EFFECT OF FLY ASH AND BAGASSE ASH ON SOIL PROPERTIES, YIELD AND QUALITY OF WHEAT IN AN INCEPTISOL

by

Mr. Durgude Shubham Anil
(Reg. No.016/085)

A thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI - 413 722, DIST.AHMEDNAGAR
MAHARSHTRA, INDIA

In partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR
MAHARASHTRA, INDIA
2018

EFFECT OF FLY ASH AND BAGASSE ASH ON SOIL PROPERTIES, YIELD AND QUALITY OF WHEAT IN AN INCEPTISOL

by

Mr. Durgude Shubham Anil
(Reg. No. 016/085)

A thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI - 413 722, DIST.AHMEDNAGAR
MAHARSHTRA, INDIA

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Approved by

Dr. A.L. Pharande
(Chairman and Research Guide)

Dr. A.D. Kadlag
(Committee Member)

Dr. M.R. Chauhan
(Committee Member)

Dr. C.A. Nimbalkar
(Committee Member)

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA
2018

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part

there of has not been submitted

by me or other person to any

other University or Institute

for a Degree or

Diploma

Place : MPKV, Rahuri (S.A. Durgude)

Date : / / 2018

Dr. A.L. Pharande
Dean (F/A) & Director of Instructions
Mahatma Phule Krishi Vidyapeeth,
Rahuri – 413 722Dist. Ahmednagar,
Maharashtra, India

CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF FLY ASH AND BAGASSE ASH ON SOIL PROPERTIES, YIELD AND QUALITY OF WHEAT IN AN INCEPTISOL**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**, embodies the result of a piece of bonafide research work carried out by **MR. DURGUDE SHUBHAM ANIL** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

Place: M.P.K.V., Rahuri **(A.L. Pharande)**
Date : / / 2018 Chairman & Research Guide

Dr. A.D. Kadlag
Head
Department of Soil Science and
Agricultural Chemistry,
Mahatma Phule Krishi Vidyapeeth,
Rahuri – 413 722Dist. Ahmednagar,
Maharashtra, India

CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF FLY ASH AND BAGASSE ASH ON SOIL PROPERTIES, YIELD AND QUALITY OF WHEAT IN AN INCEPTISOL**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**, embodies the result of a piece of bonafide research work carried out by **MR. DURGUDE SHUBHAM ANIL** under the guidance and supervision of **DR. A.L. PHARANDE** and that no part of the thesis has been submitted for any other degree or diploma.

Place: M.P.K.V., Rahuri **(A.D. Kadlag)**
Date : / / 2018

Dr. R.S. Patil
Associate Dean
Post Graduate Institute
Mahatma Phule Krishi Vidyapeeth,
Rahuri – 413 722Dist. Ahmednagar,
Maharashtra, India

CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF FLY ASH AND BAGASSE ASH ON SOIL PROPERTIES, YIELD AND QUALITY OF WHEAT IN AN INCEPTISOL**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**, embodies the results of a piece of bonafide research work carried out by **MR. DURGUDE SHUBHAM ANIL** under the guidance and supervision of **DR. A.L. PHARANDE** and that no part of the thesis has been submitted for any other degree or diploma.

Place: M.P.K.V., Rahuri **(R.S. Patil)**
Date : / /2018

ACKNOWLEDGEMENTS

"Gratitude unlocks the fullness of life. It turns what we have into enough, and more. It turns denial into acceptance, chaos to order, confusion to clarity. It can turn a meal into a feast, a house into a home, a stranger into a friend. Gratitude makes sense of your past, brings peace for today and creates a vision for tomorrow."

The research work is a mile stone in my life with the research guide being the driving force behind. Because "Dnyana" can only be acquired with blessing of an able "Guru".

Words are inadequate to convey the depth of my feelings of gratitude and sincere thanks to my Research Guide and Chairman of Advisory Committee, Dr. A.L. Pharande, for his versatile, untiring and scholastic guidance and constant inspiration during the course of research work and preparation of manuscript.

I wish to express my profound sense of gratitude Dr. J.V. Patil, Associate Dean (PGI), MPKV, Rahuri and Dr. A.D. Kadlag, I/C Head, Department of Soil Science and Agricultural Chemistry, MPKV, Rahuri.

I profoundly express my deepest appreciation to the members of my advisory committee Dr. A.D. Kadlag, Soil Chemist (STCRC), Dr. M.R. Chauhan, Professor, Department of Soil Science and Agricultural Chemistry and Dr. C.A. Nimbalkar, Professor, Department of Statistics, M.P.K.V. Rahuri for their valuable suggestions and encouragement during the conduct of this research.

It is my pleasure to specially thank my teachers and faculty members, Dr. A.D. Kadlag, Dr. P.P. Kadu, Dr. M.R. Chauhan, Dr. B.D. Bhakare, Dr. N.J. Ranshur, Dr. S.R. Patil, Dr. V.S. Patil, Dr. S.R. Shelke and Prof. S.M. Todmal, Department of Soil Science and Agricultural Chemistry, for their guidance in completing the course work and research work successfully.

I extend my special thanks to all the staff members Shri. Adhav, Mrs. Barange madam, Ghatage, Pote and Shaikh Mama for their timely and important help and co-operation. Research was unable to conduct in absence of Shri. P.Y. Dhage, Agril. Asst., PGI Research, SSAC farm, Jadhav mavshi, Shaikh mavshi, Popat mama and Gavde dada.

Words are not enough to express my gratitude, love and affection to my loving father Dr. A.G. Durgude, Analytical Chemist, Micronutrient Research Scheme, MPKV Rahuri, mother Sau. Anita Durgude, Grand mother Kesharbai Durgude, Grandfather Late. Gangadhar Durgude, brother Dr. Rahul Durgude, Garden Inspector, Thane Municipal Corporation, brother Saurabh Rokade, sister Shubhangi Rokade my mama Yogesh Mhase, Deepak fertilizers, Ganesh Mhase for their everlasting love unfailing support, constant inspiration, moral support and encouragement during my life. I have pleasure to express my heartiest gratitude towards the help rendered by my close friend Prasad Yeawale, Pratik Kolelar, Shashikant Gangarde, for her support and encouragement.

I avail this opportunity to extend my sincere, heartfelt gratitude to my seniors Avinash sir, Prakash sir, Torane sir, Atish sir, Akshay sir and beloved junior Ramakant Tekale, Amol Lohar, Nilesh Jadhav.

I like to specially thank from the bottom of my heart to my P.G. classmates Pramod, Jayesh, Bajirao, Kumar, Shubham, Rahul, Bharat and Saraswati for their help in conducting the research work.

I am deeply obliged to all authors whose literature has been cited.

While traveling on this path of education many hands pushed me fourth, learned heart put me on the right track enlightened by their knowledge and experience. I ever rest thankful to all of them.

Words will be inadequate to take account of encouraging, evergreen love and help of my friends for their excellent company, warm love and affection and co-operation during this investigation and my stay at Rahuri.

Place : M.P.K.V., Rahuri
Date : / /2018 (S. A. Durgude)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

@	:	At the rate of
%	:	Per cent
CD	:	Critical difference
cfu	:	Colony forming unit
cm	:	Centimeter
CO_2	:	Carbon dioxide
CRI	:	Crown Root Initiation
Cu	:	Copper
dSm^{-1}	:	Decisimen’s per meter
DAS	:	Day After Sowing
DTPA	:	Diethylene Triamine Penta Acetic Acid
EC	:	Electrical Conductivity
Ed^n	:	Edition
et al.	:	*Et alia* (and others)
Fe	:	Iron
fig.	:	figure
FYM	:	Farm Yard Manure
ha	:	Hectare (s)
i.e.	:	*Id est,* that is
K	:	Potassium
kg	:	kilogram (s)
kg ha^{-1}	:	Kilogram per hectare
L	:	Liter (s)
m	:	Meter
mg	:	Milligram(s)
mL	:	Milliliters(s)
Mn	:	Manganese
N	:	Nitrogen
Na	:	Sodium
O.C.	:	Organic Carbon
P	:	Phosphorus
pH	:	*Puissance de Hydrogen*
RDF	:	Recommended dose of fertilizer
$\mu g\ g^{-1}$	:	Micro gram per gram
t ha^{-1}	:	Tonnes per hectare
viz.,	:	*Vide licet*, namely
Zn	:	Zinc

ABSTRACT

EFFECT OF FLY ASH AND BAGASSE ASH ON SOIL PROPERTIES, YIELD AND QUALITY OF WHEAT IN AN INCEPTISOL

by

MR. DURGUDE SHUBHAM ANIL

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

2018

Research Guide : Dr. A.L. Pharande

Department : Soil Science and Agricultural Chemistry

A field experiment was conducted during the year 2016-17 at the Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, to study the "Effect of fly ash and bagasse ash on soil properties, yield and quality of wheat in an Inceptisol".

The experiment was laid out in randomised block design with three replications and ten treatments. Which comprised of T_1: Absolute control, T_2 : General recommended dose of nutrients where K_2O through muriate of potash, T_5 to T_6 were general recommended dose of N and P_2O_5 and 125, 100, 75 and 50 % K_2O through fly ash, respectively and T_7 to T_{10} were general recommended dose of N and P and 125, 100, 75 and 50 % K_2O through bagasse ash respectively. The result of the experiment revealed that, the application of RDF of nitrogen and phosphorous along with replacement of muriate of potash with graded levels of fly ash and bagasse ash in treatment T_3 to T_6 and treatment T_7 to T_{10}, respectively with 10 t ha^{-1} of FYM, gave significantly higher grain and straw yield of wheat especially significantly increased (42.92 and 53.88 q ha^{-1}, respectively) in treatment of application of 125 % K_2O through bagasse ash along with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM (T_7).

Application of various levels of K_2O through fly ash in soil noticed negative effect on physical properties of soil *viz*., increased in bulk density, COLE value and decreased in hydraulic conductivity of soil.

Application of various levels of K_2O through fly ash and bagasse ash in soil did not show differences in available nitrogen in soil at all the growth stages, but slight improvement was found to be significantly observed in availability of P and K in soil at crown root initiation and harvest stage due to application of bagasse ash as compared to fly ash treatment over GRDF and absolute control treatments. Similar trend of increased in availability of DTPA-Fe, Mn, Zn and Cu in soil at CRI and harvest stages observed in application of bagasse ash as source of K_2O as compared to fly ash treatments

The higher DHA and bacterial population was observed in both the treatments of application of 125 % K_2O through bagasse ash at crown root initiation and harvest stage.

The highest total chlorophyll content, N, P, K, Fe, Mn, Zn and Cu uptake in wheat crop and agronomic efficiency were also observed to be highest in treatment of application of 125% K_2O through bagasse ash along with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM (T_7).

In case of the wheat quality parameters, highest test weight was found in treatment of application of 125 % K_2O through bagasse ash along with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM (T_7), however, slightly improvement in quality parameter like crude protein and gluten contents were observed in application of bagasse ash as compared to fly ash even statistical results obtained non significant.

The higher net monetary returns (Rs. 41406/- and Rs. 39028/-) were recorded in treatments of application of bagasse ash @ 13.02 and 10.41 q ha^{-1}, respectively in soil for the supplementation of K_2O @ 50 and 40 kg ha^{-1}, respectively. The same trend was also observed in benefit : cost ratio which was found higher in treatments of T_7 (1.86) followed by T_8 (1.81).

It can be concluded that, the application of 125 % K_2O (50 kg ha^{-1} K_2O) through bagasse ash @ 13.02 q ha^{-1} along with recommended dose of N (120 kg ha^{-1}) and P_2O_5 (60 kg ha^{-1}) through chemical fertilizer + 10 t ha^{-1} FYM to wheat crop at the time of sowing was found beneficial for increase in nutrient uptake, improvement in biological properties of soil, higher net monetary returns , B:C ratio (1.86) and yield of wheat grown in an Inceptisol. This study revealed that, bagasse ash can be an alternative source of potassium which will save the foreign exchange on K fertilizers in future.

Pages 1 to 45

1. INTRODUCTION

Fly ash - a coal combustion residue of thermal power plants has been regarded as the problematic solid waste all over the world. The dust collection system removes the fly ash, as a fine particulate residue, from the combustion gases before they are discharged into the atmosphere. Fly ash particles are typically spherical, ranging in diameter from 1µm up to 150 µm. The type of dust collection equipment used largely determines the range of particle sizes in any given fly ash. The fly ash from boilers at some older plants using mechanical collectors alone is coarser than from plants using electrostatic precipitators.

The term fly ash was first used in the electrical power industry in 1930, the first comprehensive data on its use in concrete in North America were reported by Davis *et al*. (1937). The first major practical application was reported in 1948 with the publication by the United States Bureau of Reclamation if data on the use of fly ash in the construction of the Hungry Horse Dam. Worldwide acceptance of fly ash slowly followed these early efforts, but interest has been particularly noticeable in the wake of the rapid increase in energy costs that occurred during the 1970s.

Every year Indian thermal power plants produce more than 100 million tones of fly ash, which is expected to reach 200 million tonnes in near future and their disposal is a major problem all over the world due to limited use and possible toxic outcomes. While having look on recent fly ash production (2016-17) in India, we will found it is around 180 million tonnes and its utilization is around 62 per cent.

Present scenario on fly ash in India

1. Over 73 per cent of the total installed power generation is thermal.
2. 230 - 250 million MT coal is being used every year.
3. High ash contents varying from 30 to 50 per cent.
4. More than 175 million MT of ash generated every year.
5. Ash generation likely to reach 200 million MT by 2020.
6. Presently 65,000 acres of land occupied by ash ponds.
7. Presently as per the Ministry of Environment and Forest, 30 per cent of ash is being used in fillings, embankments, construction, block and tiles, etc.

Global energy demand is set to increase by almost 50 per cent in the period 2016 to 2040. Much of this growth will continue to be concentrated in the developing world, primarily China and India, as industrialization, population growth and the unprecedented expansion of the middle class will propel the need for energy in general and coal, in particular. The Indian coal is of low grade having high ash content of the order of 30 to 45 per cent producing large quantity of fly ash at coal/lignite based thermal power stations in the country. The management of fly ash has been troublesome in view of its disposal because of its potential of causing pollution of air and water.

The World Bank has cautioned India that by 2015, disposal of coal ash would require 1000 sq. km. of land. Since coal currently accounts for 70 per cent of power production in the country, there is a need of new and innovative methods for reducing impacts on the environment.

The problem with fly ash lies in the fact that not only does its disposal require large quantities of land, water and energy, its fine particles, if not managed well, can become airborne. Currently more 100 million tonnes of fly ash are being generated annually in India, with 65000 acres of land being occupied by ash ponds. Such a huge quantity dose poses challenging problems, in the form of land use, health hazards and environmental damages.

Use of fly ash in agriculture provides a fessible alternative for its safe disposal to improve the soil environment and enhance the crop productivity. Fly ash management would remain a great concern with the century. Fly ash has a great potentiality in agriculture due to its efficacy in modification of soil health and performance. Practical value of fly ash in agriculture especially in wheat can be established after repeated field experiments. Bakri *et al.* (2012) reported 0.85 per cent K_2O in fly ash. Arivazhagan *et al.* (2011) studied the effect of coal fly ash on agricultural crops. They stated that use of coal fly ash in agriculture is one way of disposal of fly ash and at the same time it improves the yield of variety of agricultural crops and physico-chemical properties of soil. They revealed that application of coal ash increase the yield of cereal crops to 15 to 20 per cent, sugarcane to 20 to 30 per cent, maize to 40 per cent, red gram to 50 per cent, potato to 25 per cent, plantation crops to 30 per cent, mustard and vegetable to 10 per cent. Besides increasing the yields of crops it also improved nutrient uptake in plants and physical properties of soil especially water holding capacity and fertility status of soil. They also revealed that, the application of fly ash @ 50 t ha^{-1} have increased the yield of wheat by 5 to 10 per cent.

