



ORIGINAL ARTICLE

Impact of Bagasse Ash Amended Soil on Growth and Yield of *Vignamungo*

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ABSTRACT

Bagasse ash is a combustion residue of sugarcane has been regarded as a problematic solid waste all over the world. Disposal of high amount of bagasse ash from sugar industries absorbs huge amount of water, energy, and land area by ash ponds. Therefore, Bagasse ash management would remain a great concern of the century. However, several studies proposed that bagasse ash can be used as a soil ameliorate that may improve physical, chemical and biological properties of the degraded soil and is a source of readily available plant micro-and macro-nutrients. Practical value of bagasse ash in agriculture as an eco-friendly and economical fertilizer or soil amendments can be establishment after repeated field experiment for each type of soil to confirm its quality and safety. To the current research work achieve the aim, sugar industry boiler ash was applied to *Cicerarietinum* crop in pots having 2 kg soil @ 10%, 20%, 30%, 40%, 60%, 80% and 100% respectively, compared to the control. The soil nature under the investigation was having a high pH (8.3), low in organic matter (8800 mg kg⁻¹), and deficient in N (150 mg kg⁻¹), P (48 mg kg⁻¹), Zn (41 mg kg⁻¹) and Fe (38 mg kg⁻¹). Bagasse ash was rich in micronutrients like Fe, Mn, Zn and Cu and also contained sufficient amount of K and P. Consequently, total porosity of soil, available P, K, Fe, Mn, Zn and Cu content in soil, increased with the levels of bagasse ash application. On the other hand, dry bulk density declined which is a positive effect. ECe and pH of the soil was minutely increased. Yields and most of the yield components of *Vignamungo* crop in pots also increased due to bagasse ash application. It is recommended that application of bagasse ash 20-40%, 40-60% will result in enhanced yield of *Vignamungo* crop soil.

Key words: bagasse ash, soil nutrients, soil characteristics, *Vignamungo* crop.

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INTRODUCTION

Black gram, *Vignamungo* (L.) Hepper is the important leguminous crop of India next to Pigeon pea (Ashwini, *et al.*, 2014). *Vignamungo* is very nutritious as it contains high levels of protein, potassium, calcium, iron, niacin, Thiamine and riboflavin (Post Harvest Profile of Black Gram, 2006). Black gram complements the essential amino acids provided in most cereals and plays an important role in the diets of the people of Nepal and India (Mungo beans, mature seeds, raw). Black gram has been shown to be useful in mitigating elevated cholesterol levels (Menon and Kurup, 1976; Indira and Kurup 2013). The medicinal value of *vignamungo* has to reduce high blood pressure, Anti inflammatory properties, strengthens nervous system, proper functioning of digestive system, increases sperm count and sperm motility erectile dysfunction (impotence) and premature ejaculation, effective in dysmenorrhea and primary amenorrhea. It increases milk secretion in lactating mothers (ayurhelp.com). Sugarcane crop is grown worldwide for producing sugar, ethanol and many more. Bagasse is produced as a waste material

