ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Impact of Bagasse Ash Amended Soil on Growth and Yield of *Pisumsativum.*

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ABSTRACT

The use of regular chemical fertilizers are known to increased crop yield, but also degrading soil quality (physically and chemically). Sugar industry wastes can be used as soil amendments to improve crop yield, soil physico-chemical characteristics and provide a reasonable economic means to recycle these wastes in an environmentally friendly manner. To the current research work achieve the aim, sugar industry bagasse ash was applied to *Pisumsativum* 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 (8.5), low in organic matter (8200 mg kg^{-1}), and deficient in N (334 mg kg^{-1}), P (4.4 mg kg^{-1}), Zn (6.1 mg kg^{-1}) and Fe (5.5 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. EC_e and pH of the soil was minutely increased. Yields and most of the yield components of *Pisumsativum* crop in pots, also increased due to bagasse ash application. It is recommended that application of bagasse ash 40-60% will result in enhanced yield of *Pisumsativum* crop soil.

Keywords: bagasse ash, soil nutrients, soil characteristics, *Pisumsativum* crop.

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INTRODUCTION

Addition of organic material to agricultural fields was widely practiced in Asia for decades but due to intensive cropping and business oriented agriculture, the trend has shifted towards chemical fertilizers [39].Chemical fertilizers were used in such high amounts that they deteriorated our soil health. Heightened environmental awareness has led to an organic revolution, with scientists turning to organic materials in search of a comprehensive strategy to save soils from further degradation and utilize organic wastes in an environmentally safe manner [18].

The fibrous residue of sugarcane after crushing and extraction of it juice, known as “Bagasse” is one of the largest agriculture residues in the world. 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. 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 [1,6,27,30]. When applied to fields as an organic amendment, its favorable effects on soil water holding capacity and aeration is also proven. Singh *et al*. [36] 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 [28] and sugar cane. India is one of the leading growers of sugarcane with an estimated production of approximately 300 million tons in the marketing 2014. Sugar distillery complexes, integrating the production of cane sugar and ethanol, constitute one of the key agro based industries. 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 scientist 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 nutritive importance of this organic waste and its positive effects on the yield of cereal crops [20,35], 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 wheat crop in soil and to recommend its most appropriate dose for higher yield of *Pisumsativum* 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 2014-2015. 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 @ T_1-10%, T_2-20%, T_3-40%, T4- 60%, T_5-80% and T_6-100%. C was kept as control. Ten seeds pot^{-1}of *Pisumsativum* 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 [7]. Ca^{++} + Mg^{++} were determined by EDTA titration where NH_4Cl-NH_4OH buffer solution and eriochrome black T indicator was used (33). Organic matter content in the soil and bagasse ash samples was determined by dichromate method recommended by MAFF [26]. Total N was determined by the Kjeldahl procedure [15]. Available K was determined by ammonium acetate method [5]. P was estimated by formation of a phosphomolybdate complex, which is reduced by using ascorbic acid to produce a blue color [23]. Zn, Cu, Fe and Mn determination was made in 0.005 M DTPA extract ant [24] 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 was 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^{O}C for two hours and then at 85^{O}C for 24hours.

Biochemical assay

ChlorophyllcontentofplantleaveswasestimatedbyArnon'smethodusing80%acetonefor preparing leaf extract. This was followed by centrifugation and measurement of the optical density of the clear supernatant. 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 coloured solution. The absorbance was read at 650nm. Carbohydrate content in leaves was estimated by Ashwell's method using anthrone and sulphuric acid as the cardinal reagents.

