professional University,Jalandhar,Punjab during Rabi season (2016-2017) are presented in the form of tables and graphs along with explanations. The results are presented on the basis of growth parameters which include plant height, number of leaves/plant, no of cobs, yield and soil parameters which include pH, EC, OC, P and k.

4.1 Growth parameters:

4.1.1 Plant height:

Height of the crop was recorded from different treatments at 30, 60 and 90 DAS. Thus a variation was observed in the height of the crop at different duration and under all the treatments.

4.1.1.2 Plant height at 30 DAS:

After analysis of the data, the maximum height was observed at T2 with 78.22cm .However it was found to be par with T7 (76.51cm), T3 (72.39cm), T4 (70.8cm) followed by T5 (67.13cm) and T6 (56.08%) whereas the least height was observed at T1 (33.31cm). Hence, it was observed that there is a wide variation in the plant height between T2 and T1. However, there is less variation between T2, T7, T3, T4 and T5 and a similar variation between T1 and T6.

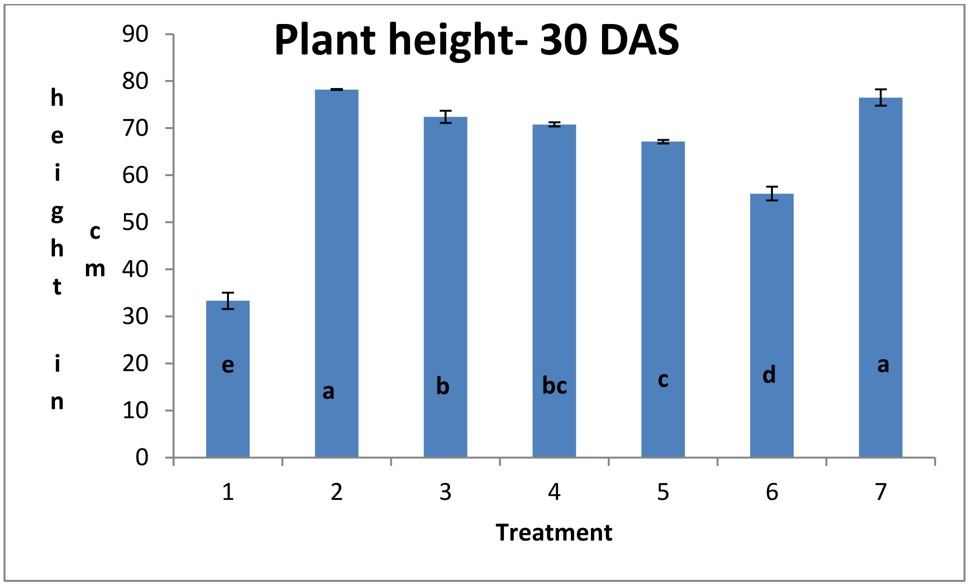


Figure 4.1 Effect of Fly ash on plant height at 30 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.1.1.2 Plant height at 60 DAS:

The maximum plant height was observed at T2 with 200.6cm .However the result was found to be at par with T7 (199.7cm) followed by T3 (173.33cm), T4 (154.82cm), T5 (130.4cm), T6 (118.4cm) whereas the least plant height was observed at T1 with 99.64cm. As observed, there is a wide variation in heights between T2 and T1 and a similar variation between T3 and T4 and between T5 and T6.

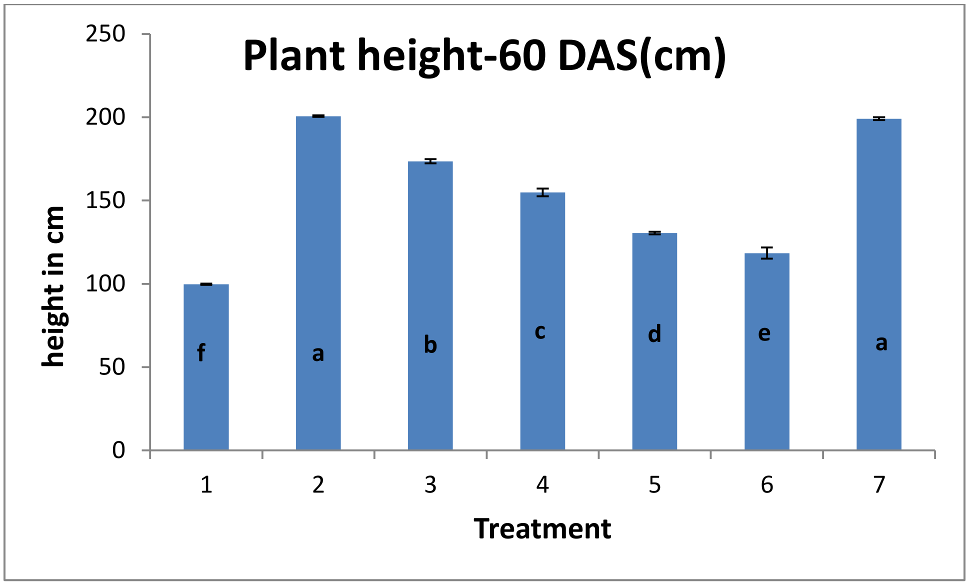


Figure 4.2 Effect of Fly ash at 60 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.1.1.3 Plant height at 90 DAS:

The maximum plant height was observed at T7 with 207.4cm. However the result was found to be at par with T2 (206.11cm) followed by T3 (174.74cm), T4 (163.02cm), T5 (138.48), T6 (130.83cm) and the least height was observed at T1 (111.4cm). The heights of each treatment increases by 86.18%, 85.12%, 56.86%, 46.34%, 24.31% and 17.44%.

Hence, it was observed that there is significant increase in height of plants at 60 and 90 DAS as compared to 30 DAS. It was also observed that T2 and T7 showed the maximum heights over rest of the treatments.

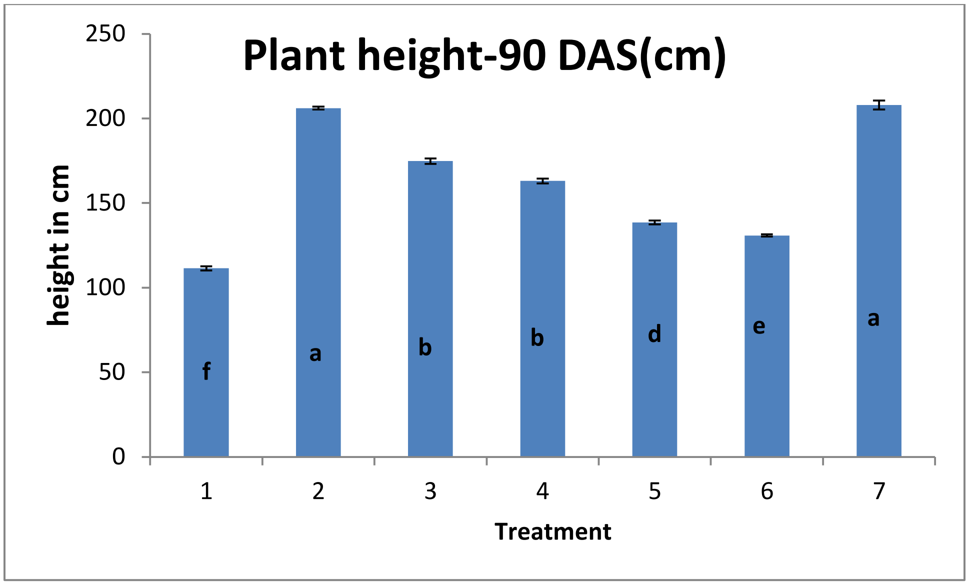


Figure 4.3 effect of Fly ash on plant height at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	30 DAS	60 DAS	90 DAS
1	T1-control	$33.31^{e} \pm 1.72$	$99.64^{f} \pm 0.4$	$111.4^{f} \pm 1.29$
2	T2-(20%Fly ash+80% RDF)	$78.22^{a} \pm 0.12$	$200.6^{a} \pm 0.51$	$206.11^{a} \pm 0.86$
3	T3-(40% Fly ash+60% RDF)	$72.39^{b} \pm 1.13$	$173.55^{b} \pm 1.18$	$174.74^{b} \pm 1.59$
4	T4-(60%Fly ash+40% RDF)	$70.80^{abc} \pm 0.44$	$154.82^{c} \pm 2.35$	$163.02^{b} \pm 1.34$
5	T5-(80%Fly ash +20% RDF)	$67.13^{c} \pm 0.37$	$130.48^{d} \pm 0.76$	$138.48^{d} \pm 1.11$
6	T6-(100%Fly ash +0% RDF)	$56.08^{d} \pm 1.47$	$118.43^{e} \pm 3.34$	$130.83^{e} \pm 0.68$
7	T7-(100% RDF)	$76.51^{a} \pm 1.75$	$199.07^{a} \pm 0.91$	$207.94^{a} \pm 2.72$

Table 4.1 Effect of Fly ash on plant height at 30, 60 and 90 DAS

4.1.2 Number of leaves/plant:

The number of leaves was counted at 30, 60 and 90 DAS for all the treatments. It was observed that the number of leaves per plant were similar at 30, 60 and 90 DAS. Hence the highest number of leaves was observed to be highest at 60 DAS followed by 30 and 90 DAS. T2 and T7 showed significantly best performance over the rest of the treatments with low performance showed by T1.

4.1.2.1 Number of leaves/plant at 30 DAS:

The numbers of leaves were observed to be significantly high at T2 (8.32). However it was found to be at par with T7 (7.92). Whereas T6, T5, T3, T4 and T1 showed similarity in the number of leaves with 5.85, 5.83, 5.8, 5.79 and 5.39 respectively. The number of leaves of each treatments increases by 54.36%, 46.94%, 8.53%, 8.16%, 7.61% and 7.42%.