after extracting juice in sugar industry. It is usually used as a fuel for boilers in the sugar mills and alcohol factories which produce high amounts of ash annually. With increasing cost of natural gas, electricity and fuel oil, dried bagasse with high calorific value has been used as the principal fuel in sugar factory boilers to produce heat and in cogeneration plants to produce electric power (Mulay, *et al.*, 2017). Sugarcane Bagasse Ash (SCBA) is usually obtained under uncontrolled burning conditions in boilers, thus the ash may contain black particles due to the presence of carbon and crystalline silica when burning occurs under high temperature (above 800 °C) or for a prolonged time. The quality of the ash can be improved by controlling parameters such as temperature, rate of heating. When the bagasse is burnt under controlled conditions it may produce ash with high amorphous silica, which has the pozzolanic properties (Frias, *et al.*, 2011). Study of using SCBA as a pozzolanic material is not well known and its uses are limited and most of SCBA is disposed in the landfills and “only a few studies have been reported on the use of SCBA as a pozzolanic material in respect of the cement medium” (Bahurudeen, *et al.*, 2014; Rukzon and Chindaprasirt 2012). At present chemical fertilizers are used by farmers to increase crop yield, but also degrading soil quality (physically, chemically and biologically). Bagasse ash use in agriculture as organic fertilizer for crop production is now-a-days becoming an established practice. Bagasse ash is one of the important organic wastes capable of supplying sufficient amount of plant nutrients such as Mg, S, P, K, Mn, Zn, and Cu to soil (Anguissola, *et al.*, 1999; Carlson and Adriano 1993; Manivannan 2014; Page, *et al.*, 1982). When applied to fields as an organic amendment, its favorable effects on soil water holding capacity and aeration is also proven. (Singh *et al.*, 2002) has reported improved water use efficiency in soil and higher yield of wheat crop amended by fly ash. Therefore, its use in agriculture for crop production will be proved more beneficial. Along with positive effect on soil nutrient contents, bagasse ash also has produced increased yield of wheat crop (Mlynkowiak, *et al.*, 2001) and sugar cane. There are presently nearly 500 sugar factories in the country alone with around 300 molasses based alcohol distilleries. Today, world face a serious problem in disposing the large quantity of agriculture waste. The disposing of agricultural waste without proper attention creates impact on environmental health. It disturbs ecosystem, causes air pollution water pollution etc. The scientists have to take challenge for safe disposal of agricultural waste. Such huge amount of bagasse ash always created disposal problems for the sugar mills owners, municipal administration and environmental organizations. Keeping in view the importance of this organic waste and its positive effects on the yield of cereal, Legume and mustard crops (Kumar, *et al.*, 1999; Sharma, *et al.*, 2001) its proper doses shall be enquired thoroughly. Therefore, the present research work was planned to investigate about the chemical composition of bagasse ash, to elucidate the effects of different rates of bagasse ash on *Cicerarietinum* crop in soil and to recommend its most appropriate dose for higher yield of *Cicerarietinum* crop.

MATERIALS AND METHODS

Material Collection and Experimental Set-up:

A pot culture experiment was conducted at the research area of the Department of Environmental Science, Bareilly College, Bareilly during winter season 2015-2016. Bulk soil samples from 0-30 cm depth were collected, air dried, ground and passed through a 2mm sieve. Bagasse ash was collected from the dumping site of Roza Sugar Mills Shahjahanpur; Variable concentration of bagasse ash and clay soil were prepared by mixing the two in different ratio @ T1-10%, T2-20%, T3-40%, T4-60%, T5- 80%, T6-100%. C was kept as control. Ten seeds pot-1of *Cicerarietinum*were sown in each pot. The experiment was laid out in a randomized complete design and each treatment was replicated four times. The crop was irrigated at appropriate times and weeds were controlled manually. After germination, thinning was done and only three plants were left

in each pot. The recorded data were plant height, number of leaves plant-1, number of flowers plants-1, number of pods plants-1, dry weight of root, shoot, leaves and pods plant-1.

Soil and Bagasse Ash Sampling and Analysis:

Bulk soil samples from 0-30 cm depth were collected before sowing. The samples were air dried ground and passed through a 2mm sieve. Bagasse ash samples were also air dried and passed through a 4mm sieve. Also after harvest of the crop, soil samples from the plots of field experiment were collected, air dried and passed through a 2mm sieve. All of the soil samples before sowing and after harvesting, and the bagasse ash samples, were analyzed for various physico-chemical characteristics. Particle size in soil samples was analyzed by a hydrometer method as described by Day (Day 1965). $Ca^{++} + Mg^{++}$ were determined by EDTA titration where NH_4Cl-NH_4OH buffer solution and eriochrome black T indicator was used (Richard 1954). Organic matter content in the soil and bagasse ash samples was determined by dichromate method recommended by MAFF (Maff. 1986). Total N was determined by the Kjeldahl procedure (Jackson 1964). Available K was determined by ammonium acetate method (Lennox 1979). P was estimated by formation of a phosphomolybdate complex, which is reduced by using ascorbic acid to produce a blue color (Lindsay and Norvell 1978). Zn, Cu, Fe and Mn determination was made in 0.005 M DTPA extractant (Arnon 1949) by atomic absorption spectrophotometer.