Bagasse ash is one of the organic waste obtained from sugar industries during the process of sugar manufacturing. After crushing and extracting juice from sugar cane, the remaining pulp (bagasse) is burnt under boilers for heating the juice and power generation. The material left behind after burning of bagasse, the ash obtained is called as 'Cogenerated Bagasse Ash' which poses a significant environmental problem. Sugarcane production in India is over 300 million tons/year leaving about 10 million tonnes of as unutilized and hence, waste material.

Bagasse ash use in agriculture as organic fertilizer for crop production is now-a-days becoming an established practice. Researchers consider bagasse ash as a good source of micronutrients like, Fe, Mn, Zn, and Cu (Anguissola *et al.*, 1999). It can also be used as soil additive in agriculture due to its capacity to supply the plants with small amounts of nutrients (Carlson and Adriano, 1993). Bagasse ash contains high concentrations of K and P without nitrogen (Page *et al*., 1979), therefore, its use in agriculture for crop production will be proved more beneficial.

Sugarcane industries are age-old industrial practices in India which contribute a significant amount of by-products as waste. Handling and management of these by-products are huge task, because those require lot of space for storage. However, it provides opportunity to utilize these by-products in agricultural crop production as organic nutrient source. Therefore, it is attempted to review the potential of sugar industries by-products, their availability, and use in agricultural production. Dotania *et al.,* 2016.

Application of sugarcane industries by-products reduces the recommended dose of fertilizers and improves organic matter of soil during the crop production. A huge possibility of sugarcane industries by-products can be used in agriculture to cut down the chemical fertilizer requirement.

Ash from co-combustion of sugarcane bagasse with wood proved to be a valuable soil amendment, particularly for acid soils, neutralizing soil acidity, and providing nutrients to plants. Plants grown on ash amended soils achieved greater biomass production compared to control or treatments using other soil amendments. In ash amended soils pH increased and stabilized faster than on limestone amended soils, which makes the use of ash advisable when fast neutralization of soil acidity is required. Ash application led to a significant increase of soil extractable P and K content and of P and K uptake, compared to limestone or control treatments. Therefore, ash may be considered both as a liming material and as a P and K fertilizer.

The cogenerated bagasse ash is a source of potassium and it consists nearly about 3 per cent K_2O. Cogenerated bagasse ash, is the new possibility for substituting the conventional K fertilizers need to be tested on scientific basis. If we can substitute K fertilizers by cogenerated bagasse ash this will be a viable option for safe disposal of this industrial waste and saving of foreign exchange on K fertilizers.

Currently India is the second largest producer of wheat in the world after China with about 12 per cent share in total world wheat production. Wheat (*Triticum spp.)* is the second most important winter cereal in India after rice. The share of wheat in total food grain production is around 36.25 per cent and share in area is about 24.83 per cent of the total area under food grains.

The area of wheat in India and Maharashtra in 2014-15 was 309.69 lakh hectares and 7.09 lakh hectares, respectively. The production of wheat in India and Maharashtra in 2014-15 is 88.94 million tonnes and 0.9 million tonnes, respectively. The productivity of wheat in India was 2749.9 kg ha^{-1}, however in Maharashtra it was 1225.9 kg ha^{-1} during 2014-15 (Anonymous, 2015). Low productivity of wheat in Maharashtra may be due to imbalance use of nutrients, deteriorated soil health, poor quality of irrigation water, poor germination of wheat seed, due to poor physical properties of soil etc. Considering the constrains and importance of fly ash and bagasse ash in agriculture, the present investigation was planned on effect of fly ash and bagasse ash on soil properties, yield and quality of wheat in an Inceptisol with the following specific objectives

1. To study the effect of fly ash and bagasse ash on physical, chemical and biological properties of soil.
2. To study the effect of fly ash and bagasse ash on total uptake of nutrients.
3. To study the effect of fly and bagasse ash on yield and quality of wheat.

2. REVIEW OF LITERATRURE

The available reviews regarding effect of fly ash, bagasse ash on soil physical, chemical and biological properties, yield and quality of wheat under Inceptisol are presented in this chapter under following heads

2.1 Fly Ash

2.2 Fly Ash Production and Utilization

2.3 Characterization of Fly Ash

2.4 Impact of Fly Ash Soil Properties

2.5 Impact of Fly Ash on Yield and Quality of Crop

2.6 Bagasse Ash

2.7 Bagasse Ash Production and Utilization

2.8 Characterization of Bagasse Ash

2.9 Impact of Bagasse Ash on Soil Properties

2.10 Impact of Bagasse Ash on Yield and Quality of Crop

2.11 As a Source of Nutrient Potassium, Its Scenario and Economy Involved in Its Import in India

2.1 Fly Ash

Paul (1982) revealed that, the fly ash as a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron sized earth elements consist primarily of silica, alumina and iron. When mixed with lime and water, the fly ash forms a cementitious compound with properties very similar to that of portland cement. Because of this similarity, fly ash can be used to replace a portion of cement in the concrete, providing some distinct quality advantages. The concrete is denser resulting in a tighter, smoother surface with less bleeding.

Adriano and Weber (2001) introduced fly ash from coal combustion is a glassy material with a very high available Si content.

Kishor *et al.* (2010) revealed that, fly ash is produced as a result of coal combustion in thermal power station and discharged in ash pond. Combustion of bituminous in thermal power station and discharged in ash ponds. Combustion of bituminous and sub bituminous coal and lignite for generation of electricity in thermal power plants produces solid wastes such as fly ash.

Murugan and Vijayarangam (2013) introduced fly ash as is regularly generated as a by-product by coal or thermal power stations. The potential of fly ash as a resource material in agriculture and related areas is now a well established fact. The application of fly ash in agriculture because of its favorable physico-chemical properties, including appreciable content of essential plant nutrients. While, compare to soil, fly ash consists all the elements except organic carbon and nitrogen.

Ramezanianpour (2014) introduced fly ash as a by-product of the combustion of pulverized coal in thermal power plants. The dust collection system removes the fly ash, as a fine particulate residue, from the combustion gases before they are discharged into the atmosphere.

Surabhi (2017) reported that the generation of coal fly ash is anticipated to increase for many more years, as a result of the world's increasing reliance on coal fired power generation. Understanding the generation and characterizations provides a background and a basis for the alternative uses of fly ash.

2.2 Fly Ash Production and Utilization

Sharma and Kalra (2006) reported that every year Indian thermal power plants produce more than 100 million tons of fly ash, which is expected to reach 175 million tons in near future. Disposal of this huge quantity of ash is a great problem due to its limited utilization in manufacturing of bricks, cements, ceiling and other civil construction activities.

Yeledhalli *et al*. (2008) reported that in India, the generation of huge quantity of fly ash nearly 120 million tonnes/year with its overall 10-15 per cent utilization mainly in the area of civil construction, being far below the fly ash utilization in overseas countries, if not seriously considered and taken care of the associated problems of environmental pollution and occupation of large area for its disposal seem to be much more alarming in future.

Tejasvi and Kumar (2012) concluded that, the management of fly ash is a major environmental and economic concern for the coal fired power generators all over the world

2.3 Characterization of Fly Ash

Kunavankrit (1993) reported that, fly ash contained high amount of Ca and Mg with a high pH and high CEC.

Ratanasthein *et al*. (1996) analysed average elemental concentration of fly ash and found 17 % Si, 11 % Fe, 9.8 % Al, 6.4 % Ca, 1.4 % K, 1.2 % Na and 0.4 % Mg.

Upadhyay and Kamal (2007) reported 36-93% SiO_3, 3.3-6.4% Fe_2O_3, 0.01-0.5% MgO in fly ash along with 0.2-3.4 % of organic matter lost on ignition (LOI).

Basu *et al*. (2009) stated that, fly ash has great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. The high concentration of elements (K, Na, Zn, Ca, Mg and Fe) in fly ash increases the yield of many agricultural crops. They also stated that, fly ash is also useful for stabilizing erosion prone soils. Phyto-remediation can prevent cycling of toxicants from fly ash and growing of multipurpose tree species on problem soils.

Kishor *et al*. (2010) analysed fly ash and reported the moisture content, BD and colour of fly ash as 18-38 %, 1-1.8 Mg m^{-3}, gray-black, respectively and also reported the 0.6 % of K_2O, SiO_2 36.9 %, AlO_3 17.6 % with trace amount of heavy metals in class C type of fly ash.

Bakri *et al*. (2012) studied properties of fly ash. They reported 0.85% K_2O in fly ash. They also reported use of fly ash is more environment friendly due to reduced emission of CO_2.

Mishra *et al*. (2017) reported that, the pH and EC of fly ash 6.15 and 0.62, respectively while working under the title impact of coal fly ash as soil amendment on physico-chemical properties of soil.

Singh and Kaushik (2017) reported the pH and EC of fly ash 7.9 and 0.22 dS m^{-1}, respectively while working on impact of fly ash and press mud amendment on properties and heavy metal concentration of an alkali soil and their impact on plant growth.

2.4 Impact of Fly Ash on Soil Properties

Moliner and Street (1982) reported that, the addition of alkaline fly ash, which has a pH over 9.0 can reduce soil acidity to a level suitable for agriculture and can increase the availability of Si, Na, K, Ca, Mg, B, and S.

Fulekar and Dave (1986) revealed that, the beneficial effect of fly ash on improvement of soil health in respect of physico-chemical parameters, nutritional status and microbial population may be due to the cumulative effect of improvement in individual physico-chemical characteristics. Due to the presence of CaSi minerals, having pozzolanic properties. On its addition to soil likely to improve physical properties.

Gaind and Gaur (2002) studied the impact of fly ash and phosphate solubilising bacteria on soybean productivity. They reported that the application of fly ash at 40 t ha^{-1} in conjunction with *Pseudomonas striata* inoculation improved the bean yield and P uptake by grain. The available phosphorus of soil also showed an upward trend. The fly ash did not exert any detrimental effect on the population of inoculated bacteria.

Garg *et al*. (2005) studied the use of fly ash and biogas slurry for improving wheat yield and physical properties of soil. They revealed that, the leaf area index, root length density and grain yield of wheat were higher in plots amended with fly ash or biogas slurry as compared to unamended plots. They also revealed that both types of amendments reduced bulk density, and increased saturated hydraulic conductivity and moisture retention capacity of soil.

Lee *et al*. (2006) studied the fly ash effect on improving soil properties and rice productivity in Korean paddy soils. They revealed that, the fly ash increased the soil pH and available Si and P contents of silt loam and loamy sand. They concluded that fly ash could be a good supplement to other inorganic soil amendments to improve the nutrient balance in paddy soils.

Sharma and Kalra (2006) reviewed the effect of fly ash incorporation on soil properties and productivity of crops. They stated that fly ash can be used for reclaiming the problematic soil and enhance the crop productivity depending upon the nature of soil and fly ash. It may improve physical, chemical and biological properties of problem soils and enhance the available macro and micronutrients for plants.

Basu *et al*. (2009) stated that fly ash has great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. The high concentration of elements (K, Na, Zn, Ca, Mg and Fe) in fly ash increases the yield of many agricultural crops. They also stated that fly ash is also useful for stabilizing erosion prone soils. Phytoremediation can prevent cycling of toxicants from fly ash and growing of multipurpose tree species on problem soils.

Pandey and Singh (2010) studied impact of fly ash incorporation in soil systems. They revealed that fly ash can be used as potential nutrient supplement for degraded soils thereby solving the solid waste disposal problem to some extent. They also revealed that fly ash could be effectively used in the barren or sterile soil for improving quality and enhancing fertility.

Tejasvi and Kumar (2012) observed that, fly ash altered the soil texture, decrease bulk density, increase water holding capacity, soil porosity, pH, electrical conductivity and organic carbon values of the soil. A marginal increase was also observed in the concentration of P, K, S, Fe, Zn, Mn, B, Ca and Mg elements in the fly ash amended soil. However, there was marked decrease in N content of the soil.

Sharma and Rajwar (2016) reported that, the fly ash vary widely in its physical and chemical composition, therefore, the mode of use in agriculture is different and depends on the characteristics of soil or soil type. Fly ash can be used as liming material on acid soils or acid mine soils or alkali soils for improving the pH of the soils depending on nature of soil and ash. Increases in pH induced by alkaline fly ash addition is a desirable property and could be used for detoxifying elements like Cd, Al and Mn. Similarly, acidic fly ash can successfully be used for reclaiming the alkali soils. The high concentration of elements like K, Na, Zn, Ca, Mg and Fe in fly ash increases yield of agricultural crops. Due to fine nature of fly ash, it improves the WHC of sandy soils removing the compaction of clay soils.

2.5 Impact of Fly Ash on Yield and Quality of Crop

Slims (1993) reported that, fly ash increased soil test levels of P, K, Ca, Mg, Mn, Cu, Zn, B, Cd, Cr, Ni, and Pb. Nutrient concentrations in plants grown in the ash-amended soils, except P, Mn, and B, remained within established sufficiency ranges. The 20 and 40 per cent ash rates increased soil soluble salt (EC) levels from 0.2 to 1.1–1.5 and 1.7–2.1 mmho cm^{-1}, soil pH from 5.6 to 6.0–6.4 or 6.3–6.9.

Gaind and Gaur (2002) studied the impact of fly ash and phosphate solubilising bacteria on soybean productivity. They reported that, the application of fly ash at 40 t ha^{-1} in conjunction with *Pseudomonas striata* inoculation improved the bean yield and P uptake by grain. The available phosphorus of soil also showed an upward trend. The fly ash did not exert any detrimental effect on the population of inoculated bacteria.

Sharma and Kalra (2006) reviewed the effect of fly ash incorporation on soil properties and productivity of crops. They stated that, fly ash can be used for reclaiming the problematic soil and enhance the crop productivity depending upon the nature of soil and fly ash.

Basu *et al*. (2009) stated that, fly ash has great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. The high concentration of elements (K, Na, Zn, Ca, Mg and Fe) in fly ash increases the yield of many agricultural crops.

Arivazhagan *et al*. (2011) studied the effect of coal fly ash in agricultural crops. They stated that use of coal fly ash in agriculture is one way of disposal; of fly ash and at the same time it improves the yield of variety of agricultural crops and physico-chemical properties of soil. They revealed that, the application of coal ash increased the yield of cereal crops to 15-20 per cent; sugarcane to 20-30 per cent; maize to 40 per cent red gram to 50 per cent; potato to 25 per cent plantation crops to 30 per cent and mustard and vegetable to 10 per cent. Besides increasing the yields of crops it also improved nutrient uptake in plants and physical properties of soil especially water holding capacity and fertility status of soil. They also revealed that the application of fly ash @ 50 t ha^{-1} have increased the yield of wheat by 5-10 per cent.

Sheoran (2014) reported the use of fly ash as an admixture in agriculture up to 60 per cent for the wheat (*Triticum aestivum*), 10-20 per cent for mung bean (*Vigna radiata*), and 20 per cent for urad beans (*Vigna mungo*) is suitable for maximum growth and yield. Cd, Cu, Fe, Mn, Mg Ni, Pb, and Zn were accumulated in the plants under study, but at very low concentrations and below the permissible limits provided for human consumption.

2.6 Bagasse Ash

Jamil *et al*. (2004) reported bagasse ash is one of the organic wastes obtained from sugar industry during the process of sugar manufacture. Its use in agriculture as organic fertilizer for crop production is now-a-days becoming an established practice.

Hailu and Dinky (2012) introduced sugarcane bagasse ash as the byproduct of sugar industry found after burning sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane. The disposal of this material is already causing environmental problems around the sugar factories.

Dhengare *et al*. (2015) revealed that, bagasse is often used as a primary fuel source for sugar mills; when burned in quantity, it produces sufficient heat energy to supply all the needs of a typical sugar mill. The dumping of these industrial wastes in open land poses a serious threat to the society by polluting the air and waste bodies. This also adds the no availability of land for public use. After the extraction of all economical sugar from sugarcane, about 40-45 per cent fibrous residue was obtained, which is reused in the same industry as fuel in boilers for heat generation leaving behind 8 -10 per cent ash as waste, known as sugarcane bagasse ash (SBA). The SBA contains high amounts of un-burnt matter, silicon, aluminum and calcium oxides.