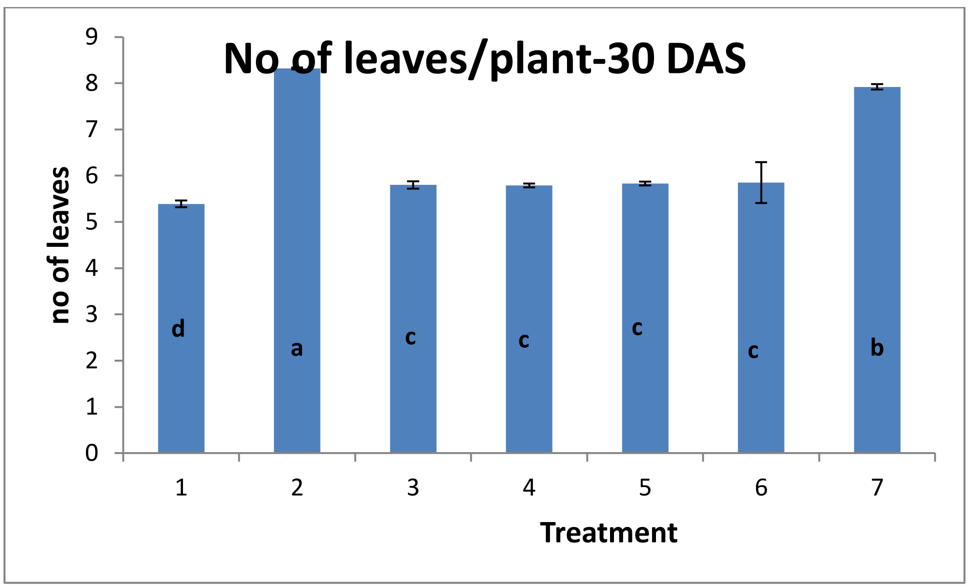


Figure 4.4 Effect of Fly ash on no of leaves/plant at 30 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.1.2.2 Number of leaves at 60 DAS:

The number of leaves was found to be significantly high at T2 (10.16). However the result was found to be at par with T7 (10). Whereas T6, T3, T4 and T5 showed similarity in the number of leaves with 8.04, 7.94, 7.28 and 7.06 respectively with the least number number of leaves showed by T1 at 6.12. The number of leaves of each treatments increases by 66.01%, 63.39%, 31.37%, 29.74%, 18.95% and 15.36%.

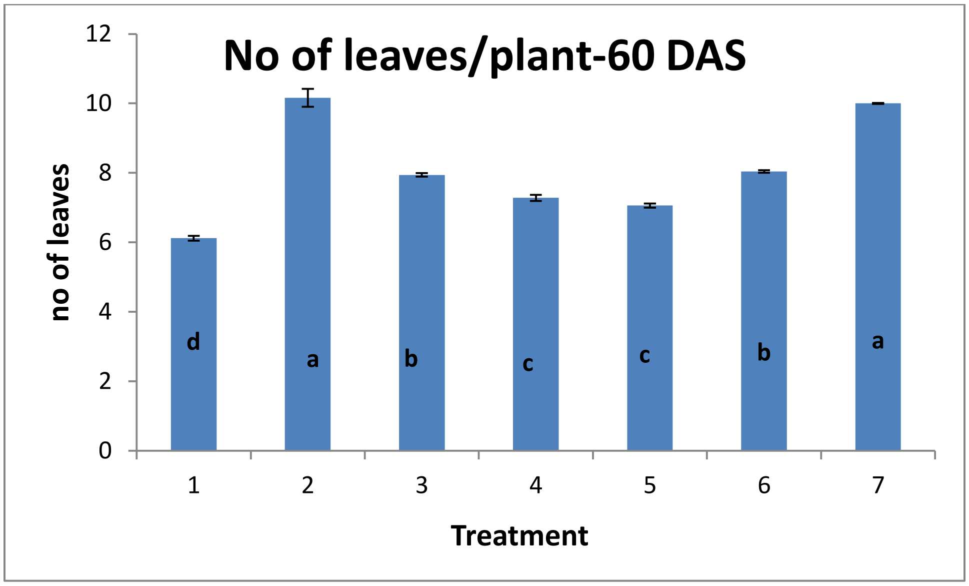


Figure 4.5 Effect of Fly ash on no of leaves/plant at 60 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.1.2.3 Number of leaves/plant at 90 DAS:

The number of leaves was found to be significantly high at T2 (7.95).However the result was found to be at par with T7 (7.77). Whereas T3 and T4 showed similarity in the number of leaves with 7.4 and 6.79 respectively. T6 and T5 showed similarity at 5.88 and 5.64 respectively with the least number of leaves showed by T1 at 4.52.The number of leaves of each treatments increase by 75.88%, 71.90%, 63.72%, 50.22%, 30.09% and 24.78%.

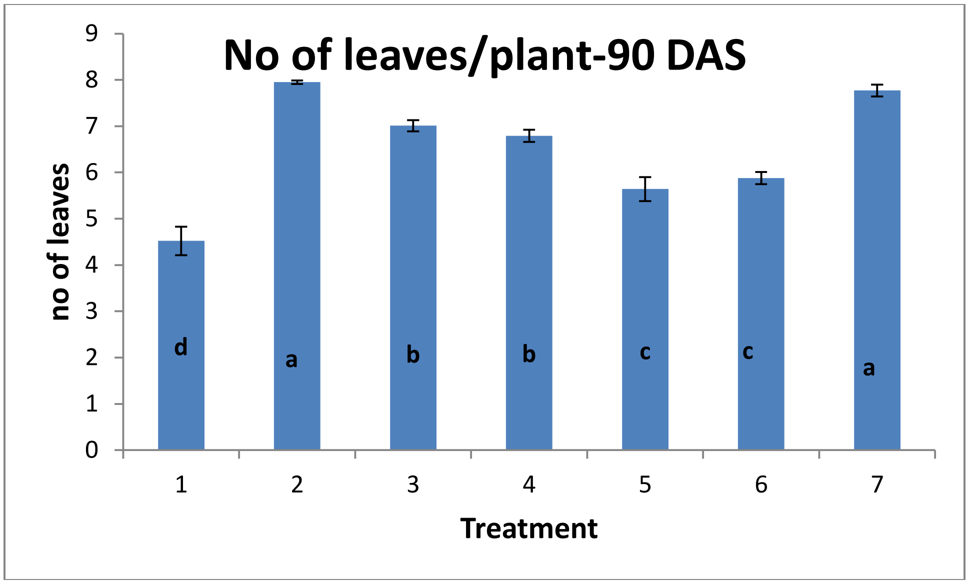


Figure 4.6 Effect of Fly ash on no of leaves/plant at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	30 DAS	60 DAS	90 DAS
1	T1-control	$5.39^{d}\pm 0.07$	$6.12^{d}\pm 0.7$	$4.52^{d}\pm 0.31$
2	T2-(20%Fly ash+80% RDF)	$8.32^{a}\pm 0.02$	$10.16^{a}\pm 0.26$	$7.95^{a}\pm 0.04$
3	T3-(40% Fly ash+60% RDF)	$5.80^{c}\pm 0.08$	$7.94^{b}\pm 0.05$	$7.01^{b}\pm 0.12$
4	T4-(60%Fly ash+40% RDF)	$5.79^{c}\pm 0.04$	$7.28^{c}\pm 0.09$	$6.79^{b}\pm 0.13$
5	T5-(80%Fly ash +20% RDF)	$5.83^{c}\pm 0.04$	$7.06^{c}\pm 0.06$	$5.64^{c}\pm 0.26$
6	T6-(100%Fly ash +0% RDF)	$5.85^{c}\pm 0.44$	$8.04^{b}\pm 0.04$	$5.88^{c}\pm 0.13$
7	T7-(100% RDF)	$7.92^{b}\pm 0.06$	$10.00^{a}\pm 0.01$	$7.77^{a}\pm 0.13$

Table 4.2 Effect of Fly ash on no of leaves/plant at 30, 60 and 90 DAS

4.1.3 Stem girth:

The stem girth from each treatment was measured at 30, 60 and 90 DAS.Hence it was found T2 with 20%FA+80% RDF showed the best performance. However the result was at par with T7-100% RDF.

4.1.3.1 Stem girth at 30 DAS:

T2 with 20%FA+80%RDF was found to have the highest girth with 7.24cm.It was however followed by T7(6.53), T4(5.18), T5(5.14), T1(5.12), T6(5.11) and T3(4.87).There was increase of 41.41% over the control.

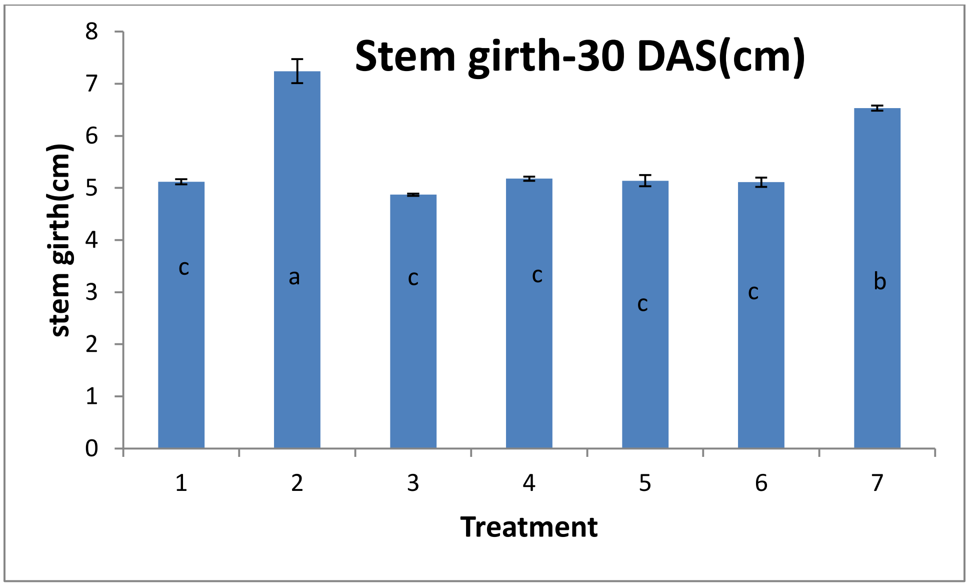


Figure 4.7 Effect of Fly ash on stem girth at 30 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.1.3.2 Stem girth at 60 DAS:

T2 with 20%FA+80%RDF was found to have the highest girth with 7.37cm.It was however followed by T7(6.66), T6(5.24) ,T4(5.22),T1(5.16),T5(4.94),and T3(4.59).There was increase of 42.83% over the control.

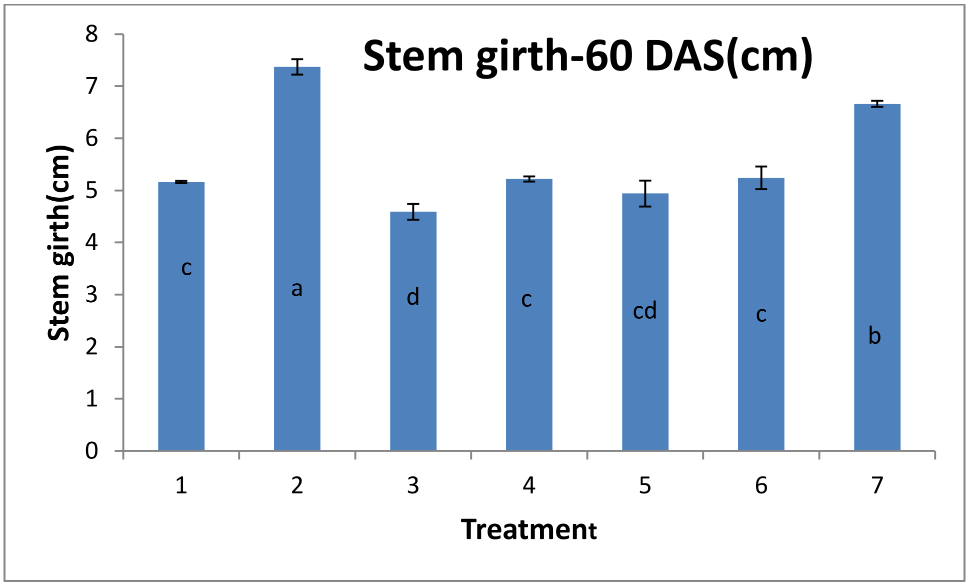


Figure 4.8 Effect of Fly ash on stem girth at 60 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.1.3.3 Stem girth at 90 DAS:

T2 with 20%FA+80%RDF was found to have the highest girth with 7.26cm.It was however followed by T7(6.7), T6(5.32) ,T4(5.29),T1(5.23),T5(4.98),and T3(4.62).There was increase of 42.83% over the control.

