African Journal of Agricultural Research Vol. 6(21), pp. 4857-4861, 5 October, 2011
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR10.1049
ISSN 1991-637X ©2011 Academic Journals

Full Length Research Paper

Integrated application of fertilizers and biocane (organic fertilizers) to enhance the productivity and juice quality of autumn planted sugarcane (*Saccharum officinarum* L.)

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Accepted 21 February, 2011

An experiment was conducted to study the effect of different levels of fertilizers and biocane on the growth, yield and juice quality of sugar cane Var. SPSG-26 at Agronomic Research Farm, University of Agriculture Faisalabad, Punjab, Pakistan during the year 2007 to 2009. Randomized Complete Block Design (RCBD) was applied having four replications with a net plot size of 7.5 × 7 m. The study comprised of five treatments, which are, T_1 = N.P.K; 170:85:85 kg ha^{-1}, T_2 = biocane 2.5 l ha^{-1}, T_3 = biocane 2.5 l ha^{-1} + N.P.K: 170:85:85 kg ha^{-1}, T_4 = biocane 2.5 l ha^{-1} + N.P.K; 85:42:42 kg ha^{-1} and T_5 = biocane 1.25 l ha^{-1} + N.P.K; 170:85:85 kg ha^{-1}. All doses of P, K and ½ N was side dressed at the time of sowing and remaining ½ N was top dressed at the time of 3rd irrigation while biocane was sprayed as foliar fertilizers in December after seedling establishment. Cultivar SPSG-26 was used as test crop for experiment. All the growth and yield parameter was significantly affected with biocane application along with synthetic fertilizers. Number of millable canes, cane length, cane diameter, number of internodes per cane, internodal length, trash weight, weight per stripped cane, tops weight and stripped can yield, were all significantly affected by the application of biocane. T3 (2.5 l ha^{-1} + N.P.K; 170:85:85 kg ha^{-1}), gave maximum cane yield (109.5 t ha^{-1}). The sucrose contents were non-significantly differed among all treatment means and varied between 7.7 to 12.78%. The present study concluded that in the case of sugarcane variety SPSG-26 when applied Biocane 2.5 l ha^{-1} + N. P. K; 170:85:85 kg ha^{-1} gave higher cane yield. Integrated application of synthetic and bio fertilizers can improve the soil physical conditions, microbial activity, plant growth and helps to sustain the environment, therefore, reducing the fertilizer pollutants into the atmosphere and under ground water.

Key words: Synthetic fertilizers, biocane fertilizer, sugarcane.

INTRODUCTION

Agriculture ranks first as profession in Pakistan. More than 70% of the country's employment, directly or indirectly, depends upon agriculture. The trade of Pakistan is driven by agriculture. So, it will not be wrong to entitle Pakistan as an "Agriculture country". Pakistan is blessed with favorable environmental conditions but agriculture in the country suffers from under-production in terms of yield per hectare (Anonymous, 2006).

Sugarcane (*Saccharum officinarum* L.) is typically native to the tropical regions of the world but its cultivation has been extended rapidly over the sub-tropics between latitude 50°North and 55°South because of its wide range of ecological adaptability. It is a perennial crop, belonging to the family Gramineae (Poaceae), and requires a temperature above 20°C in order to thrive, and a period of about eight to twenty four months to reach maturity. It is very sensitive to sunlight. Abundant light promotes tillering, while subsequent crowding may cause a high mortality of tillers because of insufficient light.