Dotaniya *et al*. (2016) reported that the sugarcane industries are age old industrial practices in India which contribute a significant amount of by-products as waste. Handling and management of these by-products are huge task, because those require lot of space for storage. However, it provides opportunity to utilize these by-products in agricultural crop production as organic nutrient source.

Kumar *et al*. (2017) reported over 300 million tons of industrial wastes are being produced per annum by chemical and agricultural process in India. These materials pose problems of disposal and health hazards. Out of several wastes being produced at present, the use of phosphogypsum, fluorogypsum, lime sludge, bagasse ash, red mud, and mine tailing is of paramount significance to protect the environment.

2.7 Bagasse Ash Production and Utilization

Raymohapatra (2015) stated that, if the bagasse ash is used on expansive soils as a replacement; it can solve the various geo-environmental problems rising due to its deposition and can also save the valuable space of the sugar industry and the expansive soil can also be suitably modified.

Dhengare *et al*. (2015) reported that, the sugarcane is major crop grown in over 110 countries and its total production is over 1500 million tons. Sugarcane production in India is over 300 million tonnes per year. The processing of it in sugar-mill generates about 10 million tonnes of SCBA as a waste material. One tonne of sugarcane can generate approximate 26 per cent of bagasse and 0.62 per cent of residual ash.

Dotaniya (2016) reported bagasse ash production in Maharashtra, Punjab, Haryana, UP, Karnataka in year 2011 was 9.62, 0.55, 0.80, 17.57 and 4.56 MT, respectively and production over India was 43.84 MT.

Bangar *et al*. (2017) revealed that, the demand and consumption of cement is increasing day by day which has led researchers and scientists to search for locally available alternate binders that can replace cement partially and are ecofriendly and contribute towards waste management. In this direction the industrial and agricultural waste play vital role. The agricultural waste product like Sugarcane Bagasse Ash (SBA) is used as alternate binding material in various cement industries.

2.8 Characterization of Bagasse Ash

Jamil *et al*. (2004) reported pH and EC of bagasse ash 9.2 and 24.73 dSm^{-1}, respectively and revealed some chemical properties like Cl 51 mmol L^{-1}, CO_3 mmol L^{-1}, Fe 267 ppm, Mn 194,Cu 55 and Zn 65 ppm.

Dhengare *et al*. (2015) analysed bagasse ash and reported some chemical properties like SiO_2 87.59 %, K_2O 3.64 %, CaO 2059 %, MgO 1.65 %, Fe_2O_3 0.67 %, Al_2O_3 0.51 %, Na_2O 0.17 %, Mn 0.05 %, SO_3 0.05 % along with trace quantity of heavy metals.

Saluhudeen and Ochepo (2015) reported the oxides per cent in bagasse ash as a following SiO_2 57.95 %, Al_2O_3 8.23 %, Fe_2O_3 3.96 %, CaO 4.55 %, MgO 4.47 %, K_2O 2.41 %, LOI 5.0 % etc.

Reddy *et.al.* (2015) analysed bagasse ash and reported its specific gravity 1.84 Mg m^{-3} and its colour as black, SiO_3 78.34, AlO_3 8055, Fe_2O_3 3.61, CaO 2.15, Na_2O 0.12, K_2O 3.46, MnO 0.13, TiO_2 0.50, P_2O_5 1.07 per cent.

Dotaniya *et al*. (2016) reported bagasse ash contains cellulose, hemicellose and lignin 47-52, 25-28 and 20-21 per cent, respectively.

Benbi *et al*. (2017) reported the chemical properties of bagasse that it contains C 10.4%, N 0.41 %, P 0.73 % , K 0.90 % and Cd, Cr, Ni,and Pb 0.2, 8.7, 5.1 and 4.2 $\mu g\ g^{-1}$, respecctively.

2.9 Impact of Bagasse Ash on Soil Properties

Jamil *et al*. (2004) reported bagasse ash as a good source of micronutrients like Fe, Mn, Zn, and Cu. It can also be used as soil additive in agriculture due to its capacity to supply the plants with small amounts of nutrients (Carlson and Adriano, 1993). Bagasse ash contains no N, but there are commonly high concentrations of K and P (Page *et al*., 1979).

Salahudeen and Ochepo (2015) reported bagasse ash improved the CBR (California bearing ratio) value of lateritic soil when compacted at optimum moisture content and maximum dry density.

Dotaniya *et al*. (2016) stated that, application of sugar industries by-products, such as press mud and bagasse, to soil improves the soil chemical, physical and biological properties and enhanced the crop quality and yield. A huge possibility of sugarcane industries by-products can be used in agriculture to cut down the chemical fertilizer requirement. If all the pressmud is recycled through agriculture about 32,464, 28,077, 4,038, 3434, 393, 1030, and 240 tonnes of N, P, K, Fe, Zn, Mn and Cu, respectively can be available and that helps in saving of costly chemical fertilizers.

Benbi (2017) reorted that, the disposal of ashes from agro-industrial waste has become an important issue that can cause serious environmental problems. These materials may be used in agriculture for soil fertility improvement and carbon sequestration. The effect of applying bagasse ash (BA), rice husk ash (RHA) and RHA mixed with fly ash (FA) to wheat was evaluated on soil organic carbon (SOC) and microbial activity in a loamy sand soil after four years of wheat-rice cropping. BA application resulted in C accrual at 525 kg ha^{-1} y^{-1} in soil.

2.10 Impact of Bagasse Ash on Yield and Quality of Crop

Jamil *et al*. (2004) conducted a field experiment to study the impact of various rates of bagasse ash on wheat (*Triticum aestivum* L.) in a calcareous soil. The results showed that the yield and yield components of wheat increased significantly with various rates of bagasse ash over control. Treating the soil with bagasse ash has been found to enrich it with utilizable plant nutrients associated with enhanced yield of wheat crop. Amending the soil with bagasse ash @ 2.0 t ha^{-1} was found to be the most appropriate dose for higher yield of wheat crop in a calcareous soil.

Khan (2011) revealed that, the most of the yield parameters of wheat crop like plant height, spike length, number of tillers, number of productive tillers, number of grains spike, 1000 grains weight, grain and straw yields were positively affected by the application of sewage sludge, press mud and bagasse ash, respectively.

Pita (2012) ash from co-combustion of sugarcane bagasse with wood proved to be a valuable soil amendment, particularly for acid soils, neutralizing soil acidity and providing nutrients to plants. Corn plants grown on ash amended soils achieved greater biomass production compared to controls or treatments using other soil amendments. In ash amended soils pH increased and stabilized faster than on lime stone amended soils, which makes the use of ash advisable when fast neutralization of soil acidity is required. Ash application led to a significant increase of soil extractable P and K content and of P and K uptake of corn, compared to limestone or control treatments. Therefore, ash may be considered both as a liming material and as a P and K fertilizer.\

Dotaniya *et al*. (2016) reported that, the sugarcane industries are age-old industrial practices in India which contribute a significant amount of by-products as waste. Handling and management of these byproducts are huge task, because those require lot of space for storage. However, it provides opportunity to utilize these by-products in agricultural crop production as organic nutrient source.

Bhushan *et al*. (2016) conducted a pot culture experiment to study the impact of bagasse ash amended soil on growth and yield of *Pisum sativum*. Their results showed that yield and most of the yield components of *Pisum sativum* crop in pots increased due to bagasse ash application. It was recommended that application of bagasse ash 40-60 per cent will result in enhanced yield of *Pisum sativum*.

Sharma and Rajwar (2016) reported that the growth, pigment and productivity of soybean increased significantly in bagasse biochar treatment followed by mixed biochar treatment. The results obtained may be attributed to highly porous nature of bagasse biochar that ultimately increases WHC.

2.11 As a Source of Nutrient Potassium, its Scenario and Economy Involved in its Import in India

Baque *et al*. (2006) reported the raised levels of potassium increased the dry matter production and grain yield in wheat crop, the uptake of N and P was also increased with raised levels of potassium under stress condition.

Kinekar (2011) revealed that, the total import of potash (in lakh metric tonnes) by India was 56.72 in year 2008-2009 and potash consumption in India during last five years (2004-05 to 2009-10) has increased by average growth rate of 10 per cent.

Prajapati (2012) reported the role of potassium in plants enzyme activities, stomatal activities, photosynthesis, transport of sugar and in protein synthesis and also concluded that the potassium is extremely important in many ways to the productivity of plant. It not only performs the important physiological functions, but it improves nitrogen use efficiency. As we know, nitrogen is directly related to yield. However, if potassium is the limiting nutrient, forage production will decrease. It has reconfirmed the vital role of potassium in the modulation of plant stomata apertures; by inference, the latter would be linked to potassium deficiency in plants. If potassium is deficient for a plant, it probably activates a signaling mechanism which leads to the translocation of mobile K^+ ions from old to new leaves to support stomata aperture osmo-modulation in the latter.

The import of MOP in India during 2011-12 and 2012-13 was 39.85 and 24.96 lakh MT (Anonymous, 2013)

Mala (2013) reported that India made impressive gains in the field of agricultural production and harvested a record in food grains production of 230 million tonnes during 2007-2008. Introduction of HYV's and hybrid varieties brought optimism about fertilizer response superiority of modern varieties. The total nutrient consumption ($N + P_2O_5 + K_2O$) touched level of 264 lakh million tonnes during 2009-10, the highest so far. Since the rainfed areas, which constitute 70 per cent of the cultivated areas, consume only 20 per cent of the total fertilizers, the government has been taking steps in recent years to increase the consumption of fertilizers in these areas. Even though India is the third largest fertilizer user, average rate of nutrient application is only 85 kg ha^{-1}. The use of fertilizers is affected by a number of factors like irrigation, high yielding variety seeds, size of the farm credit etc. and imports meet the entire MOP requirement as there are no known natural potash deposits in the country. In 2010, MOP imports were 4.74 million tonnes with per hactor consumption of MOP 12.66 kg ha^{-1} in year 2005-2006

Many scientist done reaserch work on fly ash and bagasse ash as an amendment for neutralizing the acid or lateritic soil and as a source of nutrient P and K for paddy and wheat crops. Very limited review and research work on black shrink swell soil was observed and hence, present research work has been planned as a amendment and a source of potassium nutrient through fly ash and bagasse ash to wheat crop.

3. MATERIAL AND METHODS

The present investigation on "Effect of fly ash and bagasse ash on physico-chemical and biological properties of soil, yield and quality of wheat in an Inceptisol" was conducted at the Post Graduate Institute, Research Farm of the Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri in *Rabi* 2016. This experiment was planned for studying the effect of fly ash and bagasse ash on soil properties, yield and quality of wheat crop in an Inceptisol.

The details of the material used in experimental techniques and analytical methods adopted during the investigation are presented in this chapter under the following heads.

3.1 Details of Experimental Material

3.1.1 Experimental Site

The experiment was conducted during *Rabi,* 2016 at Post Graduate Institute, Research Farm of Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, MS (India). The experimental sit was uniform and nearly leveled, medium deep black soil belonging to soil order Inceptisol.The experimental plot was situated at 19^{0}34' N latitude and 74^{0}64' E longitude .

3.1.2 Climate and Weather

The field experimental site climatically belongs to semi arid zone with an average rainfall of 519 mm. The meteorological data with respect to temperature, humidity and rainfall was obtained from the Chief Scientist, All India Coordinated Research Project on Water Management, MPKV, Rahuri and presented in table 3.1. The minimum and maximum temperature during growing period of wheat crop was 26.5^{0}C to 40.5^{0}C and 8.5 to 21.5^{0}C, respectively . The morning and evening relative humidity during the crop growth period was 36.14 to 87.29 and 13.57 to 71.43 per cent in morning and evening, respectively. Total rainfall during *rabi* crop growing period was 15.8 mm. Sowing was done on 18^{th} November, 2016.

3.1.3 Soils

The experimental soil belongs to Masala soil series of Inceptisol order (*Vertic Haplustept*), The soil was moderately alkaline with medium status of organic carbon and high in calcium carbonate content. Low in available N, medium in available P, very high in available K and deficient in Zn and Fe (Table 4.2).

A composite soil sample from the experimental site was collected and processed for analysis of soil properties and fertility status. After collection of soil, the soil was air dried under diffused sunlight and processed for initial chemical and physical properties.

Table 3.1. Weather data during experimental period

Met. Week	Temperature ^{0}(C)		Relative humidity (%)		Sun shine (hrs)	Wind velocity (kmhr^{-1})	Rainfall (mm)
	Max.	Min.	Morn.	Even.			
October 2016							
40	28.6	21.5	87.29	71.43	2.8	3.9	15.8
41	31.6	20.6	80.43	53.28	0.7	7.1	0
42	31.8	17.2	66.57	39.00	0.4	8.1	0
43	31.3	16.4	65.86	35.57	0.3	9.1	0
44	30.6	13.9	52.33	46.33	0.4	9.6	0
November 2016							
45	29.6	11.6	52.14	25.57	0.4	9.5	0
46	29.4	12.6	64.28	41.57	0.4	7.5	0
47	29.1	10.1	56.00	27.14	0.6	9.3	0
48	30.9	10.5	62.00	26.00	0.5	11.0	0
December 2016							
49	28.9	11.2	64.86	34.14	1.0	8.6	0
50	28.6	11.7	52.57	37.71	1.1	7.8	0
51	29.2	10.2	54.28	34.28	0.3	9.3	0
52	29.4	8.6	56.28	28.22	0.4	9.5	0
January 2017							
1	26.5	08.9	60.57	34.00	1.0	9.4	0
2	28.8	13.5	68.14	39.28	1.0	6.7	0
3	31.0	13.0	61.86	30.00	1.1	9.4	0
4	30.3	11.9	62.33	31.00	1.2	10.0	0
5	32.0	13.2	57.71	29.14	1.1	9.7	0
February 2017							
6	31.4	14.0	57.28	29.71	1.1	9.5	0
7	33.6	14.3	49.43	25.43	2.2	10.2	0
8	34.4	12.7	41.86	14.42	1.6	10.7	0
9	34.2	14.8	47.00	18.90	1.3	9.1	0
March, 2017							
10	32.0	12.5	36.14	18.85	2.5	9.3	0
11	34.4	16.0	37.85	17.85	2.5	9.1	0
12	38.0	18.9	38.00	13.57	1.7	9.2	0
13	40.5	21.2	45.67	14.67	1.4	9.2	0

3.1.4 Fly Ash and Bagasse Ash

In this experiment addition of graded levels of fly ash and bagasse ash was managed along with replacement of potash as per treatments. The quantity of fly ash and bagasse ash are reported in table 3.2.

Table 3.2. Quantity of nutrient, FYM, fly ash and bagasse ash added

Tr. No.	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	FYM (t ha^{-1})	Fly ash (kg ha^{-1})	Bagasse ash (kg ha^{-1})
T_1	Control	Control	Control	Control	Control	Control
T_2	120	60	40	10	-	-
T_3	120	60	50	10	8333	-
T_4	120	60	40	10	6666	-
T_5	120	60	30	10	5000	-
T_6	120	60	20	10	3333	-
T_7	120	60	50	10	-	1302
T_8	120	60	40	10	-	1041
T_9	120	60	30	10	-	781
T_{10}	120	60	20	10	-	520

Note : Deficient micronutrient Fe and Zn was applied as a ferrous sulphate and zinc sulphate @ 25 kg ha^{-1} and 20 kg ha^{-1}, respectively in all the treatments except absolute control

3.1.5 Characterization of Fly Ash and Bagasse Ash

The fly ash was procured from Thermal Power Station, Eklahare, Nashik, Dist. Nashik (MH) and bagasse ash from Pravara Sugar Factory, Pravaranagar, Dist. Ahmednagar (MH), both the ashes were characterized by adopting specific analytical procedures and the values are mentioned in the table 4.1.