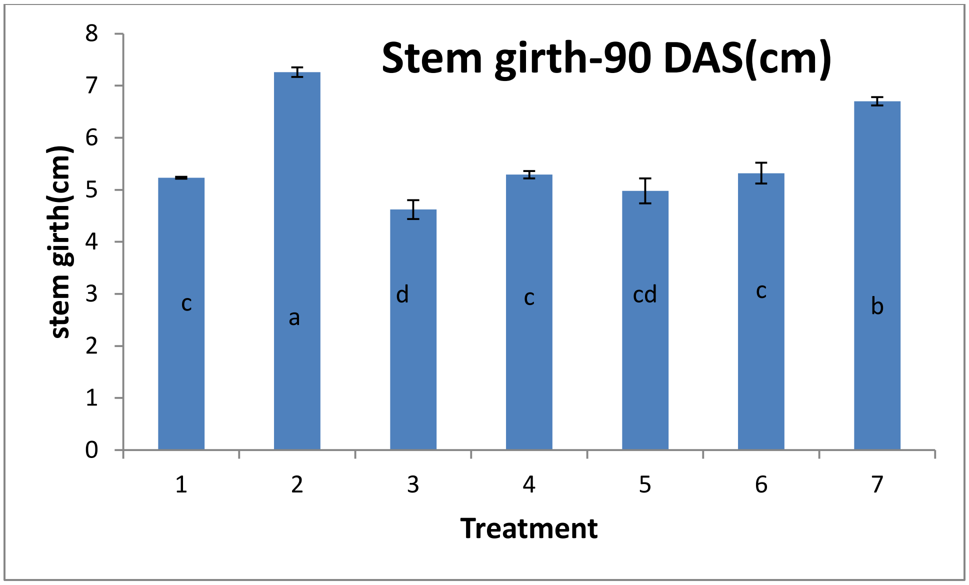


Figure 4.9 Effect of Fly ash on stem girth at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	30 DAS	60 DAS	90 DAS
1	T1-control	$5.12^{c} \pm .06$	$5.16^{c} \pm .02$	$5.23^{c} \pm .02$
2	T2-(20%Fly ash+80% RDF)	$7.24^{a} \pm .23$	$7.36^{a} \pm .15$	$7.26^{a} \pm .09$
3	T3-(40% Fly ash+60% RDF)	$4.86^{c} \pm .02$	$4.59^{d} \pm .15$	$4.62^{d} \pm .18$
4	T4-(60%Fly ash+40% RDF)	$5.18^{c} \pm .04$	$5.22^{c} \pm .05$	$5.29^{c} \pm .07$
5	T5-(80%Fly ash +20% RDF)	$5.14^{c} \pm .11$	$4.94^{cd} \pm .25$	$4.98^{cd} \pm .23$
6	T6-(100%Fly ash +0% RDF)	$5.10^{c} \pm .09$	$5.24^{c} \pm .22$	$5.32^{c} \pm .20$
7	T7-(100% RDF)	$6.53^{b} \pm .05$	$6.66^{b} \pm .06$	$6.70^{b} \pm .08$

Table 4.3 Effect of Fly ash on stem girth at 30, 60 and 90 DAS

4.1.4 Number of cobs/plant:

The number of cobs was counted from the different treatments and it was observed that there was less variation in the number of cobs from each treatment whereas T2 (1.59) was recorded to obtain the highest number of cobs followed by T4 (1.17), T3 (1.16), T5 (1.04), T6 (1.03), T7 (1) and T1 (1). T7 and T1 showed to have obtained the same number of cobs. There was 59% increase in number of cobs between T2 and T1.

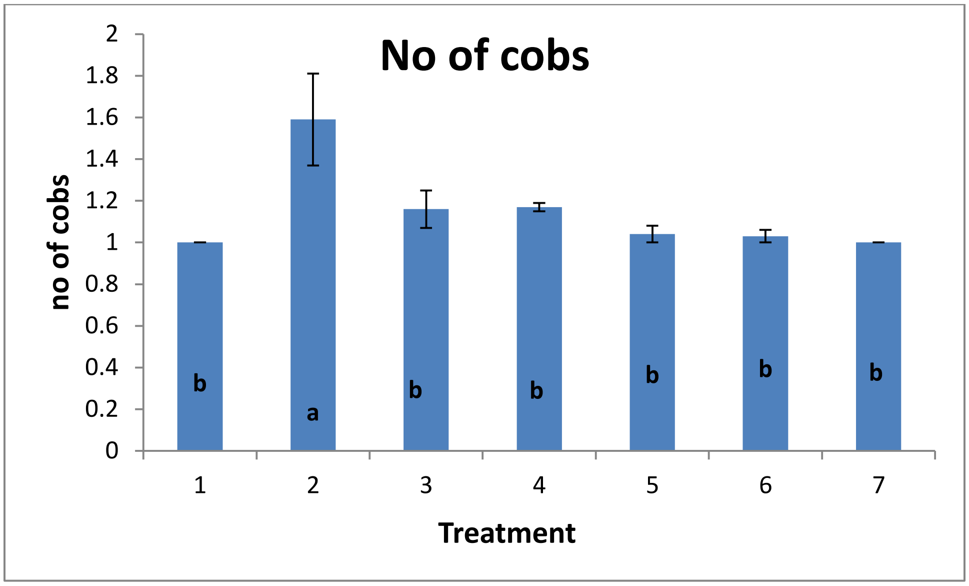


Figure 10 Effect of Fly ash on No of cobs

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	
1	T1-control	$1.00^{b} \pm 0$
2	T2-(20%Fly ash+80% RDF)	$1.59^{a} \pm 0.22$
3	T3-(40% Fly ash+60% RDF)	$1.16^{b} \pm 0.09$
4	T4-(60%Fly ash+40% RDF)	$1.17^{b} \pm 0.02$
5	T5-(80%Fly ash +20% RDF)	$1.04^{b} \pm 00.04$
6	T6-(100%Fly ash +0% RDF)	$1.03^{b} \pm 0.03$
7	T7-(100% RDF)	$1.00^{b} \pm 0$

Table 4.5 Effect of Fly ash on No of cobs

4.1.5 Yield:

The yield was recorded at the time of harvest and it was found T2 with 20% FA gave the best performance with 2.54 followed by T4(2.17), T3(1.95), T6(1.71), T1(1.52) and T5(1.14).However the result was at par with T7 (2.52). Hence there was 67.11% increase over the control.

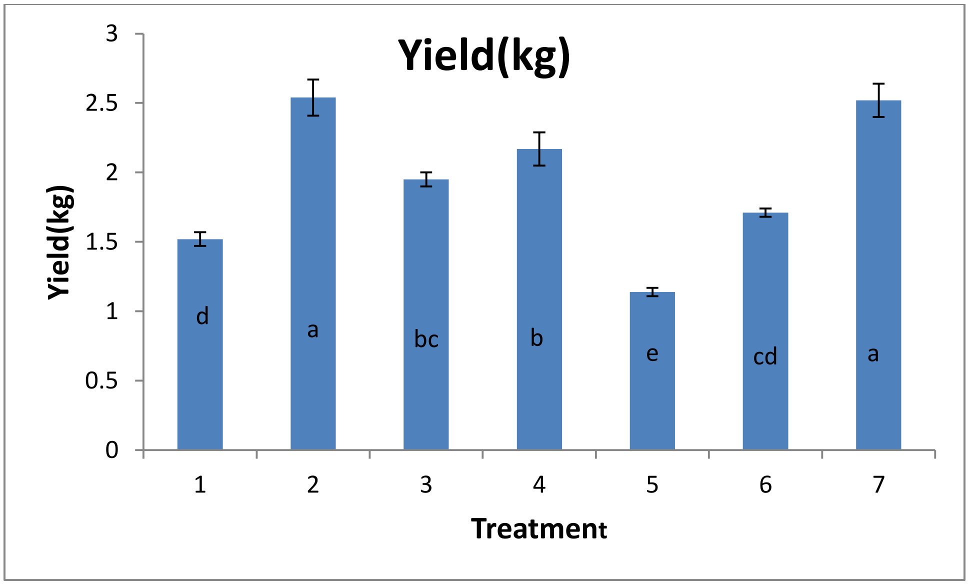


Figure 4.11 Effect of Fly ash on yield

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	
1	T1-control	$1.52^{d} \pm .05$
2	T2-(20%Fly ash+80% RDF)	$12.54^{a} \pm .13$
3	T3-(40% Fly ash+60% RDF)	$1.95^{bc} \pm .05$
4	T4-(60%Fly ash+40% RDF)	$2.17^{b} \pm .12$
5	T5-(80%Fly ash +20% RDF)	$1.14^{e} \pm .03$
6	T6-(100%Fly ash +0% RDF)	$1.71^{cd} \pm .03$
7	T7-(100% RDF)	$2.52^{a} \pm .12$

Table 4.5 Effect of Fly ash on Yield

4.2 Soil parameters:

4.2.1 pH:

The soil from each treatment was collected at 30, 60 and 90 DAS and analyzed .It was observed that the use of Fly ash from each treatment at different rates has increased the soil pH with T6 recorded to have the maximum increase in the soil pH as compared to T1- control. It was also observed that the soil pH slightly decreased from 30, 60 and 90 DAS.

4.2.1.1 pH at 30 DAS:

The soil pH was observed to have significant increase at T6 with 9.6 .Whereas T5, T7, T3, T4 and T2 showed similar increase in soil pH with 8.67, 8.62, 8.29, 8.28 and 8.07 respectively. T1 was recorded to have the lowest soil pH at 7.64. The soil pH of all the treatments was found to increase by 25.65%, 13.48%, 12.83%, 8.51%, 8.38% and 5.63%.