Morphological Parameters:

The plants were harvested and washed carefully to remove the dust particles adhering to the surface. Root hairs were wiped carefully to prevent breakage. They were then blotted with a blotting paper. Root and shoot length and number of leaves were counted thrice at a month's interval each. Dry matter weight was taken after partitioning the plant into leaf, stem and roots followed by drying at 40°C for two hours and then at 85°C for 24 hours.

Biochemical assay:

Chlorophyll content of plant leaves was estimated by Arnon's method using 80% acetone for preparing leaf extract. This was followed by centrifugation and measurement of the optical density of the clear supernatant (Lowry, *et al.*, 1959). Protein content was assayed by Lowery method as modified by Herbert, *et al.*, 10% Trichloroacetic acid was used to prepare leaf extract followed by centrifugation after which the pellet was mixed with 1N NaOH followed by heating. This solution was further centrifuged and 0.5ml of the supernatant was mixed with 5ml of reaction mixture and allowed to stand for 15min. 0.5ml of folin's reagent was added to get a blue colored solution. The absorbance was read at 650nm (Herbert, *et al.*, 2071; Deshmukh, *et al.*, 2001). Carbohydrate content in leaves was estimated by Ashwell's method using anthrone and sulphuric acid as the cardinal reagents (Ashwell 1957).

RESULTS AND DISCUSSION

Impact of Bagasse Ash on Physico-chemical Characteristics of the Soil:

Table 1 contains the detailed laboratory analysis of soil receiving different doses of bagasse ash during the pot experiment. The analysis reveals that like other organic wastes, bagasse ash also affects the physico-chemical characteristics of the soil positively. The dry bulk density of the soil decreased from 1.38 gm cm⁻³ to 1.22gm cm⁻³ and the total porosity of the soil increased from 50.0 to 52.840%, while the textural class remained the same. There was also a slight increase in soil pH from 7.6 in control to 8.3 in the treatment receiving bagasse ash @ 100%. An increase in exchangeable calcium and magnesium contents was observed due to bagasse ash. Available micronutrients, ECe, P and K also increased in comparison to the control. The highest amounts of Phosphorus (48 mg kg⁻¹) and Potassium (220 mg kg⁻¹) were found in the treatments amended with 100% bagasse ash. Maximum Zn (41 mg kg⁻¹), copper (14 mg kg⁻¹), iron (40 mg kg⁻¹)

and manganese (110 mg kg⁻¹) contents were also recorded in bagasse ash. The values recorded for E_{Ce} (1.905 dsm⁻¹) and Ca⁺⁺ + Mg⁺⁺ (293 mg kg⁻¹) were also highest in getting bagasse ash. The decrease in dry bulk density and improvement in soil porosity positively affect the water retention and moisture availability in the root zone. This ultimately results in better availability of plant nutrients and enhances plant roots proliferation in the soil. The analysis also reveals that, along with improvement in soil physical properties, boiler ash also increases the Ca, Mg, K, P and Micronutrient content of the soil. Deshmukh, *et al.* (2000), during their treatments improved the nutrients status and physiological properties of the soil (Grewal, *et al.*, 2001). Although the amendments had some effects on soil bulk density, CEC, available micronutrients and slight improvement in exchangeable Ca and Mg, they did not have an effect on soil pH, soil EC, organic C content and available N status of the soil. (Grewal, *et al.* 2001) also found that fly ash application also resulted in greater moisture storage in the plough layer of soil at all the stages of crop growth. (Braman, *et al.* 1999) observed during a wide range experiments that metal contents (Cd, Cu, Zn, Fe, Ni, Cr and Pb) in the soil samples having fly ash were higher than in the control soil. (Kumar, 2002) studied the possibility of fly ash application to agricultural soils (Lee, *et al.*, 2006). The result revealed that fly ash application, particularly in higher amount (8% w/w) increased the pH and electrical conductivity of the soils, however, the application of low amount (2% and 4% w/w) favored plant growth and improved yield. Although the element concentration was found more in fly ash amended soils than the control. Lee, *et al.* (2006) also concluded that fly ash could be mixed as a supplement with other inorganic soil amendments to improve the nutrient balance in paddy soils (Pawar and Dubey, 1988).