3.1.6 Soil Sampling

In order to study the chemical and biological properties of soil, before the beginning of the experiment, a representative composite soil sample was collected from experimental field. Surface soil samples (0-15 cm) were drawn before sowing, at crown root initiation and after harvest of the wheat crop. The soil samples were collected in polythene bags which were used for analysis of biological properties and remaining samples were then air dried in the shade for processing. The samples were then ground in wooden mortar and pestle and sieved through 2 mm sieve for analysis of chemical and physical properties of the soil and soil fertility attributes.

3.1.7 Culture Media

Table 3.3. Preparation of nutrient agar media

i.	**Nutrient agar medium (Bacteria)**		
1.	Beef extract	:	3 g
2.	Peptone	:	5 g
3.	Agar	:	20 g
4.	Sucrose	:	20 g
5.	Distilled water	:	1000 ml
6.	pH	:	6.8-7.2
ii.	**Potato dextrose agar medium (Fungi)**		
1.	Potato (Peeled)	:	250 g
2.	Dextrose	:	20 g
3.	Agar	:	20 g
4.	Distilled water	:	1000 ml
5.	pH	:	6.0-6.5
iii.	**Kenknight's agar medium (Actinomycetes)**		
1.	Glucose	:	1 g
2.	Monopotassium phosphate	:	0.1 g
3.	Potassium chloride	:	0.1 g
4.	Magnesium sulphate	:	0.1 g
5.	Agar	:	15 g
6.	Sodium nitrate	:	0.1 g
7.	Distilled water	:	1000 ml
8.	pH	:	7.0-7.2

3.2 Details of Field Experiment

3.2.1 Layout and Experimental Design

The representative soil samples were collected plot wise to assess the initial soil fertility status of experimental plot. The experiment was laid out in a randomized block design (Fig.3.1) with 10 treatments and 3 replications. The gross plot size was 3.6 m. x 3.2 m. and net plot size was 3.15 m. x 3.0 m. The recommended inter row spacing of 22.5 cm was adopted.

The general recommended fertilizer dose of wheat is 120:60:40 kg ha^{-1} N, P_2O_5 and K_2O respectively along with FYM @10 t ha^{-1}. All the nutrients, fly ash and bagasse ash and FYM were added in soil as per treatment (Table 3.2)

Table 3.4. Details of field experiment

1.	**Location**	**:**	Post Graduate Research Farm, Department of Soil Science and Agril. Chemistry, M.P.K.V., Rahuri.
2.	**Soil type**	**:**	Medium deep black soil (Inceptisol)
3.	**Crop**	**:**	Wheat
4.	**Variety**	**:**	Samadhan (NIAW 1994)
5.	**Season**	**:**	*Rabi* (2016)
6.	**Treatments**	**:**	Ten
7.	**Replications**	**:**	Three
8.	**Design**	**:**	RBD (Randomised Block Design)
9.	**Spacing**	**:**	22.5 cm
10.	**Plot size**	**:**	Gross : 3.60 m x 3.20 m Net :3.15 m x 3.00 m
11.	**Sowing date**	**:**	18-11-2016
12.	**Harvesting date**	**:**	08-03-2017

3.2.2 Initial Properties and Fertility Status of Soil

The soil was moderately alkaline with medium status of organic carbon content and high in calcium carbonate content. The soil fertility status showed low in available N, medium in available P and very high in available K. The soils were deficient in Zn and Fe, however, sufficient in Mn and Cu (Table 4.2) .

3.2.3 Treatment details

T_1 : Absolute control
T_2 : GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)
T_3 : GRDF of N + P_2O_5 + 125% K_2O through fly ash
T_4 : GRDF of N + P_2O_5 + 100% K_2O through fly ash
T_5 : GRDF of N + P_2O_5 + 75% K_2O through fly ash
T_6 : GRDF of N + P_2O_5 + 50% K_2O through fly ash
T_7 : GRDF of N + P_2O_5 + 125% K_2O through bagasse ash
T_8 : GRDF of N + P_2O_5 + 100% K_2O through bagasse ash
T_9 : GRDF of N + P_2O_5 + 75% K_2O through bagasse ash
T_{10} : GRDF of N + P_2O_5 + 50% K_2O through bagasse ash

Note : 1) Fly and bagasse ash were applied with FYM at the time of sowing.
2) Deficient micronutrient Fe and Zn was applied as a ferrous sulphate and zinc sulphate @ 25 kg ha^{-1} and 20 kg ha^{-1}, respectively in all the treatments except absolute control treatment.
3)FYM @10 t ha^{-1} was common to all treatments except Absolute control

3.3 Details of Field Operations

3.3.1 Seed

Healthy wheat seeds of variety Samadhan, recently released by university obtained from Chief Seed Sale Counter, M.P.K.V., Rahuri.

Table 3.5. Calendar of the field operations for wheat during *rabi* 2016-17

Sr. No.	Field operations	Frequency	Date
A.	**Preparatory tillage**		
1.	Ploughing	1	26-10-16
2.	Discing and harrowing	1+2	7-11-16
3.	Stubble collection of previous crop	1	8-11-16
4.	Preparation of layout	1	10-11-16
5.	Initial soil sampling	1	11-11-16
B.	**Sowing**		
1.	Sowing of wheat as per treatment	1	18-11-16
C.	**Fertilizer(NPK)**		
	Basal dose	1	18-11-16
	30 DAS	1	18-12-16
D.	**Inter cultivation**		
1.	Weeding	3	19-12-16 15-1-17 10-2-17
2.	Irrigation	5	19-11-16 10-12-16 24-1-17 10-2-17 25-2-17
E.	**Plant protection**		
1.	Spraying ((Dimethoate)	2	1-12-16 19-1-17
F.	**Harvesting**		
1.	Harvesting	1	8-3-17

3.3.2 Fertilizers

The recommended dose of fertilizers for wheat was 120:60:40 kg ha^{-1} N, P_2O_5 and K_2O. The N was given through urea, P through single super phosphate and K_2O through muriate of potash in T_2 treatment, however K_2O was given @ 50,40,30 and 20 kg ha^{-1} through fly ash in T_3 to T_6 and bagasse ash in treatments of T_3 to T_{10} , respectively. Organic manures i.e farm yard manure was given @ 10 t ha^{-1} to all the treatments except T_1 treatment (Absolute control).

3.3.3 Seed Inoculation

The seed was treated with *Azotobactor* @ 250 g per 10 kg of seed.

3.3.4 Sowing

The sowing of inoculated wheat seed was done on 17th November, 2016. The wheat seeds were sown at 22.5 cm between row.

3.3.5 Irrigation

The field was irrigated at an interval of eight to ten days starting from 2nd to 3rd days after sowing.

3.3.6 Plant Protection

The incidence of sucking pests like aphids were observed during the course of investigation. Two foliar sprays of insecticide (Dimethoate) were done.

3.3.7 Harvesting

The wheat plants in net plots after maturity were harvested carefully and recorded the grain and straw yield from each net plot

3.4 Details of Laboratory Analysis

3.4.1 Laboratory Material

3.4.1.1 Glasswares

The necessary glassware *viz*., beaker, conical flask, volumetric flask, pipette, glass rod, burette, funnel, measuring cylinder, digestion tubes, etc. were used for analytical work.

3.4.1.2 Equipments

The equipments *viz.,* digestion and distillation unit, hot air oven, weighing balance, grinding machine, mechanical shaker, kel plus distillation, spectrophotometer, flame photometer, atomic absorption spectrophotometer, pH meter, conductivity meter, hot plate etc. were used during the laboratory analysis.

3.4.1.3 Chemicals

The high purity (AR grade) chemicals such as sulphuric acid, sodium hydroxide, hydrogen peroxide, hydrochloric acid, potassium permanganate, sodium bicarbonate, ammonium acetate, ammonium molybdate, ammonium vanadate, boric acid, phenolphthalein, methyl red, bromocresol green etc. were used.

3.4.2 Methods

3.4.2.1 Soil Analysis

Representative surface soil sample of the experimental site were collected up to 0-15 cm depth at harvest stage of wheat from each plot. The collected soil samples were used for analysis of biological property and remaining soil samples were air dried under shade, ground in wooden mortar and pastel, sieved through 2 mm sieve and were analyzed for available macro and micronutrients. For organic carbon soil was sieved with 0.5 mm sieve.

3.4.2.2 Total Plant Analysis

The straw samples were collected at harvest of wheat. The samples were air dried in sunlight and then dried in oven at 60^0C till constant weight. The whole stover sample of each treatment was ground after oven drying. Digestion of plant samples were done and used for estimation of nutrient concentration *viz.,* N, P, K and micronutrients (Fe, Zn, Mn and Cu) by using standard methods.

$$\text{Agronomic efficiency (kg kg}^{-1}) = \frac{\text{Grain yield in kg ha}^{-1}\text{ (Fertilized)} - \text{Grain yield in kg ha}^{-1}\text{ (Controlled)}}{\text{Quantity of nutrient applied (kg ha}^{-1})}$$

3.4.2.3 Total Microbial Population

Total microbial counts were determined by serial dilution and standard plate count method. At initial, CRI and harvest stage soil samples were collected for total microbial counts.

The population of bacteria, actinomycetes and fungi was enumerated by the serial dilution and standard plate count method using nutrient agar media and isolation was carried out by using the following procedures:

- One gram (l g) of fresh soil sample was dispersed in 9 ml of autoclaved distilled water and thoroughly shaken.
- One mililitre (1 mL) of the above solution was transferred to 9 mL of sterile distilled water to form 10^2 dilution.
- Similarly, 10^3, 10^4, 10^5, 10^6, 10^7 and 10^8 serials were made for each soil sample.
- One miililitre (1 mL) of each dilution was transferred to sterile petri plates separately.
- Solidifiable respective agar mediums having 45°C temperature was poured in the petri plates.
- The contents were mixed by rotating the plates gently. Care was taken that medium did not touch the lid.
- The medium was allowed to solidify and the plates were incubated at 27-30°C for 7 days.

The same procedure was followed for the isolation of fungi using potato dextrose agar medium. The development of whitish colonies of bacteria were observed within 24-48 hrs in the nutrient agar medium plate and whitish, blackish and greenish cottony colonies of fungi were observed after 4 days of incubation in the potato dextrose agar medium plate. The average number of bacterial and fungal colonies per plate was counted separately and population count was computed.

3.4.2.4 Fly Ash and Baggase Ash Analysis

The ash sample (0.2 g) was taken into the platinum crucible. Few drops of concentrated H_2SO_4 was added. Then 5 mL of HF and 0.5 mL of $HClO_4$ were added in the crucible. The crucible was heated on sand bath till the fumes of acid evolved. The crucible was cooled and again 5 mL of HF was added to it. The crucible was again placed on the sand bath for heating and evaporated the contents of the crucible at 200-225^{0}C temperatue to dryness. After complete drying of the sample, the crucible was cooled and treated with 2 mL of water and few drops of $HClO_4$ and again evaporated to dryness. The procedure was repeated four times to complete the digestion of the ash sample. After completion of digestion, 5 mL of 6 N HCl and 5 mL of distilled water were added to the crucible and boiled gently to confirm the complete digestion. Volume was made up to 100 mL and the aliquot was used for determination of total elements (Lim and Jackson, 1982).

3.4.2.5 Standard Methods Used for Soil and Plant Analysis

The standard methods used for soil and plant analysis are reported in table 3.6

Table 3.6. Standard methods used for soil and plant analysis

Sr. No.	Parameter	Method used	Reference
A)	**Physical properties**		
1.	Bulk density	Clod method	Blake and Hartage (1986)
2.	Hydraulic conductivity	Constant head method	Klute and Dirksen (1986)
3.	COLE	Soil paste rod	Schafer and Singer(1976)
B)	**Chemical properties**		
1.	pH (1:2.5)	Potentiometry	Jackson (1973)
2.	EC (1:2.5)	Conductometry	Jackson (1973)
4.	Organic carbon	Walkely and Black, (Wet oxidation method)	Nelson and Sommer (1982)
5.	Available N	Alkaline permanganate	Subbiah and Asija (1956)
6.	Available P	0.5 M $NaHCO_3$ (pH 8.5)	Watanabe and Olsen (1965)
7.	Available K	Flame photometry *N* NH_4OAc extract	Jackson (1973)
8.	Micronutrients (DTPA Fe, Mn, Zn & Cu)	DTPA extraction (Atomic Absorption Spectrophotometry)	Lindsay and Norvell (1978)
C)	**Biological properties**		
1.	Dehydrogenase activity	Spectophotometry	Casida *et al.* (1964)
2.	Total bacterial count	Serial dilution plating technique	Halvorsun and Zeiglor (1993)
3.	Total fungal count	Serial dilution plating technique	Halvorsun and Zeiglor (1993)
4.	Total actinomycetes count	Serial dilution plating technique	Halvorsun and Zeiglor (1993)
D)	**Plant analysis**		
1.	Total nitrogen	Diacid H_2SO_4:H_2O_2 (1:1)	Jackson (1973)
2.	Total phosphorus	Diacid HNO_3:$HClO_4$ (9:4)	Chapman and Pratt (1961)
3	Total potassium	Diacid HNO_3:$HClO_4$ (9:4)	Chapman and Pratt (1961)
4	Total chlorophyll	Colorimetric method	Arnon (1949)
5	Total micronutrient (DTPA-Fe,Mn,Cu, Zn)	Atomic Absorption Spectrophotometry	Zososki and Burau (1977)

Table 3.7. Quality parameters of wheat grain

Sr No	Quality parameters	References
1.	Test weight (g/1000 grain)	A.O.A.C (2016)
2.	Crude protein (%)	A.O.A.C (2016)
3.	Gluten content (%)	A.O.A.C (2016)

3.4.2.6 Statistical Analysis

The field experiment was conducted by using randomized block design. The data obtained were statistically analysed as per the methods described by Panse and Sukhatme (1985).

4. RESULTS AND DISCUSSION

A field experiment was conducted at Post Graduate Institute, Research Farm, M.P.K.V., Rahuri during *rabi* 2016 with a view to study "Effect of fly ash and bagasse ash on soil properties, yield and quality of wheat in an Inceptisol". The sailent findings of the research are presented and discussed in this chapter.

4.1 Characterization of Fly Ash and Bagasse Ash

Characterization of fly ash and bagasse ash are presented in table 4.1. The colour of fly and bagasse ash are white and black ash, respectively. Specific gravity of fly and bagasse ash were higher 1.83 and 1.80 Mg m^{-3} , respectively. COLE value of both the ash not showed swell-shrink properties (0.036 and 0.035) as COLE value indicating less than 0.09 value . The moisture content of fly and bagasse ash was 2.09 and 2.5 per cent , respectively. However, hydraulic conductivity of fly ash was 0.26 cm h^{-1} and bagasse ash was 0.64 cm h^{-1}. Lower hydraulic conductivity of fly ash may be due to fineness of particles with high pH and low electrical conductivity as compare to bagasse ash.

The chemical properties of fly ash and bagasse indicated very strongly alkaline in pH (9.42 and 9.27, respectively). The electrical conductivity of fly ash showed lower value (0.47 dS m^{-1}) however, it showed higher (2.50 dS m^{-1}) in bagasse ash.

Total nitrogen was in trace amount in fly ash and bagasse ash however, total P content in fly ash was 0.06 per cent and in bagasse ash it was 0.12 per cent. Total K as K_2O was 0.60 and 3.84 per cent observed in fly and bagasse ash, respectively, which may substitute for K containing chemical fertilizers of high salt index, which is mostly imported in India. Bakri *et al.* (2012) reported 0.85 per cent in fly ash, they also reported use of fly ash is more environment friendly due to reduced emission of CO_2. Fly and bagasse ash also had small quantity of total CaO, total MgO and total Na *viz*., 0.36, 0.37 and 0.07 per cent in fly ash, respectively and 0.51, 0.48 and 0.14 per cent in bagasse ash, respectively. Total micronutrients content *viz*., 538, 219, 201 and 110 mg kg^{-1} of Fe, Mn, Zn and Cu, respectively in fly ash and 462, 200, 36 and 21 mg kg^{-1} of Fe, Mn, Zn and Cu, respectively. Total nitrogen content was not found in both the ashes. The total organic carbon content was 0.01 per cent in fly ash however it was 3.38 per cent in bagasse ash. The heavy metals content in fly ash were very less amount i.e. 23, 58, 38 and 21 mg kg^{-1} of Cd, Co, Cr and Ni, respectively, however, in bagasse ash were comparatively less amount i.e. 12, 45, 31 and 14 mg kg^{-1} of Cd, Co, Cr and Ni, respectively. Kishor *et al.* (2010) analysed fly ash and reported trace amount of heavy metals.