RESULTSAND 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 1.32 gm cm^{-3} to 1.25 gm 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 8.2 in control to 9.05 in the treatment receiving bagasse ash @ 100%. An increase in exchangeable calcium and magnesium contents was observed due to bagasse ash. Available micronutrients, EC_e , P and K also increased in comparison to the control. The highest amounts of Phosphorus (52 mg kg^{-1}) and Potassium (240 mg kg^{-1}) was found in the treatments amended with 100% bagasse ash. Maximum Zn (45 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 EC_e (1.905 dsm^{-1}) and Ca^{++} + Mg^{++} (295 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, bagasse ash also increases the Ca, Mg, K, P and Micronutrient content of the soil. Deshmukh*et al*. [9], during their treatments improved the nutrients status and physiological properties of the soil. 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.* [11] 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*etal.* [4] 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 [21] studied the possibility of fly ash application to agricultural soils. 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.* [22] also concluded that fly ash could be mixed as asupplement with other inorganic soil amendments to improve the nutrient balance in paddy soils.

Morphological characteristics of the Plant

The effect of bagasse ash on the various morphological parameters of *Pisumsativum* was studiedSeed germination, Root length and shootlength, Number of leaves, flowers and pods.

Effect of bagasse ash amendment (Figures 1) revealed maximum percentage of seed germination in the T_4(3 : 2, Bagasse ash and soil) as recorded at the end of second week. the seed germination increased gradually from control to T_3 (72.04 - 97.75 %) and then decreased from T_4 to T_6 (69.00 – 64.00 %). This 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 (32) 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. this result coincides with the finding of Gautum*et al.(10)* in *Brassica juncea*.

Effect of bagasse ash amendment on root length and shootlength of *Pisumsativum* (Figure2a, 2b)revealed that both the length of root and shoot were observed maximum in the amendment in T_4(3 : 2, flyash and soil) as recorded on 30, 60 and 90 days of experiment. The length of root increasedgradually from T_1(11.02 cm) to T_4(26.21cm) and then decreased from T_5(21.04cm) to T_6(10.2cm)ascompared tocontrol. Minimum shoot length (27.54 cm) was obtained from the control and maximum shoot length (56.96 cm) from the T_4 treatment (3:2, Bagasse ash and soil) (Figure 2a, 2b).

Effect of fly ash amendment was studied with respect to the number of leaves, flowers and pods perplant.ResultsinTable-2revealedthatthenumberofleavesandflowersperplantincreased from control to T_4. However, the number of pods showed a 100% increase from control to T_4(3 : 2, Bagasse ash and soil). A maximum of seventy pods was observed in T_4(3 : 2, Bagasse ash and soil). The plant height(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 (14) 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*. (38) reported an increase in plant height and biomass of three native forest species treated with bagasse ash. Stosio and Tomaszewicz, [37] also found a significant increase in different yield parameters of four winter crop varieties, including wheat, due to fly ash application.