Table 1: Comparative analysis of soil and bagasse ash

PARAMETER	SOIL	BAGASSE ASH
PH	7.6	8.3
Dry Bulk Density gmcm ⁻³	1.38	1.22
EC(DSM ⁻¹)	0.52	1.905
Organic Carbon (%)	2.30	7.12
N%	336	150
C/N	1.5	4.76
P%	4.2	48
K%	160	220
Zn(mg/kg)	5.9	41
Fe(mg/kg)	5.3	38
Cu(mg/kg)	7	14
Mn(mg/kg)	9	110
Ca ⁺⁺ Mg ⁺⁺	102	293

Morphological Characteristics of the Plant:

The effect of bagasse ash on the various morphological parameters of *Vignamungowas* studied Seed germination, Root length and shootlength, Number of leaves, flowers and pods. Effect of bagasse ash amendment (Table 2) revealed maximum percentage of seed germination in the T1 (1:4, Bagasse ash and soil) was recorded. The seed germination increased gradually from control to T2 (80-93 %) and then decreased from T3 to T4 (66-53 %). These work that significant increase the germination of seed, due to improvement in soil physical and chemical properties and abundance of different dose of bagasse ash. Pawar and Dubey (1988) also found an increase in germination of maize, sorghum, wheat and gram treated with up to 10% fly ash and decreased with higher fly ash dose expected in gram, which tolerated a 30% fly ash dose (Prajapati, *et al.*, 2016). This result coincides with the finding of Bhushan, *et al.* in *Sesamumindicum*, *Brassica juncea* and *Pisumsativum*, Gautam, *et al.* in *Brassica juncea* (Sabanoor, *et al.*, 2016; Bhushan, *et al.*, 2015; Gautam, *et al.*, 2002; Hernandez 2000).

Table 2: Effect of Bagasse ash amended of soil on the percentage Seed Germination of *Vignamungo*.

Seed germination (%)	
Treatment	After two week
Control	73%
T1	93%
T2	80%
T3	66%
T4	60%
T5	53%

Effect of bagasse ash amendment on root length and shoot length of *Cicerarietinum* (Table 3) revealed that both the length of root and shoot were observed maximum in the amendment in T₄ (3:2, bagasse and soil) as recorded on 30, 60 and 90 days of experiment. The length of root increased gradually from Control (8.3 cm) to T₄ (25.4cm) and then decreased from T₅ (20.8cm) to T₆ (10.6cm) as compared to control. Minimum shoot length (28.7 cm) was obtained from the control and maximum shoot length (54.1 cm) from the T₄ treatment (3:2, Bagasse ash and soil).

Table 3: Effect of Bagasse ash amended of soil on Root and Shoot Length (in cm) *Vignamungo* at 90 Days.

Treatment		Days
		90 Days
Control	Root	4.8 cm
	Shoot	30.2cm
T1	Root	7 cm
	Shoot	39 cm
T2	Root	5.4 cm
	Shoot	36 cm
T3	Root	5 cm
	Shoot	27.6cm
T4	Root	4 cm
	Shoot	19.3 cm
T5	Root	3 cm
	Shoot	17.8cm

Effect of bagassed ash amendment was studied with respect to the number of leaves, flowers and pods perplant. Results in Table- 4 revealed that the number of leaves and flowers perplant increased from control to T2. However, the number of pods showed a 100% increase from control to T2 (2:3, Bagasse ash and soil). A maximum of seventy pods was observed in T4 (3: 2, Bagasse ash and soil). The plant heights (root and shoot length) in pots experiment might have increased due to abundant K and micronutrients and improved soil physical condition. Improvement in soil porosity also contributes to better crop growth, regarding roots and shoots development in the soil and better availability of essential nutrients. Hernandez (2000) also found the best growth (height, diameter and biomass production) of *Hyeronimaalchorneoides* and *Terminalia Amazonia* due to the application of organic wastes (including bagasse ash) (Upadhayay, *et al.*, 2001). Reported an increase in plant height and biomass of three native forest species treated with bagasse ash. Stosio and Tomaszewicz 1999 also found a significant increase in different yield parameters of four winter crop varieties, including wheat, due to fly ash application (Selvakumari, *et al.*, 1999).