The same characterization of fly ash and bagasse ash also reported by Dhengare *et al*. (2015), Upadhyay and Kamal (2007), Dhodse *et al*. (2008) and Yeledhalli *et al*. (2008).

Table 4.1 Characterization of fly ash and bagasse ash

Sr. No.	Parameters	Fly ash	Bagasse ash
A)	**Physical properties**		
1	Colour	Ash white	Ash black
2	Specific gravity (Mg m^{-3})	1.83	1.80
3	COLE value	0.036	0.035
4	Moisture content (%)	2.09	2.5
5	Hydraulic conductivity (cm h^{-1})	0.26	0.64
B)	**Chemical properties**		
1	pH (1:2.5)	9.42	9.27
2	EC (dS m^{-1})	0.47	2.50
3	Total organic carbon (%)	0.01	3.38
4	Total N (%)	Trace	Trace
5	Total P (%)	0.06	0.12
6	Total CaO (%)	0.36	0.51
7	Total MgO (%)	0.37	0.48
8	Total Na (%)	0.07	0.14
9	Total K (K_2O, %)	0.60	3.84
10	Fe (µg g^{-1})	538	462
11	Mn (µg g^{-1})	219	200
12	Zn (µg g^{-1})	201	36
13	Cu (µg g^{-1})	110	21
14	Cd (µg g^{-1})	23	12
15	Co (µg g^{-1})	58	45
16	Cr (µg g^{-1})	38	31
17	Ni (µg g^{-1})	21	14

4.2 Initial Properties of Experimental Soil

The initial, physical, chemical and biological properties of the experimental soils are presented in table 4.2.

The textural class of soil was clay, normal in bulk density (1.28 Mg m^{-3}), moderately low in hydraulic conductivity (0.61 cm h^{-1}) and high in COLE value 0.20, indicating swell shrink characteristics (COLE > 0.09).

pH of soil was moderately alkaline (8.31), normal in EC (0.26 dSm^{-1}), medium in organic carbon content (0.58 %) and high in calcium carbonate (11.6 %) .The fertility of soil showed low status in available nitrogen (220.40 kg ha^{-1}), medium status in available phosphorous (19.87 kg ha^{-1}), and very high status of available potassium (414.80 kg ha^{-1}) however, soils were deficient in available iron (3.71 ppm) and zinc (0.48 ppm) and sufficient in available manganese (14.22 ppm) and copper (0.69 ppm).

The initial total bacteria, fungal and actinomycetes counts were 21.77 cfu x 10^6 g^1 soil, 3.03 cfu x 10^5 g^{-1} soil and 6.77 cfu x 10^5 g^{-1} soil,respectively whereas, DHA was 20.97 µg TPF g^{-1} 24 hr^{-1} in soil.

Table 4.2 Initial properties of experimental soil

Sr. No.	Parameters	Value
A.	**Physical properties (%)**	
	a) Sand	16.85
	b) Silt	23.51
	c) Clay	59.64
	Textural class	Clay
1	Bulk density (Mg m^{-3})	1.28
2	Hydraulic counductivity (cm h^{-1})	0.61
3	COLE value	0.20
B.	**Chemical properties**	
1.	pH (1:2.5)	8.31
2.	EC (dS m^{-1})	0.26
3.	Organic carbon (%)	0.58
4	Calcium carbonate (%)	11.6
5.	Available N (kg ha^{-1})	220.40
6.	Available P (kg ha^{-1})	19.87
7.	Available K (kg ha^{-1})	414.80
8.	DTPA Fe (mg kg^{-1})	3.71
9.	DTPA Mn (mg kg^{-1})	14.22
10.	DTPA Zn (mg kg^{-1})	0.48
11.	DTPA Cu (mg kg^{-1})	0.69
C.	**Biological properties**	
1.	Total bacterial count (cfu x 10^6 g^{-1} soil)	21.77
2.	Total fungal count (cfu x 10^5 g^{-1} soil)	3.03
3	Total actynomycetes (cfu x $10^5 g^{-1}$ soil)	6.77
4	DHA (µg TPF g^{-1} 24 hr^{-1})	20.97

4.3 Effect of Application of Fly Ash and Bagasse Ash on Physical Properties of Soil at Different Stages of Crop Growth

The bulk density, hydraulic conductivity and COLE values as influenced by application of fly ash and bagasse ash at initial, CRI and harvest stage are presented in table 4.3 and fig. 4.1

The bulk density of soil did not show any significant difference at CRI stage however, singnificantly influenced at harvest. The bulk density of soil showed significantly higher in application of fly ash treatment of T_3 (1.36 Mg m^{-3}) over all the treatment except treatment T_4 (1.33 Mg m^{-3}) and T_7 (1.34 Mg m^{-3}) which were at par. The incresed in bulk density of soil at harvest due to application of higher level of fly ash in soil may be due to fine particles of fly ash resulted in clogging of micropores of soil. Which also reflected in slight decreased in hydraulic conductivity of soil in same treatment.

The hydraulic conductivity of initial soil was moderately low (0.61 cm h^{-1}) however, it was significantly decreased due to application of fly ash treatment of T_3 (0.51 cm h^{-1}) at CRI stage over all the treatments. The hydraulic conductivity was slightly increased in treatments of bagasse ash as compared to treatments of application of fly ash however, the treatment T_7 (0.68 cm h^{-1}) showed the highest hydraulic conductivity as compared to all treatments. The same trend was also found at harvest stage.

The COLE value of soil showed swell-shrink nature of soil (0.20) , it was significantly increased in treatment of fly ash and bagasse ash at CRI and harvest stage. The COLE value was found significantly higher in treatments of T_3 (0.31) at CRI and harvest satge, respectively over all treatments except T_3 which was at par with T_4 (0.29) and T_7 (0.30) at CRI and also treatment T_3 (0.32) was at par with T_4 to T_8 at harvest. The COLE value of soil was found higher in treatments of application of fly ash as compared to the treatments of application of bagasse ash. This might be due to very strongly alkaline pH, low electric conductivity and finess of fly ash particle. These findings are in concomitance with Salahudeen and Ochepo (2015), Raymohapatra (2015) and Sharma and Rajwar (2016).

Table 4.3 Physical properties of soil as influenced by application of fly ash and bagasse ash in soil

Tr. No.	Bulk density ($Mg\ m^{-3}$)			Hydraulic conductivity ($cm\ h^{-1}$)			COLE value		
	Initial	**CRI**	**Harvest**	**Initial**	**CRI**	**Harvest**	**Initial**	**CRI**	**Harvest**
T_1	1.28	1.26	1.28	0.61	0.60	0.58	0.20	0.19	0.20
T_2	1.28	1.27	1.26	0.62	0.62	0.60	0.19	0.22	0.21
T_3	1.29	1.32	1.36	0.61	0.51	0.48	0.20	0.31	0.32
T_4	1.28	1.30	1.33	0.62	0.56	0.50	0.19	0.29	0.29
T_5	1.28	1.28	1.30	0.61	0.56	0.49	0.20	0.30	0.31
T_6	1.29	1.27	1.28	0.59	0.58	0.51	0.20	0.27	0.29
T_7	1.28	1.31	1.34	0.60	0.68	0.67	0.20	0.28	0.30
T_8	1.28	1.29	1.30	0.62	0.64	0.62	0.19	0.26	0.28
T_9	1.29	1.31	1.32	0.61	0.61	0.58	0.20	0.26	0.26
T_{10}	1.28	1.28	1.29	0.61	0.62	0.56	0.19	0.22	0.24
S.Em. $\pm$		0.01	0.01		0.01	0.01		0.01	0.01
CD at 5%		NS	0.04		0.05	0.04		0.03	0.04

4.4 Effect of Fly Ash and Bagasse Ash on Chemical Properties of Soil at Different Stages of Crop Growth

The soil pH, EC and organic carbon content in soil as influenced by application of fly ash and bagasse ash at initial, CRI and harvest stage are presented in table 4.4.

The soil pH was found non significant at initial stage however, the significant results were found in CRI and harvest stage, the soil pH at CRI stage was significantly increased in treatment T_3 (8.40) over all treatments except T_4 to T_7 which were at par. Slightly increased in soil pH might be due to presence of secondary and small quantities of micronutrients with oxides forms in fly ash and bagasse ash. Application of bagasse ash treatment showed comparatively low pH value as compared to treatments of application of fly ash. This might be due to high electrolyte concentration of bagasse ash (EC 2.50 dS m^{-1}). The same trend was also found at harvest stage.

The EC of soil showed normal value (0.26 dS m^{-1}) at initial stage however, it significantly influenced at CRI and harvest. The EC of soil significantly increased in treatment of T_7 (0.44 dS m^{-1}) over all the treatments except T_3, T_8 and T_9 ,which were at par. The higher EC in soil application of bagasse ash treatment of T_7, T_8 and T_9 may be due to higher EC of bagasse ash (EC 2.50 dS m^{-1}), the same trend was also found at harvest stage. The increase in soil pH and EC was also reported by Slims (1993) in acid soils.

Table 4.4 Soil chemical properties as influenced by application of fly ash and bagasse ash in soil

Tr. No.	pH (1:2.5)			EC (dS m^{-1})			Organic carbon (%)		
	Initial	CRI	Harvest	Initial	CRI	Harvest	Initial	CRI	Harvest
T_1	8.32	8.30	8.31	0.25	0.24	0.26	0.58	0.58	0.56
T_2	8.30	8.27	8.28	0.26	0.30	0.29	0.60	0.62	0.61
T_3	8.32	8.40	8.41	0.25	0.39	0.37	0.58	0.60	0.60
T_4	8.31	8.38	8.40	0.27	0.36	0.34	0.58	0.60	0.60
T_5	8.32	8.36	8.38	0.26	0.32	0.31	0.58	0.61	0.58
T_6	8.30	8.38	8.40	0.25	0.30	0.29	0.60	0.62	0.60
T_7	8.31	8.34	8.36	0.27	0.44	0.41	0.56	0.64	0.62
T_8	8.30	8.32	8.33	0.26	0.43	0.39	0.58	0.62	0.61
T_9	8.30	8.32	8.30	0.25	0.40	0.37	0.58	0.61	0.60
T_{10}	8.31	8.30	8.32	0.25	0.38	0.35	0.60	0.62	0.58
S.Em. $\pm$		0.02	0.01		0.02	0.02		0.01	0.01
CD at 5%		0.07	0.04		0.06	0.06		NS	NS

The organic carbon content in soil as influenced by application of fly ash and bagasse ash showed non significant results at all the growth stages. Similar observations were also reported by Lee *et al*. (2006) and Tejasvi and Kumar (2012).

4.5 Effect of Fly Ash and Bagasse Ash on Soil Available Nitrogen, Phosphorous and Potassium at Different Stages of Crop Growth

The soil available nitrogen, phosphorous and potassium contents as influenced by application of fly ash and bagasse ash at CRI and harvest stage are presented in table 4.5.

Available nitrogen content in soil showed low status (220 kg ha^{-1}) at initial and at CRI and harvest stage. It was not influenced by the application of fly ash and bagasse ash.

Available phosphorous content in soil showed medium status (19.37 kg ha^{-1}) at initial stage, it showed significant diffrences at CRI and harvest stage. The available phosphorous content in soil was found significantly higher in T_8 (24.71 kg ha^{-1}) over all the treatments except T_7 (24.02 kg ha^{-1}) at CRI stage. At harvest stage, available phosphorous content in soil was significantly higher in treatment of T_7 (18.66 kg ha^{-1}) over all the treatments except T_2 and T_4 which were at par. Overall, available P content in soil was found higher in treatment of soil application of bagasse ash as compared to fly ash application treatments. This might be due to higher content of total P (0.12 %), in bagasse ash as compared to trace amount in fly ash.

The available potassium content in soil showed very high status (414 kg ha^{-1}) at initial stage, however, it significantly influenced at CRI and harvest stage (fig 4.2). The available potassium in soil was found to be significantly higher in treatment T_7 (532 kg ha^{-1}) over T_1 (390 kg ha^{-1}) however, rest of the treatments were at par with T_7 at CRI stage. At harvest stage, available potassium content in soil was found higher in treatment T_7 (490 kg ha^{-1}) over all the treatments except T_8 (478 kg ha^{-1}). Overall, higher status of potassium in soil was found in treatment of application of bagasse ash as it had 3.84 per cent K_2O as compared to treatments of application of fly ash as it had 0.6 per cent K_2O.

These results were in agreement with the findings of Inthasan *et al*. (2002) and Tejasvi and Kumar. (2012).

Table 4.5 Soil available N, P and K as influenced by application of fly ash and bagasse ash in soil

Tr. No.	Available N (kg ha^{-1})			Available P (kg ha^{-1})			Available K (kg ha^{-1})		
	Initial	CRI	Harvest	Initial	CRI	Harvest	Initial	CRI	Harvest
T_1	218	212	205	20.37	18.20	14.20	412	390	339
T_2	220	221	216	19.76	22.99	17.95	416	478	402
T_3	224	219	215	19.93	22.33	17.02	416	490	428
T_4	218	222	214	19.80	21.43	18.15	412	484	421
T_5	218	220	214	19.92	22.05	17.26	414	482	419
T_6	220	218	212	19.65	20.89	16.33	414	471	410
T_7	222	222	216	20.71	24.02	18.66	416	532	490
T_8	224	225	216	20.14	24.71	16.10	420	528	478
T_9	222	222	218	19.42	22.05	17.26	416	498	432
T_{10}	218	220	214	19.00	22.16	16.83	412	486	402
S.Em. $\pm$		2.28	2.54		0.46	0.25		23.31	10.49
CD at 5%		NS	NS		1.39	0.76		69.26	31.18

4.6 Effect of Fly Ash and Bagasse Ash on DTPA-Fe, Mn, Zn and Cu Status in Soil at Different Stages

The DTPA-Fe, Mn, Zn and Cu content in soil as influenced by application of fly ash and bagasse ash at initial, CRI and harvest stage are presented in table 4.6 and 4.7.

The DTPA-Fe status in soil was found deficient (3.71 mg kg^{-1}) at initial stage however, significant results were observed at CRI and harvest stage. The DTPA-Fe status in soil was found significantly higher in T_7 (4.31 mg kg^{-1}) over all the treatments except treatment T_3, T_5 and T_8 which were at par at CRI stage. At harvest stage, DTPA-Fe status in soil was significantly higher in treatment T_7 (3.80 mg kg^{-1}) over all the treatments except T_2, T_3 and T_8 which were at par. Overall, at all the growth stages, DTPA-Fe status was found deficient in soil, as critical limit of iron is 4.5 mg kg^{-1}.

The DTPA-Mn content in soil was found sufficient (14.22 mg kg^{-1}) at initial stage, however, significant results were found in CRI and harvest stage. The DTPA-Mn content in soil was found significantly higher in T_7 (14.98 mg kg^{-1}) over all the treatment except treatment T_3 (14.85 mg kg^{-1})

and T_8 (14.79 mg kg^{-1}) which were at par at CRI stage. At harvest stage, the DTPA-Mn content in soil was significantly higher in treatment T_7 (13.88 mg kg^{-1}) over all the treatments except T_2, T_3 and T_8 which were at par. Overall, at all the growth stages, the DTPA-Mn contents were found sufficient in soil as a critical limit of Mn is 2.0 mg kg^{-1}.