Sugarcane is an important cash crop of Pakistan. It is

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mainly grown for sugar, confectionary, and used in chemicals, plastics, paints, synthetics, fiber, insectides, detergents and related products. It is an important source of income and employment for the farming community of the country (Pakistan). It also forms essential items for industries like sugar, chipboard, and paper. Its share in value added of agriculture and GDP are 4.5 and 0.9%, receptively. For 2007 to 2008, the area under sugarcane crop was targeted at 103.9 thousand hectares as against 102.9 thousand hectares of last year. However, sugarcane was sown on an area of 124.1 thousand hectares, 20.6% higher than the last year. Sugarcane production for the year 2007 to 2008 is estimated at 63 million tons, highest ever in the country's history against 54.7 million tons last year. This indicates significant improvement of 16.8% over the production of last year. The main reason of higher sugarcane production is high prices of sugarcane received by the grower last year, encouraging them to increase area under production, judicious application of fertilizer, improvement in cultural practices and non-significant attack of pest and diseases (Government of Pakistan, 2008)

The average yield of sugarcane in the world is around 60 metric tons ha^{-1} while India and Egypt are getting 66 and 105 metric tons ha^{-1}, respectively. Egypt, with the highest cane yield in the world, is getting about 142% higher than Pakistan. India, with almost similar soil and climate conditions, is obtaining about 35% higher cane yield than Pakistan. As it is one of the cash crops of the country, therefore, efforts should be made to improve its productivity, hence bringing substantial improvement in its yield.

Nowadays, synthetic fertilizers are being used extensively to maximize crops yield and among all the fertilizers applied in the fields, nitrogen is the most important for plant growth, plant productivity and grain quality (Frink et al., 1999).

Keeping this in view, the present study was designed to determine the suitable level of N.P.K. fertilizers and the efficiency of biocane fertilizer for the sugarcane quality.

MATERIALS AND METHODS

Experiment site and treatments

Studies regarding to the effect of different levels of fertilizers and biocane (foliar fertilizer) on the growth, yield and juice quality of sugarcane was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad during 2007 to 2009 after maize harvesting (latitude = 31°30/N, longitude = 73°10/E and altitude = 184.4 m). Experiment was laid out in randomized complete block design (RCBD) having four replications. Sugarcane cultivar SPSG-26 that was sown in 75 cm spaced row, was used as the test crop. The net plot size was 7.5 × 7 m. The soil pH and electrical conductivity (EC) were measured as 7.8 and 1.4 dS m^{-1}, respectively. The study comprised of five treatments which are, T_1 = N:P:K - 170:85:85 kg ha^{-1}, T_2 = biocane 2.5 l ha^{-1}, T_3 = biocane 2.5 l ha^{-1} + N:P:K - 170:85:85 kg ha^{-1}, T_4 = biocane 2.5 l ha^{-1} + N:P:K - 85:42:42 kg ha^{-1} and T_5 = biocane 1.25 l ha^{-1} + N:P:K - 170:85:85 kg ha^{-1}. All doses of P, K and ½ N was side dressed at the time of sowing and remaining ½ N was top dressed at the time of 3rd irrigation while biocane was sprayed as foliar fertilizers in December after seedling establishment.

Crop husbandry

Sugarcane was sown during 4th week of September 2007, using seed rate 10000 kg ha^{-1} with row to row distance 75 cm. Urea, diammonium phosphate, potassium sulphate and biocane (N.P.K. 7, 2 and 11 % respectively) was used as sources of nitrogen, phosphorous and potash. Nitrogen, phosphorous and potash were used according to the treatments and biocane was sprayed in December after seedling establishment. Weeds within the strips were removed with the help of spade and khurpa. Hoeing and earthing up was also done at the proper crop stage. Crop was irrigated according to its need. Total of 16 irrigations were applied during the growth period. The crop was harvested in the 4th week of February 2009 when crop was fully matured. Observations on growth and yield parameters of the crop were recorded using standard procedures.

Measurements

Data regarding to number of millable canes (m^{-2}), cane length and height (cm), cane diameter (cm), Number of internodes per cane and internodal length (cm) was recorded from ten different sugarcane plants from each treatment. Trash weight and tops weight were recorded by removing all trash and tops of stripped canes and then, weight of each treatment was recorded and converted to t ha^{-1}. All stripped canes of each plot were weighed and then, weight was converted to t ha^{-1}. Sucrose contents (%) was recorded by taking five stripped millable canes selected from each treatment and analyzed by the Sugarcane Technology Laboratory, Sugarcane Research Institute, Ayub Agriculture Research Institute Faisalabad (AARI), Punjab, Pakistan. These five selected sugarcane were crushed with power cane crusher for juice extraction. Brix readings were recorded with brix hydrometer standardized at 15°C. Sucrose percentage was determined by horns dry lead acetate method of sugar analysis using Saccharimeter.