Dry weight of root, stem, leaves and pods

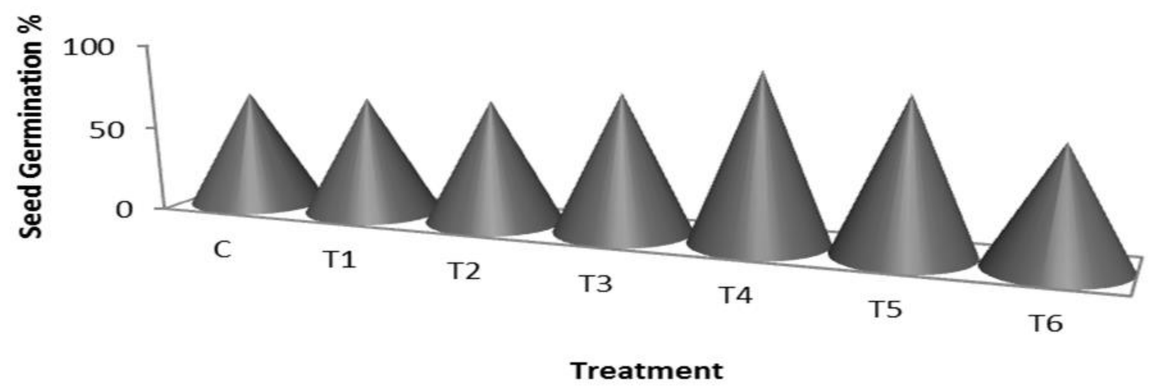
The data from the pot experiments given in (Table 3) reveal that the application of different doses of bagasse ash, significant changes in the weight of root, stem, leaves and pods over the control. The dry weight of root (88.85 mg), stem (91.03 mg), leaves (21.83 mg), and pods (77.83 mg) observed highest in T_4 (3 : 2, Bagasse ash and soil) at the end of experiment of period. However, the dry weight of root, stem, leaves and pods were found only 62.05 mg, 77.52 mg, 18.92 mg and 43.78mg 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 T_4 with a further increase in the ratio of bagasse ash at T_5 and T_6 a decline in the dry weight of plant parts was observed (Table 3). The morphological characteristics e.g., root length, shoot length, dry weight, number of leaves, flowering and fruiting (number of pods) of *Pisumsativum* growing in different concentration of bagasse ash reveals an overall increasing pattern from control to T_4 (60% bagasse ash) expect in the case of number of pods which was higher in T4 (60% bagasse ash), beyond which these parameters decreased from T_5 (80% - 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 bagasse ash. Therefore, an increase in the number of pods and dry weight of seeds might be the effect of bagasse ash application. Selvakumari*et al*. (34) 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*. [17] 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*. [20] 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*. [35] also reported increased crop yield and improvements in the soil nutrient status due to the application of fly ash to the soil. This results coincides with the finding of Niaz*et al.* [29], on *Eclipta alba*, Guatum*et al.* [10], on *Brassica juncea*, Dee *et al.* [8], on maize crop, Khan and Qusim [18]on wheat crop.

Effect of Bagasse ash on Biochemical parameters of Pisumsativum

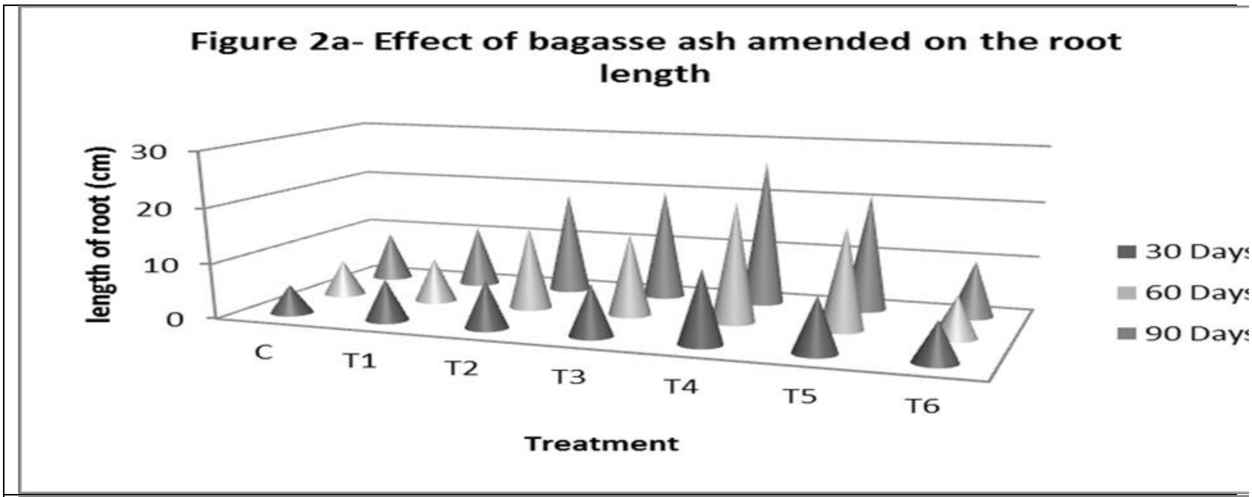
Impact of bagasse ash on the various biochemical parameters of *Pisumsativum* was studied.