Table 4.6 Available DTPA Fe and Mn in soil as influenced by application of fly ash and bagasse ash in soil

Tr. No.	DTPA - Fe (mg kg^{-1})			DTPA - Mn (mg kg^{-1})		
	Initial	CRI	Harvest	Initial	CRI	Harvest
T_1	3.87	3.56	3.27	14.18	13.84	13.08
T_2	3.70	3.94	3.66	14.01	14.20	13.61
T_3	3.41	4.08	3.68	14.17	14.85	13.58
T_4	4.03	3.98	3.61	13.97	14.36	13.10
T_5	3.60	4.01	3.52	13.69	14.08	12.98
T_6	3.71	3.56	3.47	14.40	14.48	12.47
T_7	3.54	4.31	3.80	14.46	14.98	13.88
T_8	3.72	4.20	3.68	14.42	14.79	13.77
T_9	3.62	3.69	3.52	14.30	14.56	13.21
T_{10}	3.86	3.80	3.51	14.65	14.70	12.96
S.Em. $\pm$		0.10	0.05		0.08	0.11
CD at 5%		0.32	0.17		0.24	0.33

The DTPA-Zn content in soil was found deficient (0.48 mg kg^{-1}) at initial stage, however, significant results were found in CRI and harvest stage. The DTPA-Zn content in soil was found significantly higher in T_7 (0.68 mg kg^{-1}) over all the treatments except treatment T_3 (0.64 mg kg^{-1}) and T_4, T_6 (0.62 mg kg^{-1}) which were at par at CRI stage. At harvest stage, the DTPA-Zn content in soil was significantly higher in treatment T_7 (0.51 mg kg^{-1}) over all the treatments except T_2, T_3, T_4, T_6, T_8 and T_9 which were at par. Overall, at all the growth stages, the DTPA-Zn content in soil was found deficient in initial and harvest stage however, it was sufficient at CRI stage except control as critical limit of Zn is 0.6 mg kg^{-1}. The sufficiancy status of the DTPA-Zn at CRI stage in treatment of fly ash and bagasse ash treatments may be due to application of $ZnSO_4$ @ 20 kg ha^{-1} at sowing and also contribution of Zn from the source of FYM and bagasse ash applied in soil.

Table 4.7. Available DTPA Zn and Cu in soil as influenced by application of fly ash and bagasse ash in soil

Tr. No.	DTPA - Zn (mg kg^{-1})			DTPA - Cu (mg kg^{-1})		
	Initial	CRI	Harvest	Initial	CRI	Harvest
T_1	0.48	0.42	0.38	0.71	0.64	0.51
T_2	0.45	0.61	0.46	0.68	0.66	0.54
T_3	0.48	0.64	0.50	0.70	0.74	0.62
T_4	0.45	0.62	0.49	0.68	0.70	0.61
T_5	0.48	0.60	0.44	0.71	0.72	0.64
T_6	0.50	0.62	0.46	0.66	0.70	0.57
T_7	0.45	0.68	0.51	0.68	0.76	0.66
T_8	0.48	0.63	0.50	0.70	0.71	0.62
T_9	0.50	0.61	0.48	0.71	0.74	0.60
T_{10}	0.48	0.59	0.42	0.68	0.70	0.54
S.Em. $\pm$		0.02	0.02		0.01	0.02
CD at 5%		0.06	0.06		0.04	0.06

The DTPA-Cu content in soil was found sufficient (0.69 mg kg^{-1}) at initial stage, however, significant results were found in CRI and harvest stage. The DTPA-Cu content in soil was found significantly higher in T_7 (0.76 mg kg^{-1}) over all the treatments except treatment T_3 and T_9 (0.74 mg kg^{-1}) which were at par at CRI stage. At harvest stage, the DTPA-Cu content in soil was significantly higher in treatment T_7 (0.66 mg kg^{-1}) over all the treatments except T_3, T_4, T_5,T_8 and T_9 which were at par. Overall, at all the growth stages, the DTPA-Cu content in soils were found sufficient, as a critical limit of copper is 0.2 mg kg^{-1}.

Similar findings were also reported by Inthasan *et al*. (2002) and Tejasvi and Kumar. (2012).

4.7 Effect of Fly Ash and Bagasse Ash on Heavy Metals Content in Soil at Different Stages of Crop Growth

Application of fly ash and bagasse ash in soil did not increase in the heavy metals *viz*., Cd, Co, Cr and Ni content in soil as the readings were not detected on AAS. This might be due to single application of both the ashes in one year of experimentation. It could may be possible to accumulate heavy metal in soil after a long term application of fly ash and bagasse ash. Kishor *et al.* (2010) also analysed fly ash and reported trace amount of heavy metals.These findings are in commitance with finding of Lee *et al*. (2006).

4.8 Effect of Fly Ash and Bagasse Ash on DHA, Total Bacterial, Total Fungal and Total Actinomycetes Population in Soil at Different Stages of Crop Growth

The DHA, total bacterial, total fungal and total actinomycetes population in soil as influenced by application of fly ash and bagasse ash at initial, CRI and harvest stage are presented in table 4.8 , 4.9 and plate 4.3 to 4.5.

The DHA in soil showed 20.97 μg TPF g^{-1} 24 hr^{-1} at initial stage, however, it significantly increased at CRI and harvest stage. The DHA in soil was found significantly higher in treatment of T_7 (25.63 μg TPF g^{-1} 24 hr^{-1}) over all treatments at CRI stage . The same trend was also found at harvest stage. This might be due to higher content of total organic carbon content (3.38 %) in bagasse ash which reflected in higher biological activity in soil.

Total bacterial population in soil showed 21.77 x 10^6 cfu g^{-1} of soil at initial stage but it significantly showed difference at CRI and harvest stage (Fig.4.3). Total bacterial population in soil was found significantly higher in T_7 (46.00 x 10^6 cfu $g^{-1}$of soil) over all the treatments except treatment T_3 (45.00 x 10^6 cfu g^{-1} of soil) which was at par CRI stage. The same trend was also found at harvest stage (44.33 x 10^6 cfu g^{-1} of soil).

Table 4.8. Dehydrogenase activity and total bacterial count in soil as influenced by application of fly ash and bagasse ash in soil

Tr. No.	DHA (μg TPF g^{-1} 24 hr^{-1})			Total bacterial count (x 10^6 cfu g^{-1} of soil)		
	Initial	**CRI**	**Harvest**	**Initial**	**CRI**	**Harvest**
T_1	21.84	19.80	19.79	21.67	20.67	20.33
T_2	21.10	21.45	20.72	21.67	24.67	24.33
T_3	20.57	24.47	23.56	21.00	45.00	43.00
T_4	21.77	23.33	23.38	22.33	42.00	41.33
T_5	20.08	21.40	23.11	22.67	29.00	31.67
T_6	20.94	20.04	21.44	21.67	30.33	29.00
T_7	20.66	25.63	25.58	21.67	46.00	44.33
T_8	20.06	24.34	21.77	21.33	41.33	35.00
T_9	20.72	21.07	20.08	21.67	35.00	34.67
T_{10}	21.96	20.06	19.33	22.00	31.67	29.33
S.Em. $\pm$		0.38	0.36		1.03	0.78
CD at 5%		1.15	1.09		3.08	2.33

Total fungal population in soil showed 3.03 x 10^5 cfu g^{-1} of soil at initial stage but significantly showed difrences at CRI and harvest stage. Total fungal population in soil was found significantly higher in T_3 (8.337.67 x 10^5 cfu g^{-1} of soil) over all the treatments except T_7 at CRI stage. At harvest stage, total fungal population in soil was found significantly higher in T_3 (6.33 x 10^5 cfu g^{-1} of soil) over all the treatments except treatment T_4 (5.67 x 10^5 cfu g^{-1} of soil) which was at par.

Total actinomycetes population in soil showed 6.87 x 10^5 cfu g^{-1} of soil at initial stage but significant differences at CRI and harvest stage. Total actinimycetes population in soil was found significantly higher in T_3 (9.33 x 10^5 cfu g^{-1} of soil) over all the treatments except T_5, T_7 and T_8 at CRI stage. Total actinomycetes population in soil at harvest was found significantly higher in T_7 (9.67 x 10^5 cfu g^{-1} of soil) over all the treatments except treatment T_3, T_4 and T_{10} which were at par. These results comborate those obtained by Benbi *et al*. (2017) and Sheoran. (2014).

In general, application of fly ash and bagasse ash did not exert any detrimental effect on population of bacteri, fungi and actinomycetes in soil. Similar results also reported by Gaind and Gaur (2002).

Table 4.9. Total fungi and actinomycetes count in soil as influenced by application of fly ash and bagasse ash in soil

Tr. No.	Fungi (x 10^5 cfu g^{-1} of soil)			Actinomycetes (x 10^5 cfu g^{-1} of soil)		
	Initial	**CRI**	**Harvest**	**Initial**	**CRI**	**Harvest**
T_1	3.00	2.33	1.67	7.00	7.00	6.93
T_2	3.00	4.67	4.33	7.63	7.33	7.50
T_3	3.33	8.33	6.33	7.33	9.33	9.35
T_4	3.00	6.67	5.67	6.67	7.33	8.33
T_5	3.00	4.33	4.67	6.00	8.67	6.33
T_6	2.67	4.67	3.33	6.33	6.33	7.67
T_7	3.33	7.67	3.67	6.67	9.00	9.67
T_8	3.67	5.67	3.67	7.33	9.00	7.67
T_9	2.33	3.33	3.33	6.67	6.33	7.33
T_{10}	3.00	3.67	3.00	7.00	6.33	8.00
S.Em. $\pm$		0.30	0.36		0.66	0.61
CD at 5%		0.90	1.07		1.98	1.81

4.9 Effect of Fly Ash and Bagasse Ash on Total Uptake of Nitrogen, Phosphorous and Potassium by Wheat

The total nitrogen, phosphorous and potassium uptake by wheat as influenced by application of fly ash and bagasse ash are presented in table 4.10 and depicted in fig. 4.4.

The total nitrogen uptake by wheat was found significantly higher in treatment T_7 (178.24 kg ha^{-1}) over all the treatments except T_3 (167.37 kg ha^{-1}) which was at par with T_7. The increase in total uptake of nitrogen by wheat crop may be application of bagasse ash due to increased in K uptake by wheat crop of having synergistic effect of N and K.

Table 4.10. Total nutrient uptake by wheat as influenced by soil application of fly ash and bagasse ash

Tr. No.	Treatment	Total uptake (kg ha^{-1})		
		N	P	K
T_1	Absolute control	90.44	14.06	51.98
T_2	GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)	157.79	21.32	78.73
T_3	GRDF of N + P_2O_5 + 125% K_2O through fly ash	167.37	26.22	108.06
T_4	GRDF of N + P_2O_5 + 100% K_2O through fly ash	157.12	26.04	103.04
T_5	GRDF of N + P_2O_5 + 75% K_2O through fly ash	135.69	22.65	90.73
T_6	GRDF of N + P_2O_5 + 50% K_2O through fly ash	129.56	19.86	85.72
T_7	GRDF of N + P_2O_5 + 125% K_2O through bagasse ash	178.24	36.65	121.64
T_8	GRDF of N + P_2O_5 + 100% K_2O through bagasse ash	165.15	31.02	111.45
T_9	GRDF of N + P_2O_5 + 75% K_2O through bagasse ash	157.06	29.26	104.35
T_{10}	GRDF of N + P_2O_5 + 50% K_2O through bagasse ash	151.57	28.46	106.41
	S.Em. $\pm$	4.37	0.70	2.76
	CD at 5%	12.99	2.08	8.20

The total phosphorous uptake by wheat was found significantly higher in treatment of T_7 (36.65 kg ha^{-1}) over all the treatments.

The total potassium uptake by wheat was found significantly higher in application of higher levels of bagasse ash in treatment T_7 (121.64 kg ha^{-1}) over all the treatments. This might be due to high content of K_2O in bagasse ash. The similar results were also reported by Pita *et al.* (2012).

4.10 Effect of Fly Ash and Bagasse Ash on Total Micronutrient Uptake of DTPA-Fe, Mn, Zn and Cu by Wheat

The micronutrients uptake by wheat crop as influenced by application of fly ash and bagasse ash are presented in table 4.11.

The Fe uptake by wheat was found significantly higher in treatment of T_7 (8702 g ha^{-1}) over all treatments except T_3 (8205 g ha^{-1}) which was at par. The Mn uptake by wheat was found significantly higher in T_7 (1882 g ha^{-1}) over all the treatments except treatment T_3 (1787 g ha^{-1}) which was at par. The Zn uptake by wheat was found significantly higher in T_7 (983 g ha^{-1}) over all the treatments. The Cu uptake by wheat was found significantly higher in T_7 (354 g ha^{-1}) over all the treatments except treatment T_3 (338 g ha^{-1}) which was at par. Increased in total uptake of micronutrients by wheat crop due to application of bagasse ash @ 13.02 q ha^{-1} in soil may be due to increased in grain and stover yield of wheat as well as bagasse ash also itself contain small quantities of micronutrients .The similar results were also reported by Reddy *et al.* (2015).

Table 4.11. Total micronutrient uptake by wheat as influenced by application of fly ash and bagasse ash in soil

Tr. No.	Treatment	Total micronutrient uptake (g ha^{-1})			
		Fe	Mn	Zn	Cu
T_1	Absolute control	5510	1162	514	168
T_2	GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)	6861	1576	778	291
T_3	GRDF of N + P_2O_5 + 125% K_2O through fly ash	8205	1787	892	338
T_4	GRDF of N + P_2O_5 + 100% K_2O through fly ash	7956	1555	749	254
T_5	GRDF of N + P_2O_5 + 75% K_2O through fly ash	7284	1406	685	175
T_6	GRDF of N + P_2O_5 + 50% K_2O through fly ash	7574	1432	714	213
T_7	GRDF of N + P_2O_5 + 125% K_2O through bagasse ash	8702	1882	983	354
T_8	GRDF of N + P_2O_5 + 100% K_2O through bagasse ash	7942	1547	817	325
T_9	GRDF of N + P_2O_5 + 75% K_2O through bagasse ash	7095	1480	833	268
T_{10}	GRDF of N + P_2O_5 + 50% K_2O through bagasse ash	7565	1740	755	204
	S.Em. $\pm$	223.18	41.96	19.43	6.64
	CD at 5%	663.12	124.67	57.75	19.74

4.11 Effect of Fly Ash and Bagasse Ash on Total Chlorophyll Content of Fresh Tissue of Wheat Leaves

Total chlorophyll content in fresh tissues of wheat leaves as influenced by application of fly ash and bagasse ash at 45 and 65 DAS are presented in table 4.12.

Total chlorophyll content in fresh tissue of leaves at 45 DAS was found to be significantly higher in treatment of T_7 (2.07 mg g^{-1}) over all the treatments except T_3 (2.02 mg g^{-1}) which was at par.

Total chlorophyll content of fresh tissue of leaves at 65 DAS was found significantly higher in treatment of T_7 (2.13 mg g^{-1}) over all the treatments except T_3 (2.08 mg g^{-1}) which was at par. Increased in the chlorophyll content in leaves of wheat crop due to application of bagasse ash may be due to small quantity of Mg and Fe present in bagasse ash and also in fly ash. Which reflected the role of Mg and Fe in chlorophyll synthesis in leaves. The results are in conformity with the findings of Sheoran (2014).