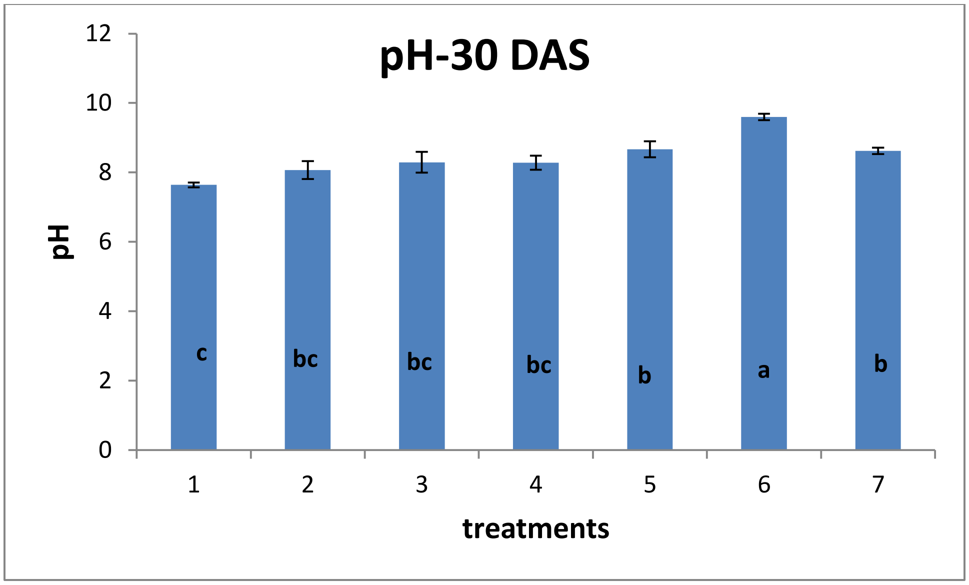


Figure 12 Effect of Fly ash on pH of soil at 30 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.1.2 pH at 60 DAS:

The soil pH was observed to have significant increase at T6 with 9.38 .Whereas T7, T5, T3, T4 and T2 showed similar increase in soil pH with 8.62, 8.49, 8.11, 8.1 and 7.85 respectively. T1 was recorded to have the lowest soil pH at 7.15. The soil pH of all the treatments was found to increase by 31.19%, 20.56%, 18.75%, 13.43%, 13.29% and 9.79%.

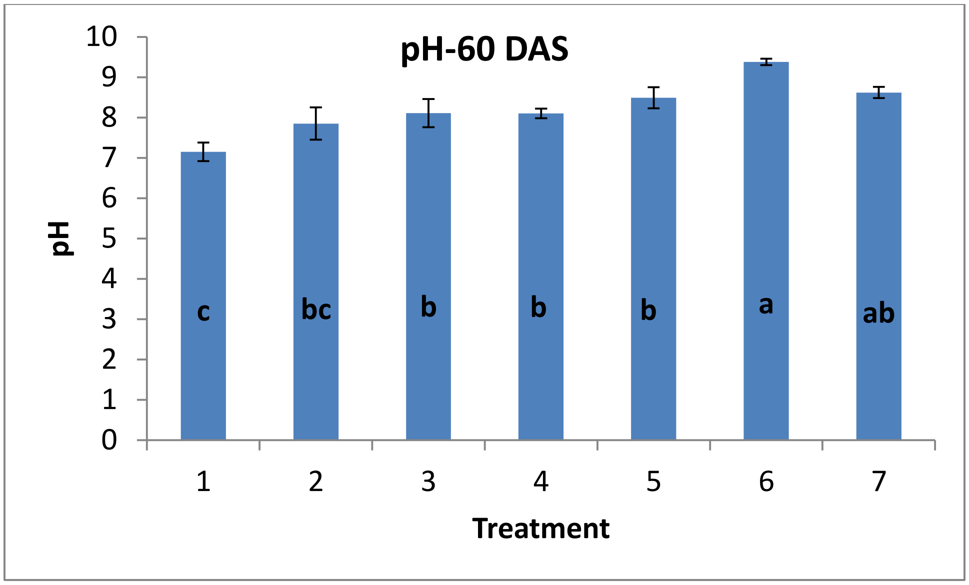


Figure 13 Effect of Fly ash on pH of soil at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.1.3 pH at 90 DAS:

The soil pH was observed to be significantly high at T6 with 9.12 .Whereas T7, T5, T3, T4 and T2 showed similar increase in soil pH with 8.43, 8.27, 7.96, 7.95 and 7.84 respectively. T1 was recorded to have the lowest soil pH at 7.13. The pH of soil of all treatments was found to increase by 27.91%, 18.23%, 15.99%, 11.64%, 11.50% and 9.96%.

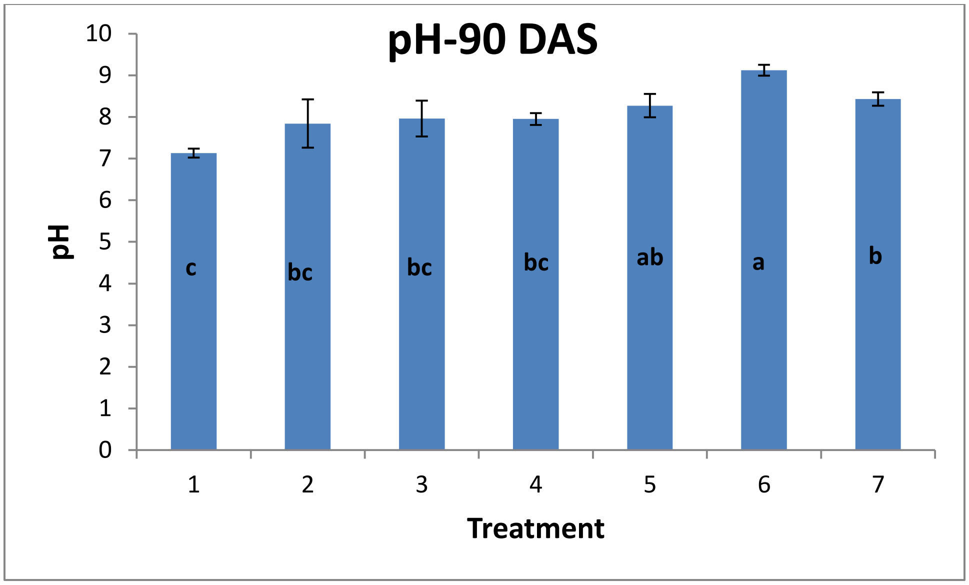


Figure 14 Effect of Fly ash at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	30 DAS	60 DAS	90 DAS
1	T1-control	$7.64^{c}\pm 0.07$	$7.15^{c}\pm 0.23$	$7.13^{c}\pm 0.11$
2	T2-(20%Fly ash+80% RDF)	$8.07^{bc}\pm 0.26$	$7.85^{bc}\pm 0.4$	$7.84^{bc}\pm 0.58$
3	T3-(40% Fly ash+60% RDF)	$8.29^{bc}\pm 0.3$	$8.11^{b}\pm 0.35$	$7.96^{bc}\pm 0.43$
4	T4-(60%Fly ash+40% RDF)	$8.28^{bc}\pm 0.2$	$8.10^{b}\pm 0.12$	$7.95^{bc}\pm 0.14$
5	T5-(80%Fly ash +20% RDF)	$8.67^{b}\pm 0.23$	$8.49^{b}\pm 0.26$	$8.27^{ab}\pm 0.28$
6	T6-(100%Fly ash +0% RDF)	$9.60^{a}\pm 0.09$	$9.38^{a}\pm 0.08$	$9.12^{a}\pm 0.13$
7	T7-(100% RDF)	$8.62^{b}\pm 0.09$	$8.62^{ab}\pm 0.14$	$8.43^{ab}\pm 0.16$

Table 4.6 Effect of Fly ash on pH of soil at 30, 60 and 90 DAS

4.2.2 Electrical conductivity:

The soil from each treatment was collected at 30, 60 and 90 DAS and analyzed .It was observed that the use of Fly ash from each treatment at different rates has increased the EC of the soil with T6 recorded to have the maximum increase in the soil EC as compared to T1- control. It was also observed that the EC of the soil slightly decreased from 30, 60 and 90 DAS respectively.

4.2.2.1 EC (mmhos/cm) at 30 DAS:

The EC of the soil was observed to be significantly high at T6 with 0.41 .Whereas T5 and T4 showed similar increase with 0.38 and 0.3 respectively. T3 and T7 with 0.26 and 0.23 respectively showed similar increase while T1 and T2 was recorded to have the lowest soil EC at 0.11 and 0.13 respectively. Hence the treatment with higher doses of Fly ash was found to have higher EC compared to the other treatments.

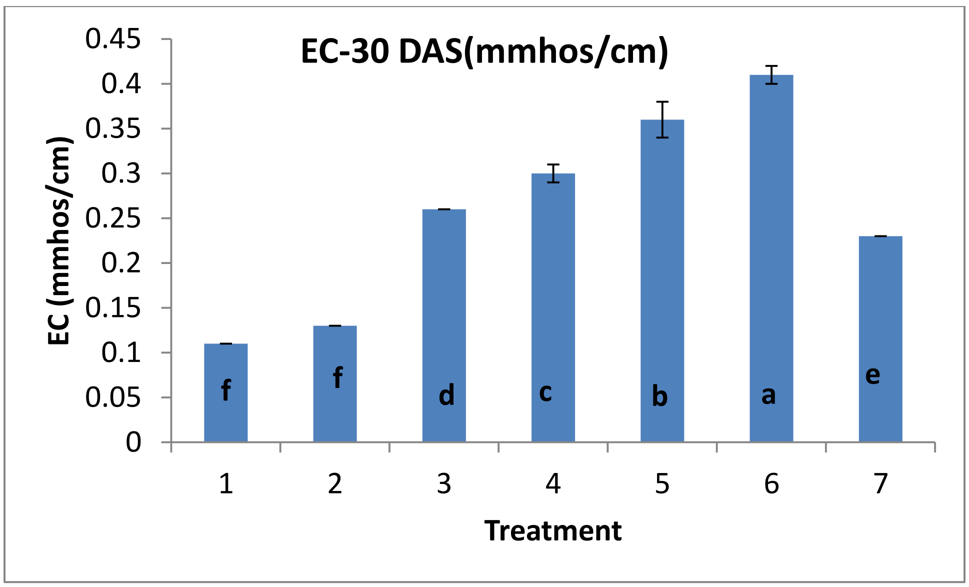


Figure 15 Effect of Fly ash on EC of soil at 30 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.2.2 EC(mmhos/cm) at 60 DAS:

The EC of the soil was observed to be significantly high at T6 with 0.4 .Whereas T5 and T4 showed similar increase with 0.34 and 0.29 respectively. T3 and T7 with 0.24 and 0.22

respectively showed similar increase while T1 and T2 was recorded to have the lowest soil EC at 0.11 and 0.13 respectively. Hence the treatments with higher doses of Fly ash were found to have higher EC.