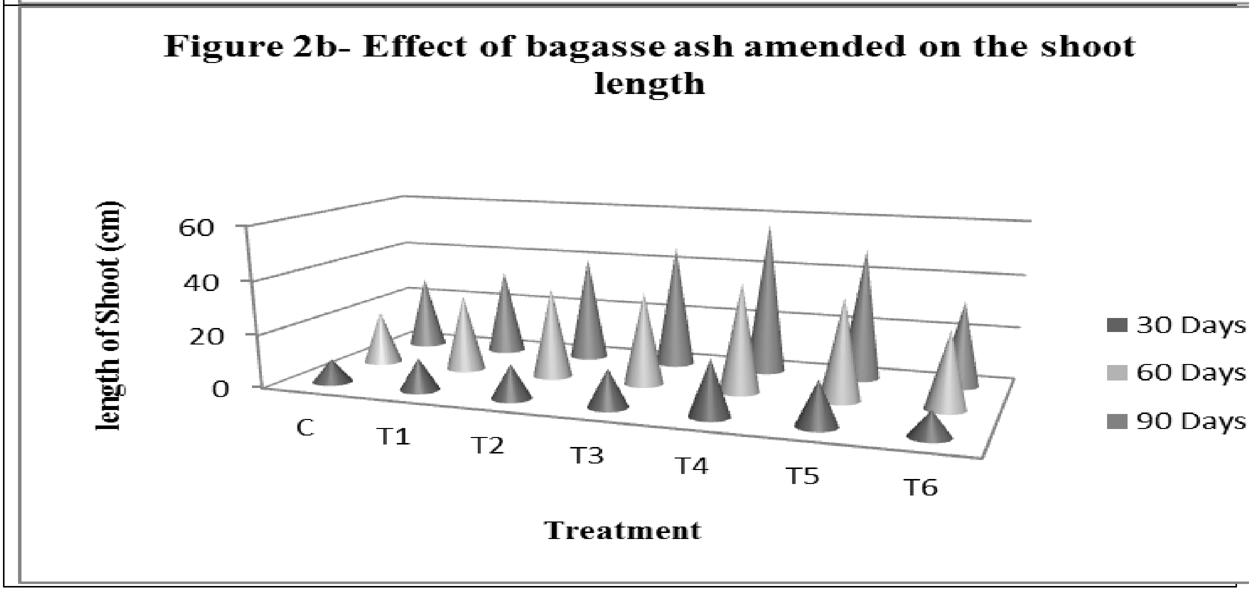
The chlorophyll a, chlorophyll b, total chlorophyll and carotenoid [Figure 3] in general was found to increase from control to T_4 (respectively) followed by a decrease in the same from T_4 to T6(respectively).Impact of bagasse ash amendment on the protein and carbohydrate content of *Pisumsativum* was studied. Results (Figure 3) revealed a 62.48% increase in the protein content in the treatment T_4 when compared to control. However, with an increases in bagasse ash amendment beyond T_4 a concentration dependent decline was observed till T_6. The maximum protein content (242.98µg gm-1 fresh weight) was observed in T_4. In contrast the maximum carbohydrate content (274.86µg gm-1 fresh weight) was observed in control. The biochemical parameter protein and chlorophyll content increased from control to T_4 (60% bagasse ash) and decreased from T_4 to T_6 (100% bagasse ash) (Figure 4). Similar finding were made by Gupta *et al.* [12] on *Phaseolus vulgaris*, Niyaz*et al* (29)on *Ecliptaalba*, Jamil*et al.* [16]on wheat crop and Gautam*et al.* [10]on *Brassica juncea*. An increase in carotenoid content from control to T_4 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 T_6 (100% bagasse ash). Decrease in concentration of carbohydrate with increase the concentration of bagasse ash from control to T_4 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., 40-60% bagasse ash with 60-40% soil, respectively, positively affected the growth of *Pisumsativum*.