Dry Weight of Root, Stem, Leaves and Pods:

The data from the pot experiments given in (Table 5) reveal that the application of different doses of bagasse ash, significant changes in the weight of root, stem, leaves and pods over the control.

Table 4: Effect of Bagasse ash amended of soil on morphological parameter number of Leaves, Flowers and Pods *Vignamungo*.

TREARMENT	Leaves	Flowers	Pods
CONTROL	9	10	6
T1	13	12	10
T2	11	11	8
T3	10	8	6
T4	8	7	4
T5	7	5	3

Table 5: Effect of Bagasse ash on morphological parameter on Root, Stem, Leaf and Pod *Vignamungo* dry weight (mg gm⁻¹ fresh weight) at 60, 90 days

Treatment		60, 90 Days
Control	Root	1.2gm
	Stem	15.6gm
	Leaf	0.8gm
	Pod	0.32gm
T ₁	Root	2.0gm
	Stem	18.9gm
	Leaf	.12gm
	Pod	0.42gm
T ₂	Root	1.5gm
	Stem	17.2gm
	Leaf	0.10gm
	Pod	0.35 gm
T ₃	Root	0.8gm
	Stem	12.0 gm
	Leaf	0.07gm
	Pod	0.28gm
T ₄	Root	0.32gm
	Stem	6.82gm
	Leaf	0.05gm
	Pod	0.21gm
T ₅	Root	0.25gm
	Stem	4.2gm
	Leaf	0.03gm
	Pod	0.12gm

The dry weight of root (2.00 mg), stem (18.9 mg), leaves (0.12 mg), and pods (1.82 mg) observed highest in T₁ (1:4, Bagasse ash and soil) at the end of experiment of period. However, the dry weight of root, stem, leaves and pods were found only 1.2 mg, 1.5 mg, 0.8 mg and 1.25 mg respectively in control at the end of ninety days. Although the dry weight of plant parts were found to increase with increasing the ratio of bagasse ash as observed in T₁ and T₂ with a further increase in the ratio of bagasse ash at T₃ and T₅ a decline in the dry weight of plant parts was observed (Table 5). The morphological characteristics e.g., root length, shoot length, dry weight, number of leaves, flowering and fruiting (number of pods) of *Vignamungo* growing in different concentration of bagasse ash reveals an overall increasing pattern from control to T₁ (20% bagasse ash) expect in the case of number of pods which was higher in T₁ (20% bagasse ash), beyond which these parameters decreased from T₃- T₅ (40%-100% bagasse ash). Improvement in soil porosity and abundant supply of micronutrients like Zn, Cu, Fe and Mn along with Ca, Mg, P and K is recorded in the soil samples having different doses of boiler ash. Therefore, an increase in the number of pods and dry weight of seeds might be the effect of boiler ash application. Selvakumari, *et al.* (1999) inferred that integration of fly ash alone and with other components of the nutrient supply system, because of synergistic effects, resulted in

better nutrient uptake, higher yield and improved maintenance of soil fertility. (Kalra, *et al.*, 1998) also reported that the 1000-grain weight in bagasse ash treatments increased significantly over the control due to the improvement in soil fertility, especially due to the availability of P and micronutrients like Zn and Cu. During their experiments, (Kumar *et al.* 1999) found that the grain yield of wheat increased due to the favorable effects of fly ash on the soil structure, moisture retention and essential nutrients available in the soil. (Sharma, *et al.*, 2001) also reported increased crop yield and improvements in the soil nutrient status due to the application of fly ash to the soil. These results coincides with the finding of (Niaz, *et al.*, 2008) on *Eclipta alba* (Dee, *et al.*, 2003) Guatumet *al.*, on *Brassica juncea* (Hernandez 2000) on maize crop (Khan and Qasim 2008), Khan and Qusim on wheat crop (Gupta, *et al.*, 2007) Bhushan, *et al.*, in *Sesamum indicum*, *Brassica juncea* and *Pisumsativum* (Sabanoor, *et al.*, 2016; Bhushan, *et al.*, 2015; Gautam, *et al.*, 2002).