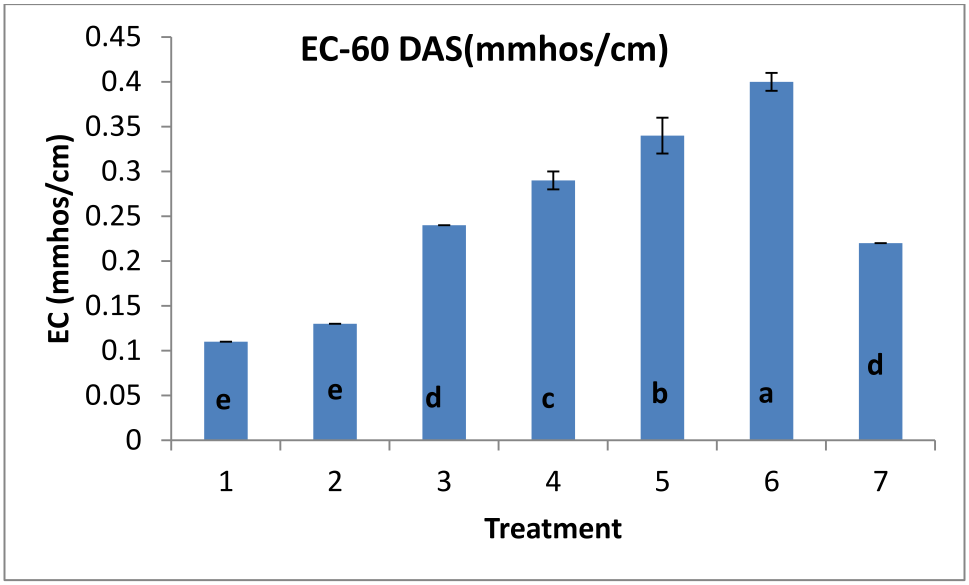


Figure 16 Effect of Fly ash on EC of soil at 60 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at $p<0.5$, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.2.3 EC(mmhos/cm) at 90 DAS:

The EC of the soil was observed to be significantly high at T6 with 0.38 .Whereas T4, T5 and T3 and T7 showed similar increase with 0.28, 0.24, 0.23 and 0.21 respectively. T2 and T1 were recorded to have the lowest soil EC at 0.12 and 0.1 respectively.

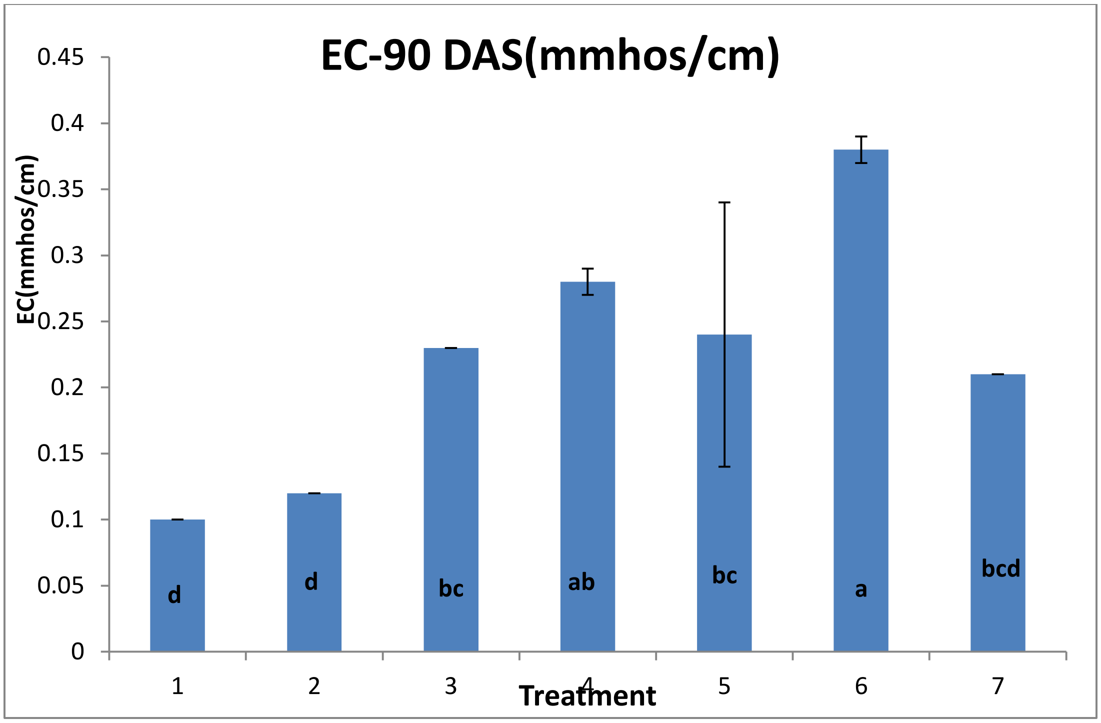


Figure 17 Effect of Fly ash on EC of soil at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	30 DAS	60 DAS	90 DAS
1	T1-control	$.11^{f}\pm 0$	$.11^{e}\pm 0$	$.10^{d}\pm 0$
2	T2-(20%Fly ash+80% RDF)	$.13^{f}\pm 0$	$.13^{e}\pm 0$	$.12^{d}\pm 0$
3	T3-(40% Fly ash+60% RDF)	$.26^{d}\pm 0$	$.24^{d}\pm 0$	$.23^{bc}\pm 0$
4	T4-(60%Fly ash+40% RDF)	$.30^{c}\pm 0.01$	$.29^{c}\pm 0.01$	$.28^{ab}\pm 0.01$
5	T5-(80%Fly ash +20% RDF)	$.36^{b}\pm 0.02$	$.34^{b}\pm 0.02$	$.24^{bc}\pm 0.01$
6	T6-(100%Fly ash +0% RDF)	$.41^{a}\pm 0.01$	$.40^{a}\pm 0.01$	$.38^{a}\pm 0.01$
7	T7-(100% RDF)	$.23^{e}\pm 0$	$.22^{d}\pm 0$	$.21^{bcd}\pm 0$

Table 7 Effect of Fly ash on EC of soil at 30, 60 and 90 DAS

4.2.3 Organic carbon (OC):

The organic carbon content in the soil does not show a wide significant difference between all the treatments. T6 and T1 showed to have the highest Organic carbon content and T3 showed to have the lowest Organic carbon content.

4.2.3.1 Organic carbon at 30 DAS:

The Organic carbon content was observed to be highest at T6(0.31).However it was found to be at par with T1(0.29), T2(0.28) , T7(0.27),T4(0.25),T5(0.22) whilst the lowest was found to be at T3(0.21). There was 47.62% increase in Organic carbon of soil between T6 and T3.

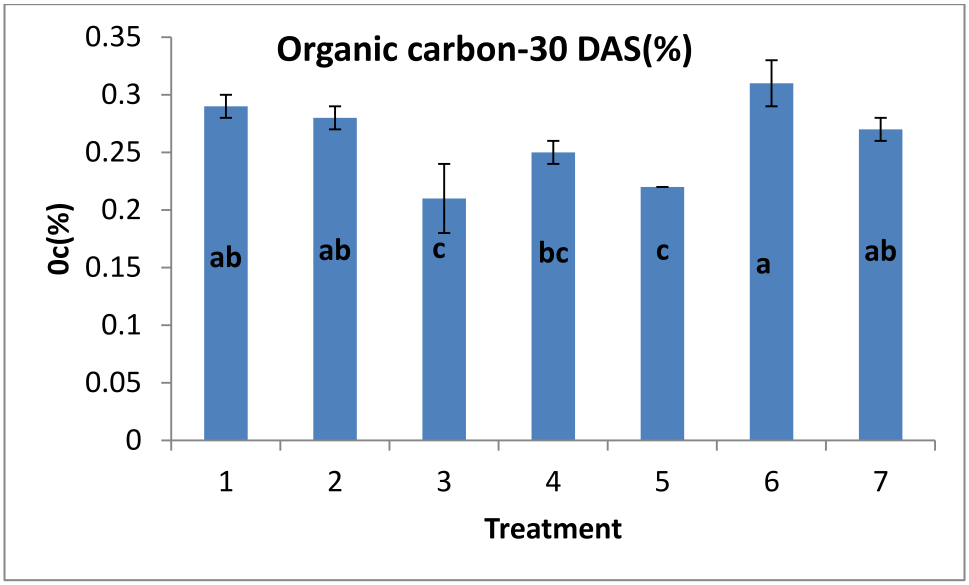


Figure 18 Effect of Fly ash on organic carbon at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.3.2 Organic carbon at 60 DAS:

The Organic carbon content was observed to be highest at T6 (0.29). However it was found to be at par with T1 (0.29), T7 (0.28), T2 (0.27), T4 (0.25), T5 (0.23) whilst the least OC content was found to be at T3 with 0.21. There was 38.09% increase in the Organic carbon content between T6 and T3.

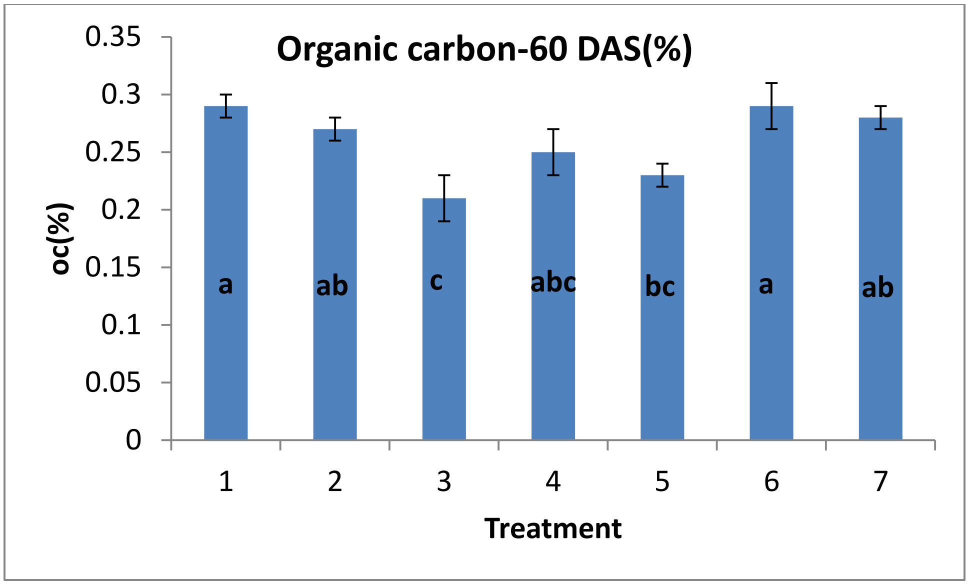


Figure 19 Effect of Fly ash on Organic carbon at 60 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.3.3 Organic carbon at 90 DAS:

The Organic carbon content was observed to be highest at T6 (0.31) .However it was found to be at par with T1 (0.29), T2 (0.28), T7 (0.27), T4 (0.24) whilst T3 and T5 with 0.23 showed to have the least Organic carbon content. There was 34.78% increase in OC content between T6 and T3.