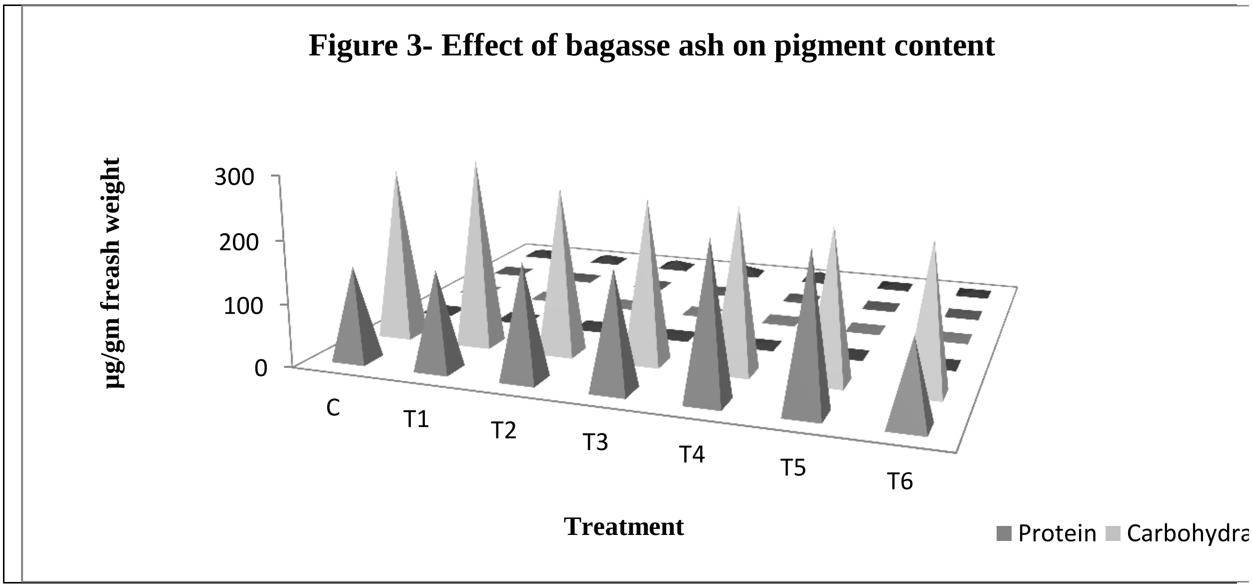
Figure 1- Effect of Bagasse ash amended of soil on the percentage Seed Germination of Pea



ISSN: 0975-8585







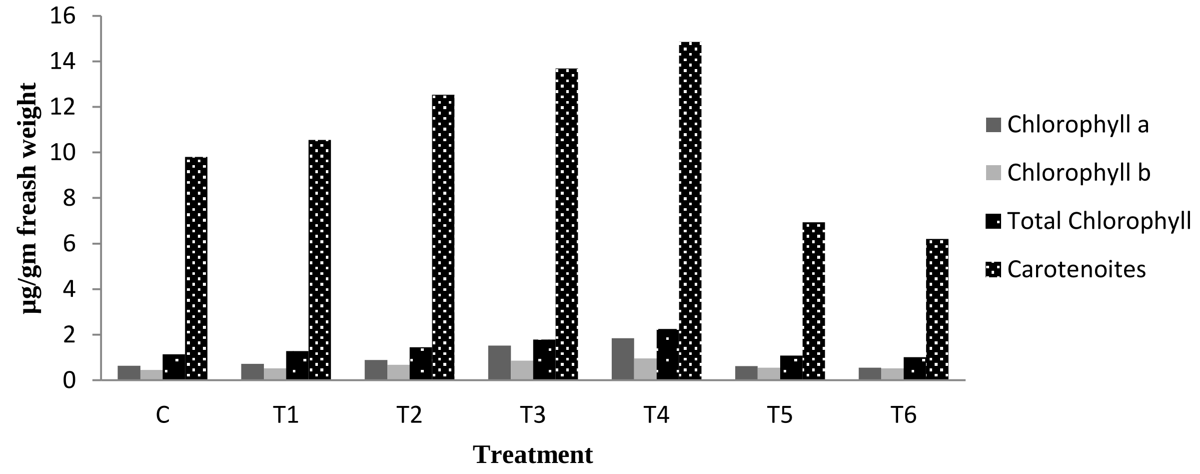


Figure 4- Effect of bagasse ash on protein and carbohydrate content

Table 1: Comparative analysis of soil and bagasse ash.