Table 4.12. Total chlorophyll content in fresh tissue of wheat leaves as influenced by application of fly and bagasse ash in soil

Tr. No.	Treatment	Total chlorophyll content (mg g^{-1} fresh tissue)	
		45 DAS	65 DAS
T_1	Absolute control	1.52	1.62
T_2	GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)	1.86	1.87
T_3	GRDF of N + P_2O_5 + 125% K_2O through fly ash	2.02	2.08
T_4	GRDF of N + P_2O_5 + 100% K_2O through fly ash	1.93	1.93
T_5	GRDF of N + P_2O_5 + 75% K_2O through fly ash	1.80	1.80
T_6	GRDF of N + P_2O_5 + 50% K_2O through fly ash	1.72	1.79
T_7	GRDF of N + P_2O_5 + 125% K_2O through bagasse ash	2.07	2.13
T_8	GRDF of N + P_2O_5 + 100% K_2O through bagasse ash	1.92	1.95
T_9	GRDF of N + P_2O_5 + 75% K_2O through bagasse ash	1.86	1.84
T_{10}	GRDF of N + P_2O_5 + 50% K_2O through bagasse ash	1.84	1.79
	S.Em. ±	0.02	0.02
	CD at 5%	0.06	0.08

4.12 Effect of Fly Ash and Bagasse Ash on Total Uptake of Heavy Metals by Plant

Total concentration of heavy metals Cd, Co, Cr and Ni in wheat grain and straw were not detected on AAS, hence, uptake was not workout. Sheoran (2014) reported that use of fly ash in agriculture accumulated very low concentration of heavy metal and below the permissible limit provided for human consumption.

4.13 Effect of Fly Ash and Bagasse Ash on Yield of Wheat Crop

The grain and straw yield of wheat as influenced by application of fly ash and bagasse ash are presented in table 4.13. and depicted in fig. 4.5.

The grain yield of wheat was found significantly higher (42.92 q ha^{-1}) in treatment of N and P as per recommended dose and 125 % K_2O kg ha^{-1} through bagasse ash (13.02 q ha^{-1}) over T_1 and T_6. However, treatments T_2, T_3, T_4, T_8, T_9 and T_{10} were at par with T_7 treatments. This indicated that bagasse ash at increasing levels in combination with GRDF can be an alternative source of potassium nutrition to wheat crop.

In respect of fly ash at higher levels also found at par results for increased in grain yield of wheat but it has detrimental effect on soil chemical and physical properties of soil.

Matte and Kene (1995), Selvakumari *et al*. (2000), Murugan and Vijayarangam. (2013) and Yeledhalli *et al*. (2008) were also reported similar increase in yield due to addition of fly as in several crops in acidic and lateritic soils.

Jamil *et al*. (2004) also reported that, the application of bagasse ash @ 2.0 t ha^{-1} was found to be the most appropriate dose for higher yield of wheat in calcareous soil.

The straw yield of wheat was found significantly higher (53.88 q ha^{-1}) in treatment of T_7 (application of N and P_2O_5 as per recommended dose and 125 % K_2O through bagasse ash) over T_1 and T_5 treatments, however, rest of the treatments were at par with T_7.

Table 4.13. Grain and straw yield of wheat as influenced by application of fly ash and bagasse ash in soil

Tr. No.	Treatment	Yield (q ha^{-1})		Agronomic efficiency (kg kg^{-1})
		Grain	Straw	
T_1	Absolute control	27.61	43.03	-
T_2	GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)	40.34	51.87	5.78
T_3	GRDF of N + P_2O_5 + 125% K_2O through fly ash	41.34	50.99	5.96
T_4	GRDF of N + P_2O_5 + 100% K_2O through fly ash	40.66	52.97	5.93
T_5	GRDF of N + P_2O_5 + 75% K_2O through fly ash	38.84	48.71	5.34
T_6	GRDF of N + P_2O_5 + 50% K_2O through fly ash	38.06	49.65	5.22
T_7	GRDF of N + P_2O_5 + 125% K_2O through bagasse ash	42.92	53.88	6.65
T_8	GRDF of N + P_2O_5 + 100% K_2O through bagasse ash	41.88	52.51	6.48
T_9	GRDF of N + P_2O_5 + 75% K_2O through bagasse ash	41.40	49.39	6.56
T_{10}	GRDF of N + P_2O_5 + 50% K_2O through bagasse ash	40.28	51.65	6.33
	S.Em. ±	1.46	1.67	
	CD at 5%	4.34	4.99	

4.14 Effect of Fly Ash and Bagasse Ash on Agronomic Efficiency

The agronomic efficiency is also one of the criteria for assessing the nutrient use efficiency which are reported in table 4.13. Which revealed that, the highest agronomic efficiency 6.65 kg kg^{-1} was obsereved in treatment of application of 125 % K_2O through bagasse ash followed by 75 % K_2O through bagasse ash (6.56 kg kg^{-1}). Application of higher levels of bagasse ash treatments were found increase in the agronomic efficiency as compared to GRDF and fly ash treatments.

4.15 Effect of Fly Ash and Bagasse Ash on Quality of Wheat Crop

The test weight, crude protein and gluten content in wheat grain as influenced by application of fly ash and bagasse ash are presented in table 4.14. and depicted in fig. 4.6.

The test weight of wheat grain was found significantly higher in treatment of T_7 (45.98 g/1000 grain) over all the treatments except T_3, T_8 and T_9 treatments which are at par.Total crude protein and gluten content in wheat grain was found non significant differences in all the treatments.

These results are in confirmity with findings of Jamil *et al*. (2004) and Khan (2011).

Table 4.14. Quality of wheat as influenced by application of fly and bagasse ash in soil

Tr. No.	Treatment	Quality parameters of wheat grain		
		Test weight (g/1000 grain)	Crude protein (%)	Gluten content (%)
T_1	Absolute control	43.29	11.96	7.03
T_2	GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)	43.70	12.22	7.11
T_3	GRDF of N + P_2O_5 + 125% K_2O through fly ash	45.93	12.13	7.11
T_4	GRDF of N + P_2O_5 + 100% K_2O through fly ash	44.93	12.04	7.03
T_5	GRDF of N + P_2O_5 + 75% K_2O through fly ash	44.58	12.03	7.07
T_6	GRDF of N + P_2O_5 + 50% K_2O through fly ash	44.32	12.00	7.06
T_7	GRDF of N + P_2O_5 + 125% K_2O through bagasse ash	45.98	12.23	7.14
T_8	GRDF of N + P_2O_5 + 100% K_2O through bagasse ash	45.92	12.15	7.12
T_9	GRDF of N + P_2O_5 + 75% K_2O through bagasse ash	45.35	12.20	7.13
T_{10}	GRDF of N + P_2O_5 + 50% K_2O through bagasse ash	44.78	12.17	7.13
	S.Em. $\pm$	0.33	0.14	0.05
	CD at 5%	0.98	NS	NS

4.16 Economics of Wheat as Influenced by of Fly Ash and Bagasse Ash in Soil

Economics of wheat as influenced by application of fly ash and bagasse ash in soil are reported in table 4.15. The cost of cultivation was found higher in treatment of T_6 and T_{10} (Rs.48816 /-), however it was lowest in control treatment (Rs.31188/-). The gross monetary return was recorded highest in treatment of T_7 (Rs. 89639/-) followed by treatment T_8 (Rs.87455/-). The net monetary return was recorded highest in T_7 treatment (Rs. 41406/-), however, it was recorded lowest in control treatment (Rs. 28066/-). The B:C ratio was recorded the highest in treatment of control treatment (1.90) followed by treatment of T_7 and T_8 (1.86 and 1.81, respectively) .

Table 4.15. Economics of wheat as influenced by application of fly ash and bagasse ash in soil

Tr. No.	Treatment	Cost of cultivation	Gross monetary returns	Net monetary returns	Benefit : Cost ratio
		------------ Rs.ha^{-1} ------------			
T_1	Absolute control	31188	59254	28066	1.90
T_2	GRDF (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM)	48454	84485	36031	1.74
T_3	GRDF of N + P_2O_5 + 125% K_2O through fly ash	48233	86166	37933	1.79
T_4	GRDF of N + P_2O_5 + 100% K_2O through fly ash	48427	85285	36858	1.76
T_5	GRDF of N + P_2O_5 + 75% K_2O through fly ash	48622	81108	32486	1.67
T_6	GRDF of N + P_2O_5 + 50% K_2O through fly ash	48816	79844	31028	1.64
T_7	GRDF of N + P_2O_5 + 125% K_2O through bagasse ash	48233	89639	41406	1.86
T_8	GRDF of N + P_2O_5 + 100% K_2O through bagasse ash	48427	87455	39028	1.81
T_9	GRDF of N + P_2O_5 + 75% K_2O through bagasse ash	48622	85974	37352	1.77
T_{10}	GRDF of N + P_2O_5 + 50% K_2O through bagasse ash	48816	84332	35516	1.73

Note : Rs.13.04 kg^{-1} N, Rs.48.75 kg^{-1} P_2O_5, Rs 19.43 kg^{-1} K_2O, Rs.1200 t^{-1} FYM, Rs. 1850 q^{-1} grain, Rs 190 q^{-1} straw, Transport cost of Rs.750/50 km for fly and bagasse ash.

5. SUMMARY AND CONCLUSION

The present investigation was carried out to study the “Effect of fly ash and bagasse ash on soil properties, yield and quality of wheat in an Inceptisol” conducted at Post Graduate Research Farm, Department of Soil Science and Agril. Chemistry, M.P.K.V. Rahuri during R*abi* 2016-17.

The experimental soil was belongs to masala soil series, order Inceptisol (*Vertic Haplustept).* Soil was moderately alkaline in reaction, low in available nitrogen, moderate in available phosphorus and high in available potassium. The soil was deficient in Fe and Zn and sufficient in Mn and Cu.

The results obtained and reported from the present investigation are summarized as follows :

5.1 Chatracterisation of Fly Ash and Bagasse Ash

The colour of fly ash and bagasse ash was ash white and ash black, high in bulk density 1.83 and 1.80 Mg m^{-3}, respectively and non swelling characteristics. Hydraulic conductivity of fly ash showed 0.26 cm h^{-1}, however, bagasse ash showed 0.64 cm h^{-1}. Both the ashes showed very strongly alkaline pH (9.42 and 9.27, respectively) and low in EC (0.47 dS m^{-1}) of fly ash but high in EC (2.50 dS m^{-1}) of bagasse ash. Fly ash and bagasse ash contain 0.60 and 3.84 per cent K_2O, respectively however, very less amount of micronutrients and heavy metals were found in both the ashes.

5.2 Effect of Fly Ash and Bagasse Ash on Physical Properties of Soil at Different Stages of Crop Growth

The bulk density at CRI stage ,showed non significant differences, however at harvest, it significantly increased (1.36 Mg m^{-3}) in treatment of T_3 (GRDF of N & P_2O_5 + 125 % K_2O through fly ash). The hydraulic conductivity of soil significantly decresed due to application of various levels of fly ash in soil.The higher levels of application of bagasse ash significantly increased the hydraulic conductivity of soil at crown root initiation and harvest stage (0.68 and 0,67 cm h^{-1}, respectively).

COLE value of soil showed swell-shrink characteristics of soil and it was significantly higher in treatment of application of fly ash as compared to bagasse ash application treatment.

5.3 Effect of Fly Ash and Bagasse Ash on Chemical Properties of Soil at Different Stages of Crop Growth

Application of various levels of fly ash and bagasse ash significantly increased the pH and EC of soil at crown root initiation stage and at harvest stage. The organic carbon content in soil as influenced by application of fly ash and bagasse ash showed non significant results at all the growth stages of wheat crop.

5.4 Effect of Fly Ash and Bagasse Ash on Soil Available Nitrogen, Phosphorous and Potassium at Different Stages of Crop Growth

Available nitrogen content in soil showed non significant results at crown root initiation and harvest stage. The available phosphorous content in soil was found significantly higher in treatment of application of 100 % K_2O through bagasse ash (24.71 kg ha^{-1}) at crown root initiation stage. At harvest stage, available phosphorous content in soil was found significantly higher in treatment of 125 % K_2O through bagasse ash ($T_{7,}$18.66 kg ha^{-1}). The available potassium in soil was found significantly higher in treatment of T_7 (532 kg ha^{-1}) at CRI stage and at harvest stage (490 kg ha^{-1}).

5.5 Effect of Fly Ash and Bagasse Ash on Soil Available DTPA-Fe, Mn, Zn and Cu at Different Stages of Crop Growth

The DTPA-Fe content in soil was significantly higher (4.31 and 3.80 mg kg^{-1}) at CRI stage and harvest stage, respectively due to 125 per cent and 100 per cent K_2O applied through bagasse ash, respectively. However the DTPA-Mn, Zn and Cu content in soil were significantly higher in (14.98, 0.68 and 0.76 mg kg^{-1} , respectively) at crown root initiation and (13.88 and 0.51 and 0.66 mg kg^{-1} , respectively) at harvest stage due to soil application of 125 % K_2O through bagasse ash along with the recommended dose of N and P_2O_5 + FYM @ 10 t ha^{-1}.

5.6 Effect of Fly Ash and Bagasse Ash on Heavy Metals in Soil at Different Stages of Crop Growth

The heavy metals contents in soils were not detected in AAS, indicating their presence in very trace amounts and not influenced due to one time application of fly ash and bagasse ash in soil.

5.7 Effect of Fly Ash and Bagasse Ash on DHA, Total Bacterial, Total Fungal and Total Actinomycetes Population in Soil at Different Stages of Crop Growth

The DHA in soil was significantly higher due to bagasse ash treatment ($T_{7,}$ 25.63 and 25.58 µg TPF g^{-1} 24 hr^{-1}) at CRI and harvest stage,respectively . Total bacterial population in soil was significantly higher in ($T_{7,}$ 46.00 x 10^6 cfu $g^{-1}$of soil) at crown root initiation stage. The same trend was also found at harvest stage.

Total fungal population in soil was significantly higher in ($T_{3,}$ 8.33 and 6.33 x 10^5 cfu g^{-1} of soil) at crown root initiation and harvest stage, respectively.

Total fungal population in soil was found significantly higher in ($T_{3,}$ 6.33 x 10^5 cfu g^{-1} of soil) at harvest stage. Total actinimycetes population in soil was found significantly higher in ($T_{3,}$ 9.33 x 10^5 cfu g^{-1} of soil) at crown root initiation stage. However, it was found significantly higher in ($T_{7,}$ 9.67 x 10^5 cfu g^{-1} of soil) at harvest stage.

5.8 Effect of Fly Ash and Bagasse Ash on Total Uptake of Nitrogen, Phosphorous and Potassium by Plant

Total nitrogen, phosphorous and potassium uptake by wheat crop was significantly increased (178.24, 36.65 and 121.64 kg ha^{-1}, respectively) due to application of 125 % K_2O through bagasse ash with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM.

5.9 Effect of Fly Ash and Bagasse Ash on Total Uptake of DTPA-Fe, Mn, Zn and Cu by Plant

Total uptake of Fe, Mn, Zn and Cu by wheat crop was found significantly higher (8702, 1882, 983 and 354 g ha^{-1}, respectively) in treatment of application of 125 % K_2O through bagasse ash along with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM.

5.10 Effect of Fly Ash and Bagasse Ash on Total Chlorophyll Content of Fresh Tissue of Plant

Total chlorophyll content in leaves at 45 and 65 DAS were found significantly higher (2.07 and 2.13 mg g^{-1}, respectively) in treatment of application of 125 % K_2O through bagasse ash along with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM.

5.11 Effect of Fly Ash and Bagasse Ash on Yield of Wheat Crop

The grain and straw yield of wheat was significantly higher (42.92 and 53.88 q ha^{-1}) in treatment of application of 125 % K_2O through bagasse ash along with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM. However, this treatment was at par with the application of fly ash, bagasse ash and GRDF treatment.

5.12 Effect of Fly Ash and Bagasse Ash on Quality of Wheat

The test weight of wheat grain was found significantly higher in treatment of 125 % K_2O through bagasse ash along with recommended dose of N and P_2O_5 through chemical fertilizer + 10 t ha^{-1} FYM of ($T_{7,}$ 45.98 g/1000 grain) over all the treatments. Total crude protein and total gluten content in wheat grain showed non significant differences in all the treatments.

5.13 Effect of Fly Ash and Bagasse Ash on Economics of Wheat

The higher net monetary returns (Rs. 41406/- and Rs. 39028/-) were recorded in treatments of bagasse ash @ 13.02 and 10.41 q ha^{-1} in soil for the supplementation of 125 and 100 % K_2O through bagasse ash, respectively. The similar treatments showed the higher benefit:cost ratio of 1.86 and 1.81, respectively.