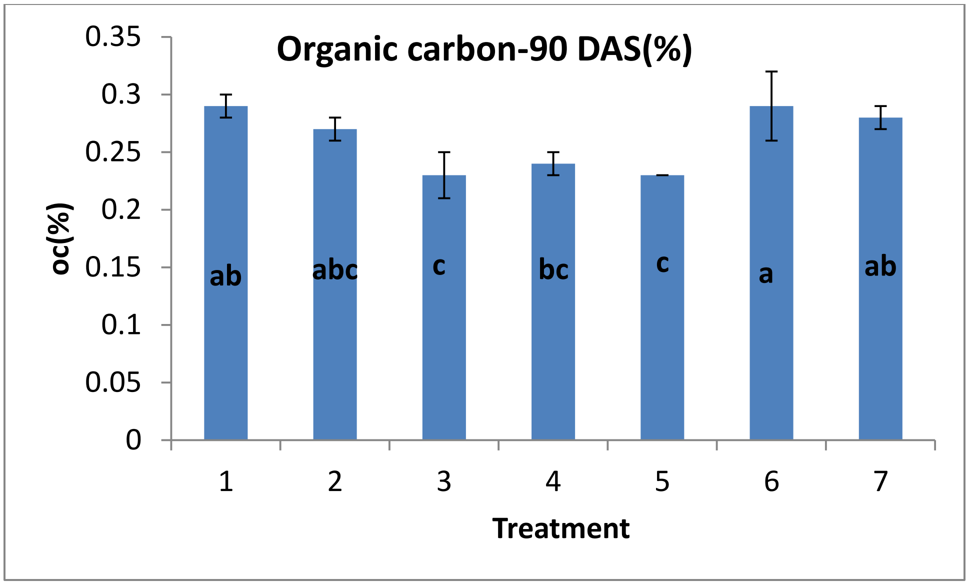


Figure 20 Effect of Fly ash on Organic carbon at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	30 DAS	60 DAS	90 DAS
1	T1-control	$.29^{ab} \pm 0.01$	$.29^{a} \pm 0.01$	$.29^{ab} \pm 0.01$
2	T2-(20%Fly ash+80% RDF)	$.28^{ab} \pm 0.01$	$.27^{ab} \pm 0.01$	$.27^{abc} \pm 0.01$
3	T3-(40% Fly ash+60% RDF)	$.21^{c} \pm 0.03$	$.21^{c} \pm 0.02$	$.23^{c} \pm 0.02$
4	T4-(60%Fly ash+40% RDF)	$.25^{bc} \pm 0.01$	$.25^{abc} \pm 0.02$	$.24^{bc} \pm 0.01$
5	T5-(80%Fly ash +20% RDF)	$.22^{c} \pm 0$	$.23^{bc} \pm 0.01$	$.23^{c} \pm 0$
6	T6-(100%Fly ash +0% RDF)	$.31^{a} \pm 0.02$	$.29^{a} \pm 0.02$	$.29^{a} \pm 0.03$
7	T7-(100% RDF)	$.27^{ab} \pm 0.01$	$.28^{ab} \pm 0.01$	$.28^{ab} \pm 0.01$

Table 8 Effect of Fly ash on Organic carbon at 30, 60 and 90 DAS

4.2.4 Available Phosphorus (P):

The P content in the soil does not show a wide significant difference between all the treatments analyzed for 30, 60 and 90 DAS. The P content was observed to be high for all the treatments with T6 and T5 shown to have the highest P content at 30 DAS, T6 at 60 and 90 DAS.

4.2.4.1 Available P at 30 DAS:

The highest P content was observed to be highest at T5 and T6 with 70.99 and 70.77 respectively. However both the results were found to be at par with T4 at 67.96. The orders of treatments were followed by T3 (61.45), T2 (59.64), T7 (57.66) and the lowest P content were found to be at T1 (53.37). The P content of each treatment increases by 33.01%, 32.60%, 27.34%, 15.14%, 11.75% and 8.03%.

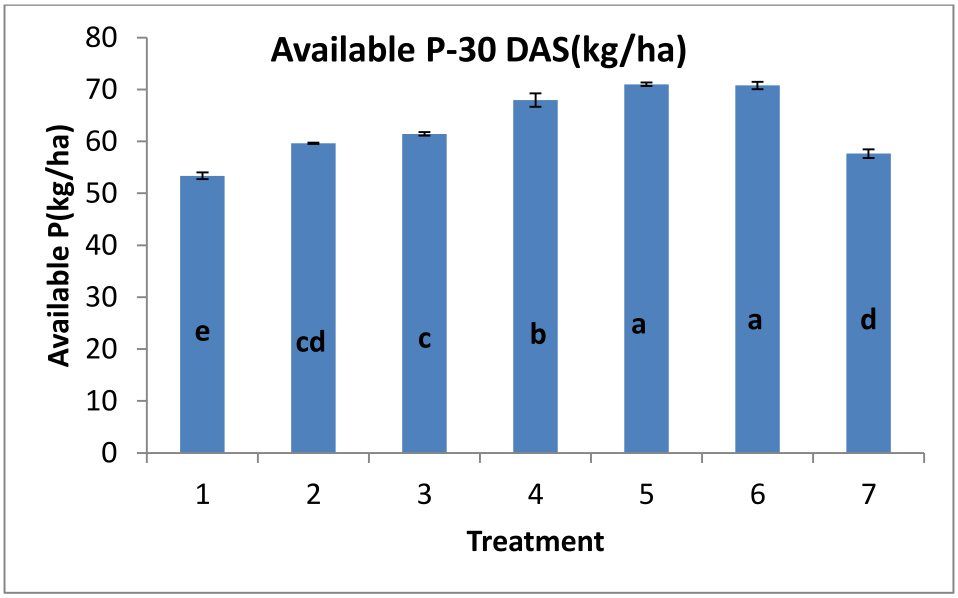


Figure 21 Effect of Fly ash on Available P at 30 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.4.2 Available P at 60 DAS:

The highest P content was observed to be highest at T6 with 65.99. However the result was found to be at par with T5 (64.16), T4 (61.46), T3 (59.65) and T2 (57.26) and the lowest P content was found to be at T7 (52.94) and T1 (50.91)). The P content of each treatment increases by 29.62%, 26.03%, 20.72%, 17.17% and 12.47%.

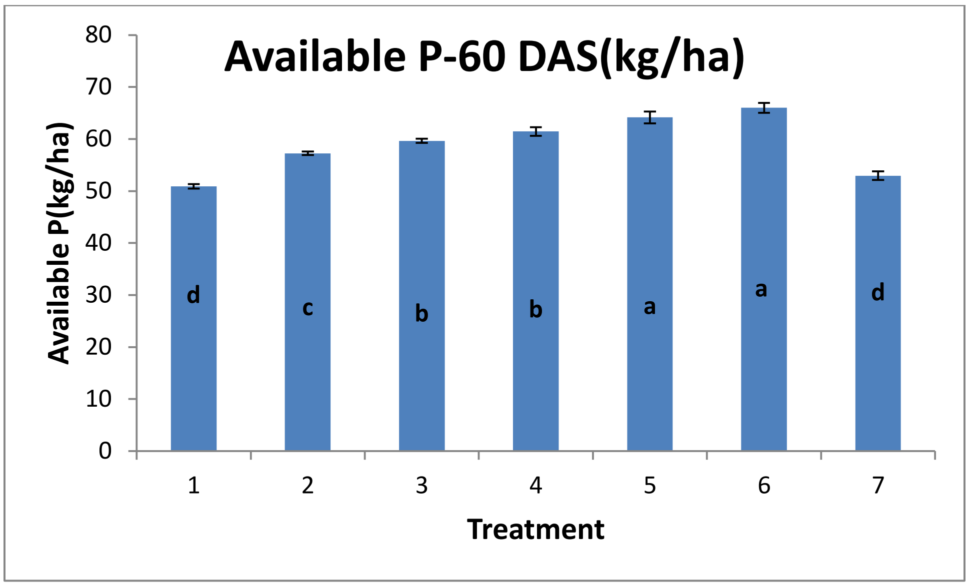


Figure 22 Effect of Fly ash on Available P at 60 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.4.3 Available P at 90 DAS:

The highest P content was observed to be highest at T6 with 60.08. However the result was found to be at par with T5 (57.05), T4 (56.64), T3 (55.99) and T2 (54.87) and the lowest P content was found to be at T1 (48.37) and T7 (43.52). The P content of each treatment increases by 24.21%, 17.95%, 17.09%, 15.75% and 13.44%.

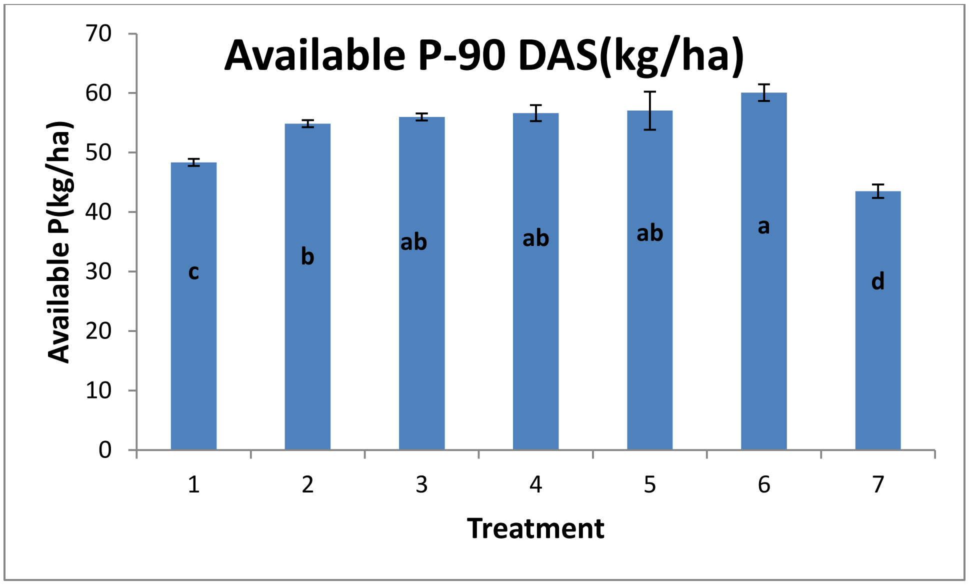


Figure 23 Effect of Fly ash on Available P at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	30 DAS	60 DAS	90 DAS
1	T1-control	$53.64^{e} \pm 0.65$	$50.91^{d} \pm 0.43$	$48.37^{c} \pm 0.58$
2	T2-(20%Fly ash+80% RDF)	$59.64^{cd} \pm 0.11$	$57.26^{c} \pm 0.36$	$54.87^{b} \pm 0.6$
3	T3-(40% Fly ash+60% RDF)	$61.45^{c} \pm 0.33$	$59.65^{b} \pm 0.38$	$55.99^{ab} \pm 0.59$
4	T4-(60%Fly ash+40% RDF)	$67.96^{b} \pm 1.28$	$61.46^{b} \pm 0.84$	$56.64^{ab} \pm 1.36$
5	T5-(80%Fly ash +20% RDF)	$70.99^{a} \pm 0.34$	$64.16^{a} \pm 0.13$	$57.05^{ab} \pm 3.21$
6	T6-(100%Fly ash +0% RDF)	$70.77^{a} \pm 0.71$	$65.99^{a} \pm 0.97$	$60.08^{a} \pm 1.41$
7	T7-(100% RDF)	$57.66^{d} \pm 0.83$	$52.94^{d} \pm 0.83$	$43.52^{d} \pm 1.11$

Table 9 Effect of Available P at 30, 60 and 90 DAS

4.2.5 Available Potassium (K):

The k content in the soil showed a significant difference between the treatments with the application of Fly ash compared to the treatments without the application of Fly ash. The presence of K content was found to be higher in the treatments with Fly ash. T6 and T5 were observed to have the highest K content amongst all the treatments.