PARAMETER	SOIL	BOILER ASH
Dry Bulk Density gmcm^{-3}	1.32	1.25
Ph	8.5	9.05
EC dsm-1	0.34	1.905
ORGANIC CARBON	2.32	7.15
N(mg kg-1)	334	149
C/N	1.4	4.72
P(mg kg-1)	4.4	52
K (mg kg-1)	170	240
Zn(mg kg-1)	6.1	45
Fe (mg kg-1)	5.5	40
Cu(mg kg-1)	6	14
Mn(mg kg-1)	11	110
O. M.(mg kg-1)	8200	Nil
$Ca^{++}+Mg^{+}$	88	295

Table 2: Effect of Bagasse ash on number of Leaves, Flowers and Pods at different days.

	Leaf			Flower		Pods
Treatment	**30 Days**	**60 Days**	**90 Days**	**45 Days**	**60 Days**	**90 Days**
Control	7±0.6	11±0.5	5±0.4	6±0.4	8±0.3	8±0.3
T_1	7±0.7	13±0.3	6±0.3	8±0.9	9±0.2	10±0.4
T_2	9±0.5	16±0.9	8±0.1	9±0.5	10±0.6	11±0.6
T_3	11±0.1	19±0.3	8±0.8	10±0.2	13±0.4	12±0.7
T_4	16±0.2	21±0.2	9±0.3	13±0.7	16±0.9	17±0.4
T_5	10±0.6	16±0.7	5±0.3	11±0.3	15±0.2	14±0.3
T_6	6±0.1	10±0.1	4±0.2	5±0.2	4±0.1	6±0.1

C- Control, T- Treatment

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 *Pisumsativum* 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 environ-mental pollution. By comparing the levels of bagasse ash application, 40-60% 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 *Pisum sativum* crop in soil.

Table 3: Effect of Bagasse ash on morphological parameter on Pods dry weight (mg gm-1 fresh weight) at different days.

Treatment		30 Days	60Days	90 Days
Control	Root	34.56±0.6	50.2±1.9	62.05±1.5
	Stem	16.31±1.2	52.65±2.1	77.52±2.3
	Leaf	19.32±0.5	22.56±0.5	18.92±1.6
	Pod	-	-	43.78±0.3
T_1	Root	36.31±0.5	52.86±0.4	67.94±0.8
	Stem	19.89±1.7	54.38±1.1	82.93±1.8
	Leaf	20±1.3	32.97±1.6	13.26±1.9
	Pod	-	-	53.09±0.3
T_2	Root	39.87±1.7	57.32±0.9	77.53±0.8
	Stem	19.99±2.0	54.89±0.3	90.22±1.6
	Leaf	22.86±1.1	34.75±1.1	16.45±2.4
	Pod	-	-	56.87±1.7
T_3	Root	40.23±0.9	60.34±1.7	82±1.6
	Stem	26.82±1.3	55.83±1.8	90.7±0.7
	Leaf	21.25±1.8	34.35±2.6	18.96±0.5
	Pod	-	-	70.86±1.2
T_4	Root	41.65±0..2	66.43±0.7	88.85±0.6
	Stem	26.98±0.7	58.53±0.3	91.03±0.8
	Leaf	41.32±1.9	56.79±1.1	21.83±1.1
	Pod	-	-	77.84±1.7
T_5	Root	31.26±2.4	65.73±1.5	58.75±2.2
	Stem	19.46±1.1	52.42±0.3	71.99±2.9
	Leaf	17.84±1.9	35.72±1.9	17.83±1.8
	Pod	-	-	51.45±1.4
T_6	Root	23.21±0.3	40.42±0.1	43.74±0.5
	Stem	15.73±0.6	48.37±0.5	55.32±0.8
	Leaf	13.87±0.1	31.93±1.8	9.8±1.2
	Pod	-	-	13.28±0.7

C- Control, T- Treatment

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