Effect of Bagasse Ash on Biochemical Parameters of *Vignamungo*:

Impact of bagasse ash on the various biochemical parameters of *Vignamungo* was studied. The chlorophyll a, chlorophyll b, total chlorophyll and carotenoid (Table 6) in general was found to increase from control to T1 (respectively) followed by a decrease in the same from T1 to T5 (respectively). Impact of bagasse ash amendment on the protein and carbohydrate content of *Vignamungo* was studied. Results (Figure 3) revealed a 17.32% increase in the protein content and 20.82% increase in the Carbohydrate in the treatment T1 when compared to control. However, with increases in bagasse ash amendment beyond T1 a concentration dependent decline was observed till T6. The maximum protein content (296.43 g gm⁻¹ fresh weight) and carbohydrate content (393.04 g gm⁻¹ fresh weights) was observed in T1. The biochemical parameter protein and chlorophyll content increased from control to T1 (20% bagasse ash) and decreased from T2 to T5 (100% bagasse ash) (Table 6). Similar finding were made by Gupta, *et al.* on *Phaseolus vulgaris* (Jamil, *et al.*, 2004) Niyaz, *et al.*, on *Ecliptaalba* (Dee, *et al.*, 2003), Jamilet *al.* on wheat crop and Gautamet *al.* on *Brassica juncea* (Upadhayay, *et al.*, 2001). An increase in carotenoid content from control to T4 point may be to indicator of strengthening of the defiance mechanism of the plant as carotenoids play an important role in protecting chlorophyll pigments under stress condition. Carbohydrate content estimated in plant leaf revealed gradual decline from control to T5 (100% bagasse ash). Decrease in concentration of carbohydrate with increase the concentration of bagasse ash from control to T1 may be due to the utilization of the plants carbon and nitrogen resources in making up plant protein whose concentration show a positive rise in the same treatment bagasse ash when added to soil in suitable proportions i.e., 20-40% bagasse ash with 80-60% soil, respectively, positively affected the growth of *Vignamungo*.

Table 6: Effect of Bagasse ash amended of soil on biochemical parameter Chlorophyll 'a' Chlorophyll 'b', Total Chlorophyll, Carotenoids, Protien, Carbohydrate (g gm⁻¹) in *Vignamungo*.

Treatment	Chlorophyll 'a' g gm ⁻¹	chlorophyll 'b' g gm ⁻¹	Total chlorophyll g gm ⁻¹	Carotenoids g gm ⁻¹	Protien g gm ⁻¹	Carbohydrate g gm ⁻¹
Control	1.89	1.74	3.89	10.64	252.62	325.16
T1	2.24	2.04	4.52	14.31	296.43	393.65
T2	2.05	1.92	4.02	12.62	284.05	380.65
T3	1.74	1.53	3.46	9.42	243.94	310.03
T4	1.52	1.28	2.79	8.62	229.62	289.43
T5	1.40	1.13	2.70	7.08	201.08	276.43

CONCLUSION

Bagasse ash is generally considered a waste product, however, the present findings show it is rich in micro-nutrients and also contains sufficient amounts of Ca, Mg and other

macro-nutrients like P and K. Different levels of bagasse ash positively influence the physico-chemical properties of soil, and most of the yield parameters of *Vignamungo* crop improved in response to its favorable effects on the soil characteristics. Utilization of bagasse ash as organic fertilizer can also save the cost of chemical fertilizer along with minimizing environmental pollution. By comparing the levels of bagasse ash application, 20-40% was found to be the optimal dose regarding important yield parameters, such as, the root and shoot length of plant-1, root and shoot dry weight of plant-1, number of leaves, flowers and pods weight and yield of *Vignamungo* crop in soil.

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