4.2.5.1 Available K at 30 DAS:

The highest content of K was found to be at T6 (528.9). However the result was found to be at par with T5 (516.5).The order of treatments were followed by T4 (483.56), T3 (458.94) and T2 (437.28) whereas the lowest K content was found to be at T7 (260.82) and T1 (284.03). The K content of each treatment increases by 86.04%, 81.85%, 70.25% and 61.58%.

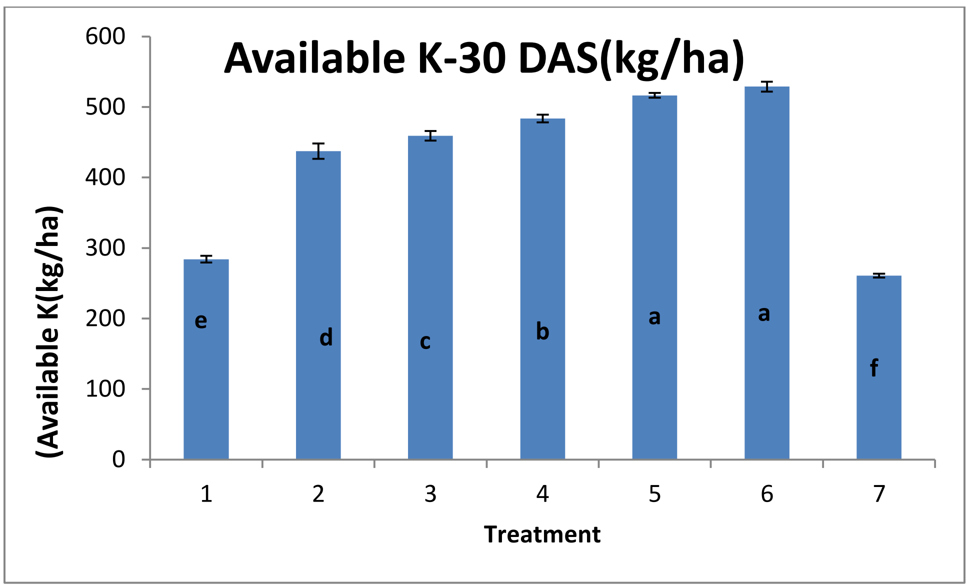


Figure 24 Effect of Fly ash on Available K at 30 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.5.2 Available K at 60 DAS:

The highest content of K was found to be at T6 (479.44). However the result was found to be at par with T5 (473.57).The order of treatments were followed by T4 (434.69), T2 (401.76) and T3 (392.97) whereas the lowest K content was found to be at T7 (212.75) and T1 (226.22). The amended treatments were found to have significantly high content of K compared to the other treatments.

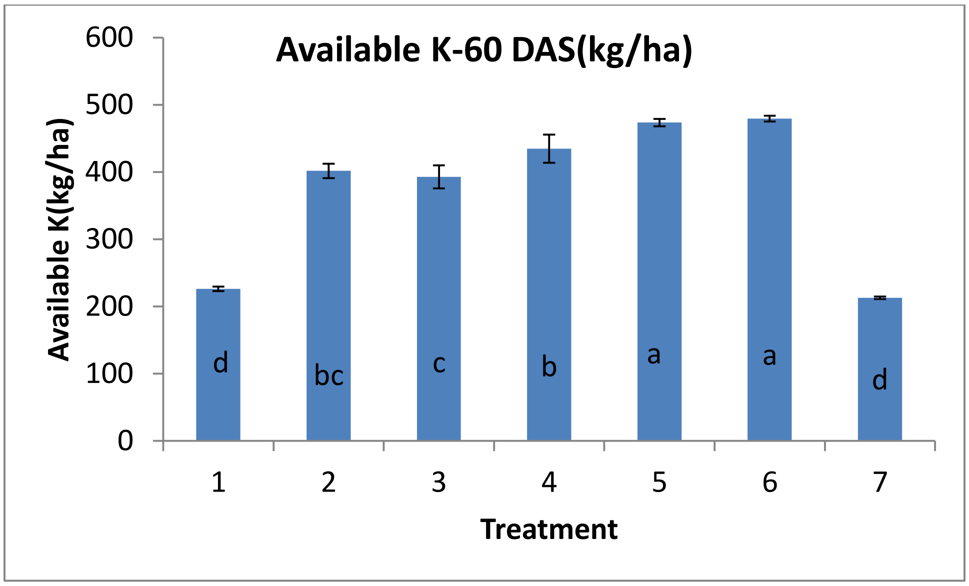


Figure 25 Effect of Fly ash on Available K at 60 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at $p<0.5$, according to DMRT (Duncan's multiple range test) for separation of means.

4.2.5.3 Available K at 90 DAS:

The highest content of K was found to be at T6- (432.44). However the result was found to be at par with T5 (421.65).The order of treatments were followed by T4 (402.26), T2 (355) and T3 (354.02) whereas the lowest K content was found to be at T7 (198.91) and T1 (194.22). The amended treatments were found to have significantly high content of K compared to the other treatments.

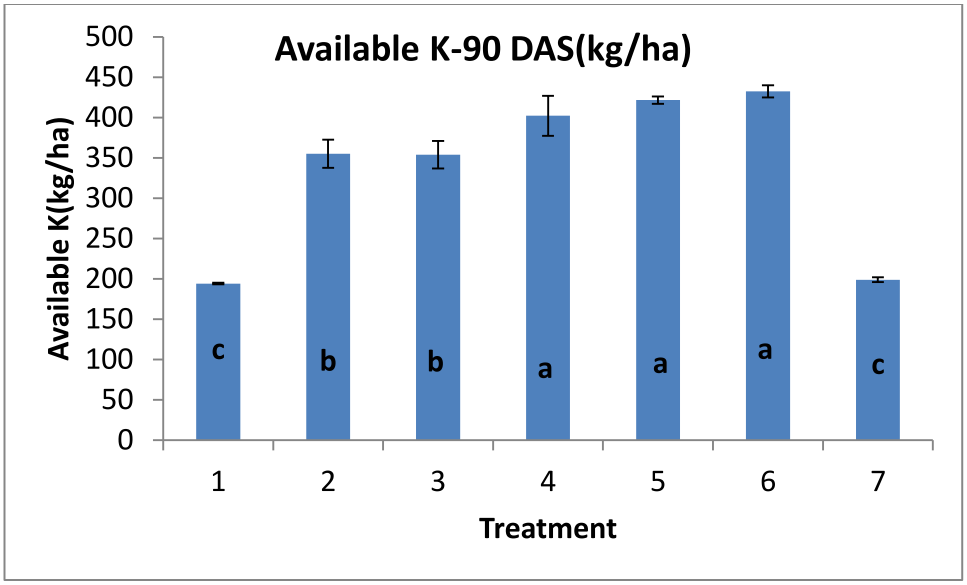


Figure 26 Effect of Fly ash on Available K at 90 DAS

T1-control, T2-(20%Fly ash+80% RDF), T3-(40% Fly ash+60% RDF), T4-(60%Fly ash+40% RDF), T5-(80%Fly ash +20% RDF), T6-(100%Fly ash +0% RDF), T7-(100% RDF). The mean followed by different letters are significantly different at p<0.5, according to DMRT (Duncan's multiple range test) for separation of means.

s.no	Treatment	30 DAS	60 DAS	90 DAS
1	T1-control	$284.03^{e} \pm 4.75$	$226.22^{d} \pm 3.31$	$284.03^{e} \pm 4.75$
2	T2-(20%Fly ash+80% RDF)	$437.28^{d} \pm 10.84$	$401.76^{bc} \pm 10.73$	$437.28^{d} \pm 10.84$
3	T3-(40% Fly ash+60% RDF)	$458.94^{c} \pm 6.85$	$392.97^{c} \pm 17.12$	$458.94^{c} \pm 6.85$
4	T4-(60%Fly ash+40% RDF)	$483.56^{b} \pm 5.43$	$434.69^{b} \pm 20.91$	$483.56^{b} \pm 5.43$
5	T5-(80%Fly ash +20% RDF)	$516.5^{a} \pm 3.38$	$473.57^{a} \pm 5.53$	$516.5^{a} \pm 3.38$
6	T6-(100%Fly ash +0% RDF)	$528.9^{a} \pm 6.98$	$479.44^{a} \pm 4.15$	$528.9^{a} \pm 6.98$
7	T7-(100% RDF)	$226.82^{f} \pm 2.74$	$212.75^{d} \pm 1.79$	$260.82^{f} \pm 2.74$

Table 10 Effect of Fly ash on Available K at 30, 60 and 90 DAS

Discussion

In the preceding chapter, the results of the experimental trial entitled **“Efficacy of Fly ash as a soil amendment under maize *(Zea mays L.)* Cultivation”** was discussed. Significant variations were noted in number in both soil and growth parameters due to effect of different doses of Fly ash application in all the treatments.