5.14 Conclusion

The application of 125 % K_2O (50 kg ha^{-1} K_2O) through bagasse ash @ 13.02 q ha^{-1} along with recommended dose of N (120 kg ha^{-1}) and P_2O_5 (60 kg ha^{-1}) through chemical fertilizer + 10 t ha^{-1} FYM to wheat crop at the time of sowing was found beneficial for increase in nutrient uptake, improvement in biological properties of soil, higher net monetary returns , B:C ratio (1.86) and yield of wheat grown in an Inceptisols. This study revealed that , bagasse ash can be an alternative source of potassium which will save the foreign exchange on K fertilizers in future.

- **Future Scope**

Present study results were based on one year experiment which has not reflected on accumulation of heavy metals in soil and found no significant change in yield of wheat. It is necessary to verify the long term application of fly ash and bagasse ash on soil physical and chemical and biological properties and also yield of various crop on medium to deep black soils of Maharashtra.

6. LITERATURE CITED

Adriano, D.C. and Weber, J.T. (2001). Influence of fly ash on soil physical properties and turfgrass establishment. *Journal of Environment and Quality* **30**,596-601.

Anguissola, S., Silva, S. and Botteschi, G. (1999) Effect of fly ash on the availability of Zn, Cu, Ni and Cd to chicory. *Agriculture Ecosystems and Environment* **72**,159–163.

Anonymous (2013). Indian Fertilizer Scenario. Departement of fertilizer ministry of chemical and fertilizers, Govt. of India.

Anonymous (2015) Annual report (2015-16). Ministry of Agriculture and farmers' welfare, Government of India pp.1-2.

A.O.A.C. (2016) Official Methods of Analysis of Association of Official Analytical Chemists,Inernational Washington, D.C. 20th Edition.

Arivazhgan, K., Ravichandran, M., Dubey, S.K., Mathur, V.K., Khandekar, R.K., Yagnanarayan, K., Kamal Pasha, M.M., Sinha, A.K., Sarangi, B.D., Tripathi, V.K.M., Gupta, S.K., Singh, R., Mushtaq, A., Thakur, A.S. and Narayan, R. (2011) Effect of coal fly ash on agricultural crops: showcase project on use of fly ash in and around thermal power station areas of National Thermal Power Corporation Ltd., India. *World of coal ash (WOCA) conference* May pp. 9-12, http:/ www.flyash.info.

Arnon, D.I. (1949). Copper enzymes in isolated chloroplast, polyphenoxydase in *beta vulgaris*. *Plant Physiology* **24**,1-15.

Bakri Al Mustafa, A.M., Kamarudin, H., Bahussain, M., Nizar, K., Ratiza, A.R. and Zariya, Y. (2012) The processing, characterization and properties of fly ash. *Reviews on Advanced Materials and Science* **30**, 90-97.

Bangar, S.S., Phalke, S.N., Gawade, A.Y., Tambe, R.S. and Rahane, A.B. (2017) A review paper on replacement of cement with bagasse ash. *International Journal of Engineering Sciences and Management* **7**, 127-130.

Basu, M., Pande, M., Bhadoria, P.B.S. and Mahapatra, S.C. (2009) Potential fly ash utilization in agriculture: a global review. *Progress in Natural Science* **19**, 1173-1186.

Baque, A., Krim, A., Rahim, A. and Tetsushi, H. (2006) Effect of fertilizer potassium on growth, yield nutrient uptake of wheat (*T. astivum*) under water stress condition. *South Pacific Studies* **27**, 25-35.

Benbi, D.K.,Thind, H.S., Sharma, S., Brar, K. and Toor, A.S. (2017) Bagasse ash application stimulates agricultural soil carbon sequestration without inhibiting soil enzyme activity. *Communications in Soil Science and Plant Analysis* **8**,1532-2416.

Bhushan, G., Kumar, S., Sharma, S.K. and Dwivedi, S. (2016) Impact of bagasse ash amended soil on growth and yield of *Pisum sativum*. *Research Journal of Pharmaceutical, Biological and Chemical Sciences* **7**, 448-454.

Blake, G.R. and Hartage, K.H. (1986) Bulk density: In methods of soil analysis, part-I, Klute, A. (Ed.) II edition, American Society of Agronomy, Inc. and Soil Science Society of America Inc., Madison, USA. pp. 371-373.

Carlson, C.L. and Adriano, D.C. (1993) Environmental impacts of coal combustion on residues. *Journal of Environment Quality* **22**, 227–247.

Casida, L.E., Klein, D. and Santora, R. (1964) Soil dehydrogenase activity. *Soil Science* **98**, 371-378.

Chapman, H.D. and Pratt, P.F. (1961) Methods of analysis for soil, plant and water. Division of Agricultural Science, California University, USA 309.

Davis, R.E., Carlson, R.W., Kelley, J.W. and Davis, H.E. (1937) Propertis of cements and concretes containing fly ash. *Journal of the American Concrete Institute* **33**, 577-612.

Dhengare, S.W., Raut, S.P., Bandwal, N.V. and Khangan, A. (2015) Investigation into utilization of sugarcane bagasse ash as supplementary cementitious material in concrete. *International Journal of Emerging Engineering Research and Technology* **3**, 109-116.

Dhodase, S., Kulkarni, P. and Bhagia, L.S. (2008) Fly ash characterization, utilization and government initiatives in India: A review. *Journal of Scientific and Industrial Research* **67,** 11-18.

Dotaniya, M.L., Datta, S., Biswas, D.R., Dotaniya, C.K., Meena, B.L., Rajendiran, S., Regar, K.L. and Manju, L. (2016) Use of sugarcane industrial by-products for improving sugarcane productivity and soil health. *International Journal of Recycling of Organic Waste in Agricultulture* **5**, 185–194.

Fulekar, M.H., and Dave, J.M. (1986) Disposal of fly ash - an environmental problem. *International Journal of Environmental Studies* **26**, 191-215

Gaind, S. and Gaur, A.C. (2002) Impact of fly ash and phosphate solubilising bacteria on soybean productivity. *Bioresource Technology* **85**, 313–315.

Garg, R.N., Pathak, H., Das, D.K. and Tomar, R.K. (2005) Use of fly ash and biogas slurry for improving wheat yield and physical properties of soil. *Environmental Monitoring and Assessment* **107**, 1–9.

Hailu, B. and Dinky, A. (2012) Application of sugarcane bagasse ash as a partial cement replacement material. *Journal of European Economic Association* **29**, 1-5.

Halvorsun, H.O. and Ziegler, N.R. (1993) Application of statistics to problems in bacteriology. I. A. means of determining bacterial population by the dilution method. *Journal of Bacteriology* **25**, 101-121.

Inthasan, J., Hirunburana, N., Hermann, L. and Stahr, K. (2002) Effect of fly ash application on soil properties, nutrient status and environment in Northen Thailand. *World Congress of Soil Science* **17**, 14-21.

Jackson, M.L. (1973) Soil Chemical Analysis. Prentice Hall Pvt. Ltd., New Delhi. pp.69-182.

Jamil, M., Qasim, M., Umar, M. and Abdus, S. (2004) Impact of organic wastes (bagasse ash) on the yield of wheat (*Triticum aestivum* L.) in a calcareous soil. *International Journal of Agriculture and Biology* **6,** 468-470.

Khan, J.M. (2011) Impact of selected doses of organic wastes on physico-chemical characteristics of the soil and yield of wheat. *International Conference on Environmental Engineering and Applications* **17**, 271-275.

Kinekar, B.K. (2011) Potassium fertilizer situation in India : Current use and perspectives. *Karnataka Journal of Agricultural Science* **24**, 1-6.

Kishor, P., Ghosh, A.K. and Kumar, A.K. (2010) Uses of fly ash in agriculture : a way to improve soil fertility and productivity. *Asian Journal of Agriculture Research* **4**, 1-14.

Klute, A. and Dirksen, C. (1986) Hydraulic conductivity and diffusivity. Laboratory method. In methods of soil analysis Part-I Ed. Klute, A. Agronomy Monograp **9**, 687-732.

Kumar, S.S., Kumar, S.B., Ali, N.A., Vijay, S. and Raj, S.P. (2017) Experimental testing on concrete by partial replacement of cement using bagasse ash. *International Conference on Emerging Trend in Engineering Science and Sustainable Technology* pp. 13-16.

Kunavankrit, W. (1993). General properties of lignite fly ash, *In Conference on the Potensial of lignite Fly Ash Utilization*.EGTA, Thailand, pp. 2-15.

Lee, H., Sung, H.B., Lee, C.H., Lee, Y.B. and Kim, P.J. (2006) Fly ash effect on improving soil properties and rice productivity in Korean paddy soils. *Bioresource Technology* **97**, 1490–1497.

Lim, C.H. and Jackson, M.L. (1982) Dissolution for total elemental analysis. In methods of soil analysis, Part-2, chemical and microbiological properties. Page, A.L. (Ed), II, American Society of Agronomy, Inc. and Soil Science Society of America, Madison, Wisconsin, USA.

Lindsay, W.L. and Norvell, W.L. (1978) Development of DTPA soil test for Zn, Fe, Mn and Cu. *Soil Science Society of American Journal* **42**, 421-428.

Mala, P. (2013) Fertilizer scenario in India. *International Journal of Social Science and Interdisciplinary Research* **2**, 62-72.

Matte, D.B. and Kene, D.R. (1995) In proceddings of National Seminar on Use of lignite fly ash in agriculture, Annamalinagar pp. 44-48.

Mishra, S., Prasad, S.V.K. and Kanungo, V.K. (2017) Impact of coal fly ash as soil amendment on physico-chemical properties of soil. *Indian Journal of Scientific Research* **13**, 15-20.

Moliner, A.M. and Street, J.J. (1982) Effect of fly ash and lime on growth and composition of corn on acid sandy soil *Crop Science Society* **41**, 217.

Murugan, S. and Vijayarangam, M. (2013) Effect of fly ash in agricultural field on soil properties and crop productivity - a review. *International Journal of Engineering Research and Technology* **2**, 54-60.

Nelson, D.W. and Sommer, L.E. (1982) Total carbon, organic carbon and organic matter. In : Methods of soil Analysis, Part-II, Page, A.L. (Ed.), American Society of Agronomy Inc. Soil Science Society of America Inc. Madison, Wisconsin, USA. pp. 539-579.

Page, A.L., Elseewi, A.A., and Straughan, I.R.(1979). Physical and chemical properties of fly ash from coal fired power plant with special reffrence to environmental impact. *Residue Review* **71**, 83-120.

Pande, V.C. and Singh, N. (2010) Impact of fly ash incorporation in soil systeme, *Agriculture, Ecosysteme and Environment* **136**, 16-27

Panse, V.A. and Sukhatme, P.V. (1985) Stastical methods for agricultural workers, Revised Edn. ICAR, New Delhi.

Paul, B.B. (1982) By- product industry based on distillery waste. *Maharashtra Sugars* **7**, 55.

Pita, V., Vasconcelos, E., Cabral, F. and Ribeiro, H.M. (2012) Effect of ash from sugarcane bagasse and wood co-combustion on corn growth and soil properties. *Archives of Agronomy and Soil Science* pp.1476-3567.

Prajapati, K. and Modi, H.A. (2012) The importance of potassium in plant growth : A review. *Indian Journal of Plant Sciences* **1**, 177-186.

Ramezanianpour, A.A. (2014) Cement replacement materials. *Springer Geochemistry/ Mineralogy* **2**, 1-5.

Ratanasthein, B., Fyfe, W.S. and Mclntyre, N.S. (1996). Elemental separation in lignite fly ash burning in maemoh power plant. Unpublished data. Chaing Mai, Thailand.

Raymohapatra, H. (2015) Effect of agricultural solid waste bagasse ash on the properties of expansive soil, Thesis- Bachelor of Technology, National Institute of Technology Rourkela. pp.12-20.

Reddy, M.V.S., Ashalatha, K., Madhuri, M. and Sumalatha, P. (2015) Utilization of sugarcane bagasse ash (scba) in concrete by partial replacement of cement. *Journal of Mechanical and Civil Engineering* **12**, 12-16.

Salahudeen, A.B., and Ochepo,J. (2015) Effect of bagasse ash on some engineering properties of lateritic soil *Jordan Journal of Civil Engineering* 9, 468-474.

Schafer, W.M. and Singer, M.J. (1976) Influence of physical and mineralogical properties on swelling of soils in Yolo Country, California. *Soil Science Society of America Journal* **40**, 557-562.

Selvakumari, G., Bhakar, M., Jayanthi, D. and Mathan, K.K. (2000) Effect of integration of fly ash and fertilizers and organic manure on nutrient availability, yield and nutrient uptake of rice on Alfisols. *Journal of the Indian Society of Soil Science* **48**, 268-278.

Sharma, I. and Rajwar, G.S. (2016) Effect of bagasse and mixed biochar on growth and productivity of *Glycine max* (L) Merril ISSN Print: 2394-7500. *International Journal of Agricultural Research* **2**, 220-225.

Sharma, S.K. and Kalra, N. (2006) Effect of fly ash incorporation on soil properties and productivity of crops: A review. *Journal of Scientific and Industrial Research* **65,** 383-390.

Sheoran, H.S. (2014) Effect of fly ash application on soil properties : A review. *Journal of Agroecology and Natural Resource Management* **1**, 98-103.

Singh, K. and Kaushik, A.(2017) Impact of fly ash and press mud amendment on properties and heavy metal concentration of an alkali soil and their impact on plant growth. *International Journal of Engineering Sciences and Research Technology* pp. 42-45.

Slims S.H.(1993) Impact of fly ash on soil physico-chemical properties. *Journal of Environment* **31**, 564-571.

Subbiah, B.V. and Asija, G.L. (1956) A rapid procedure for the estimation of available nitrogen in Soils. *Current Science* **25**, 259-260.

Surabhi (2017) Fly ash in India: generation vis-à-vis utilization and global perspective. *International Journal of Applied Chemistry* **13,** 29-52.

Tejasvi, A. and Kumar, S. (2012) Impact of fly ash on soil properties. *National Academy of Science and Letters* **35**, 13–16.

Upadhyay, A. and Kamal, M. (2007) Characterization and utilization of fly ash. Department of mining engineering. *National Institute of Technology Rourkela* pp. 9-14.

Watanabe, F.S. and Olsen, S.R. (1965) Test of ascorbic acid methods for phosphorus in water and sodium bicarbonate extract of soil. *Proceedings of Soil Science of America* **21**, 677-678.

Yeledhalli, N.A., Prakash, S.S., Ravi, M.V. and Narayanrao, K. (2008) Long term effect of fly ash on crop yield and soil properties. *Karnataka Journal of Agricultural Science* **21**, 507-512.

Zososki, R.J. and Burau, R.G. (1977) A rapid nitric perchloric acid digestion method for multi element tissue analysis. *Communication in Soil Sciences and Plant Analysis* **8**, 425-436.

7. VITAE

MR. DURGUDE SHUBHAM ANIL
MASTER OF SCIENCE (AGRICULTURE)
in
SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

2018

Title of thesis		:	Effect of fly ash and bagasse ash on soil properties, yield and quality of wheat in an Inceptisol
Major field		:	Soil Science and Agricultural Chemistry
Biographical Information		:	
Personal	**Date of Birth**	:	06 January, 1995
	Place of Birth	:	Ashwi, Tal. Sangamner, Dist. Ahmednagar
	Father's Name	:	Shri. Anil Gangadhar Durgude
	Mother's Name	:	Sau. Anita Anil Durgude
Education	**Bachlor Degree Obtained**	:	B.Sc. (Agri.)
	Class	:	First class (84.47)
	Name of University	:	Mahatma Phule Krishi Vidyapith, Rahuri
Address		:	A/p. Central Campus, MPKV Rahuri, Tal. Rahuri, Dist. Ahmednagar
	Email ID	:	sdurgude0038@gmail.com
	Contact number	:	9420007732