5.1 Effect of Fly ash on soil Properties:

According to this study, it was found that application of 100% FA at T6 increased the pH, EC, OC, P and K of soil. The pH increased by 25.65% @30 DAS, 31.19% @60 DAS and 27.91% @90 DAS. The increase in soil pH is due to the high alkaline pH which is present in fly ash. Since most of the FA in India is alkaline in nature, its incorporation and usage to agricultural soils may increase the pH value of soil and hence neutralizes acidic soils (Phung et al. 1978) .The pH and electrical conductivity (EC) of both sandy soil and sandy loam soils were increased. But it was shown to increase more in sandy soil compared to sandy loam. The availability of soil water may limit due to increase in electrical conductivity and this is mainly due to high osmotic pressure while the increase in pH would change the availability of micro-nutrients to crops (Wong et al., 1988). Fly ash application @12% has shown to increase the pH of sandy soil and sandy loam from 7.3 to 9.7 and from 6.7 to 8.6 respectively. Also the Electrical conductivity was found to increase from 56 to 2035 µmhos /cm for sandy soil and 135 to 341µmhos/ cm for sandy loam. It was also found that sandy loam had a higher buffering capacity for receiving the ash amendment than sandy soil (Wong et al., 1989).Furthermore in this study , it was also found that the application of Fly ash @ 100% FA significantly increased the EC of soil compared to T1-control. The EC of soil was found to be 0.41 for 30 DAS, 0.4 for 60 DAS and 0.38 for 90 DAS. Whereas it was found to be as low as 0.11, 0.11 and 0.1 for 30, 60 and 90 DAS respectively. In a study conducted at the Muthiani village near National Capital Power Project (NCPP), Dadri, U.P.and Research Farm CCR (PG) College, Muzaffarnagar, U.P, it was found that there was decrease in the pH value whereas the electrical conductivity (EC) was increased. However this varies with the amounts of Fly ash incorporated in the soil. The Organic carbon and sodium content also increased with the application of Fly ash to the various treatments. Whereas there was decrease in potassium, phosphorus and calcium content of the soil. The response varied depending on the soil and the amount of Fly ash used and also its characteristics. With the high buffering capacity of soil, it also becomes significantly important to carry out the work for the time up to which any change persists (Aggarwal et al., 2009).A gradual increase was observed in pH, EC, available phosphorus, organic carbon and organic matter with the application of different doses of Fly ash to agricultural soils (Sarangi et al., 2001).The organic carbon content in this study was found to increase by 0.31% at 30 Das, 0.29% at 60 DAS and again 0.31% at 90 DAS.It was also found that the OC content increased by 30-47% compared to T3-40% FA+60% RDF for all 30, 60 and 90 DAS.In a different study, it was found that the incorporation of fly ash in agriculture field provided the certain benefit that improves the soil texture, reduces bulk density of soil and Improves water holding capacity of soil. It also optimizes pH value, increasing the soil buffering capacity and provides micro nutrients like Fe, Zn, Cu, Mo, B etc. and macro nutrients like P, K, Ca, etc. (Panigrahi et al., 2014).However it was also found that there was a slight decrease in the pH of soil whereas there was a significant decrease in electrical conductivity of the soil with the incorporation of Fly ash in soil. The adsorption of sodium ratio of the soil decreased with increasing doses of Fly ash application. FA application increased the available elemental status of N, K, Ca, Mg, S, Fe, Mn, B, Mo, Al, Pb, Ni, and Co, but decreased Na, P and Zn in the soil. For reclaiming sodic soils, gypsum was optional to be substituted by up to 40% of its requirement with moderately very less acidic FA (Kumar et al., 2003).The effect of Fly ash on the different properties of soil may vary with the type of Fly ash used as the sulphur content in most of the ash differs . In India there are mainly two types of ash found, acidic Fly ash and alkaline Fly ash with alkaline Fly ash being found in most parts of the country. The type of Fly ash used in this study was alkaline. As found in this study, the use of different doses of Fly ash increased the pH, EC, OC, P and K of the soil .It was also found that the higher the dosage of Fly ash used, the higher was the increase in these properties. Hence T6 with 100% Fly ash showed increase in the aforesaid properties compared to T1-control for 30, 60 and 90 DAS.

5.2 Effect of Fly ash on growth of maize:

On the basis of growth characters of maize, it was found that application of 20% Fly ash+80% RDF at T2 showed significant increase in height, number of leaves/plant and the number of cobs of the crop. However the result was found to be at par with T7-100%RDF.Even though as seen in the aforesaid soil properties, T6 with 100% Fly ash showed the highest increase in all the properties but in the mentioned growth characters, it was seen that the treatments with higher doses of Fly ash does not show maximum increase. This may be due to late germination and unfavorable environment as the crop was sown during Rabi season. Also, although Fly ash is known to improve the various properties of soil, it is also found that since it contains high concentration of elements like Cd, B, Ni, Mo etc. When applied at higher rates may cause toxicity and hence may affect the crop's growth (Adriano et al., 1980). Plants of maize *Zea mays* L. and soybean *Glycine max* L. were treated with fly ash, a waste product of coal-fired electric generating plants, at the rates of 2, 4 and 8 g $m^{-2}day^{-1}$ for 30 consecutive days between 15 and 46 days of plant age. At the lower two rates, both crops showed an increase in plant height, metabolic rate, content of photosynthetic pigment and all dry weight fractions measured(Mishra et al.1986). In a study conducted on maize, a similar result was found. It was found that there was a significant difference in germination count between the Control and the Fly ash treated plots till 105 h after seeding, but the effect of fly ash diminished in the later stages and showed similar count values among all treatments at 115 h.The germination time was averaged 83.9 h for the Control and there was delays of 3.0, 5.3, 6.6 and 10.1 h, and DI values of 0.036, 0.063, 0.079 and 0.120 for 5%, l0%, 15% and 20% ash level treatments, respectively. It was further concluded that application of Fly ash in soil delays germination of crops. This is most likely due to the increased impedance offered by the Fly ash/soil matrix to the germinating seeds. This further causes reduction in the earlier stages of the crop's growth and hence may automatically lead to reduced yield under unfavorable environments (Kalra et al., 1997).Whereas in another study, it was found that application of Fly ash to @ 5% to soil had favorable effects on the growth of corn and soybean, as seen by their biomass and heights taken towards the end of the experiment. Henceforth, it was seen that application of higher doses of fly ash (10% or more) has adverse effect on the the growth and dry matter production of both the crops. This is mainly due to accumulation of toxic levels of boron in roots and shoots of the crops which subsequently leads to boron toxicity. Hence reducing the height and leaf area of both the crops (Mishra et al., 1986) in other studies where Fly ash was used along with FYM/Vermicompost, it has been seen that there was significant increase in growth and yield of several crops. But in this study, Fly ash alone was used; hence this may be one of the reasons for decrease in height, number of leaves and the number of cobs of the crop. In a study conducted on maize where Fly ash was used along with compost, it was found that application of 20-25% Fly ash and compost soil ratio treatments showed increase in the growth and yield of the crop. Hence the uptake of K, Mn, and Cu by the crop increased with the increasing doses (2-25%) of fly ash+ compost: soil ratios. Furthermore, the plants total K content was positively correlated with the dry matter yield of the crop. Therefore this study further proved that the application of fly ash along with compost to soil is beneficial to production of maize without causing any deleterious effects on the growth and composition of the crop (Ghuman et al., 1992).In another long term study where 30-40t/ha Fly ash was used along with 20% FYM on maize and sunflower, it was found that there was 39-48% increase in grain yield over the control during Rabi season of 2004,36.4% in 2005 and 60.35% in 2006(Yeledhalli et al.,2008).A study conducted at Orissa University Agriculture and Technology, Bhubaneswar, India during 2013-2014 where maize was used as a test crop found that conjunctive application of Fly ash +Lime+NPK gave a maximum grain yield of 57.72q/ha compared to the treatments without lime or NPK(Chandrakar et al.,2016). In a study conducted on paddy, it was found that FA and FYM amendments enhance the rates of N-transformation processes, plant available-N and paddy productivity. Thus, FA and FYM can be used as potential amendments to enrich soil productivity and crop yields for dry tropical nutrient poor soils. The most effective treatment noted for paddy grain yield was the combination of FA + FYM (92% increase over control) followed by FYM and FA. (Singh et al.,2011).

CHAPTER-5

SUMMARY AND CONCLUSION

A field experimental trial was conducted entitled **"Efficacy of Fly ash as a soil Amendment under maize (*Zea mays L.*) Under maize Cultivation"** during Rabi season of 2016-2017 at the Experimental farm of Lovely Professional University, Phagwara, Punjab. The experiment was laid out in Randomized Block Design with seven treatments and three replications. The unit plot size was $3\times2=6m^2$ with 21 numbers of plots. The treatments consist of T1-control, T2-20% FA+80%RDF, T3-40%FA+60%RDF, T4-60%FA+40%RDF, T5-80%FA+20%RDF, T6-100%FA+0%RDF and T7-100%RDF.

Growth parameters (pH, EC, Organic carbon, Available Phosphorus (P) and Available Potassium (K)) and growth parameters (plant height, number of leaves/plant, stem girth , number of cobs /plant and yield were recorded and analyzed.

- The treatments were tested on the basis of their chemical soil properties and their growth characters. After analyzed of the datas, it was found that T6 with 100% FA gave the best result with increased pH, EC, Organic carbon, Available P and Available K for 30, 60 and 90 DAS. The increased in the aforesaid parameters is due to alkaline nature of the Fly ash used which helps in increasing the above mentioned properties. Whereas on the basis of growth parameters, it was found that T2 with 20%FA+80%RDF gave the best result with increased height, number of leaves/plant, stem girth and number of cobs for 30, 60 and 90 DAS. Henceforth,T2 (20%FA+80%RDF) was recorded to have the highest yield of 2.54 with 67.11% over control. However the result was at par with T7-100% RDF.Though T6-100% showed the best performance in soil characteristics tested, it does not show the same result in the growth characters of maize. It was found that T2 with 20% FA+80%RDF gave the best result with increased plant height, number of plants/leaves,stem girth and number of cobs. This is most likely due to less doses of Fly ash applied as higher dosage of Fly ash can affect crop growth. The reduction in the aforesaid parameters maybe due to late germination or boron toxicity as Fly ash contains high concentration of B, Ni, Mo etc.

Soil parameters:

- T6-100% FA showed the best performance in soil pH with an average of 9.37
- T6-100% FA showed the best performance in soil EC with an average of 0.40mmhos/cm
- T6-100% FA showed the best performance in Organic carbon content with an average of 0.30%
- T6-100 FA showed the best performance in Available Phosphorus with an average of 65.69%

- T6-100% FA showed the best performance in Available Potassium with an average of 480.26ppm

Growth parameters:

- T2-20% FA+80%RDF showed the best performance in plant height with an average of 162.07cm
- T2 -20% FA+80%RDF showed the best performance in number of leaves /plant with an average of 8.81 number of leaves
- T2-20%FA=80%RDF showed the best performance in stem girth with an average of 7.29cm
- T2-20% FA +80% RDF showed the best performance in number of cobs with 1.59 numbers of cobs
- T2-20%FA+80%RDF showed the best performance in yield with 2.54kg.

Conclusion:

On the basis of the results mentioned in the preceding texts, it can be further concluded that T6 with 100% Fly ash gave the best result since it increases all the chemical properties like pH, EC, Organic carbon, Available phosphorus and Available potassium. Though the aforesaid properties were increased, it has no impact on the growth of maize. Hence it was found T2 with 20%FA+80%RDF has shown to have increased the growth characters with a yield of 2.54kg.It was also found that there was 67.11% increase in yield over the control. The reduction in plant's height, number of leaves, stem girth and number of cobs on using higher dosage of FA maybe due to late germination and unfavourable environment condition as the crop was sown during Rabi season. Late germination may lead to reduced yield of the crop.

As mentioned in this study, Fly ash alone was used and hence it has less impact on the growth of maize. Usage of less dosage of Fly ash is recommended as it was found T2 with 20%FA+80%RDF showed the best performance regarding growth characters. But Fly ash along with vermicompost/FYM is highly recommended for better growth and yield as various studies has proved to have increased the yield and productivity when Fly ash was used along with vermicompost/FYM.

CHAPTER- 6

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