Data collected on different parameters were analyzed statistically with Fischer's analysis of variance techniques and used least significant difference test (LSD) at 0.05 probability level to compare various treatments means (Steel et al., 1997).

RESULTS

Number of millable cane m^{-2} and cane length and height (m)

The different fertilizer levels and biocane show significant effect on the number of millable and cane length. The maximum number of millable canes m^{-2} (25.86) was observed in T_3 (biocane 2.5 l ha^{-1} + N: P: K - 170:85:85 kg ha^{-1}) treatment followed by T_5, whereas T_4 and T_5 were statistically at par. The minimum number of millable canes m^{-2} (14.89) was observed in T_2 (biocane 2.5 l ha^{-1}) treatment. While in the case of cane length, the difference among treatment means remained statistically significant as the maximum cane length (2.91m) was observed in T_3 (biocane 2.5 l ah^{-1} + N: P: K - 170: 85: 85

Table 1. Comparison among different bio-cane treatments alone and in combination fertilizers with alone use of chemical fertilizers.

Treatments	1	2	3	4	5	6	7	8	9
T_1	16.23c	2.30c	5.20bc	14.62d	11.93b	12.44c	0.59c	7.67b	92.61c
T_2	14.89d	2.04d	5.07c	13.10e	10.76c	10.76d	0.51d	6.07c	86.71d
T_3	25.86a	2.91a	5.84a	19.42a	14.03a	14.64a	0.87a	8.42a	109.5a
T_4	23.50b	2.62b	5.62ab	16.42c	13.58a	13.57b	0.74b	7.74b	102.5b
T_5	23.87b	2.73b	5.73a	17.52b	13.86a	13.81b	0.78b	8.01ab	104.6b
LSD	0.8891	0.1823	0.4219	0.9192	1.092	0.4018	0.06890	0.6482	2.212

1 = Number of milliable canes m^{-1}; 2 = cob length (m); 3 = cane diameter (cm); 4 = number of internodes per cane, 5 = internodal length (cm); 6= top weight (t ha^{-1}); 7= weight per stripped cane (kg); 8 = trash weight (tha^{-1}); 9 = stripped cane yield (tha^{-1}), 10 = sucrose contents (%) [Non-significant].

Kg ha^{-1}) treatment where recommended chemical fertilizers and biocane were applied, followed by T_5, where T_4 and T_5 were statistically at par with each other. The increase in cane length is due to the ample nutrient availability. The minimum cane length (2.04 m) was observed in T_2 (biocane 2.5 l ha^{-1}) treatment due to lone application of biocane which could not fulfill the nutrient demand of the sugarcane crop.

Cane diameter (cm), number of internodes per cane and internodal length (cm)

Data in Table 1 showed that the cane diameter on average varied from 5.07 to 5.84 cm. The maximum cane diameter (5.84 cm) was observed in T_3 (biocane 2.5 l ha^{-1} + N: P: K -170:85:85 kg ha^{-1}) treatment followed by T_5 where biocane 1.25 l ha^{-1} and N: P: K -170: 85: 85 kg ha^{-1} were applied. These treatments were statistically similar compared to each other. The minimum cane length (2.04 cm) was recorded in T_2 (Biocane 2.5 l ha^{-1}) treatment due to sole application of biocane, whereas, significantly more internodes, were observed for the crop in T_3 (Biocane 2.5 l ha^{-1} + N: P: K -170:85:85 kg ha^{-1}) followed by T_5 (1.25 l ha^{-1} and N: P: K -170: 85: 85 kg ha^{-1}). The maximum number of internodes (19.42) was recorded in T_3 where recommended biocane + fertilizers were applied, followed by T_5 (17.52). These two treatments were statistically different from each other. T_2 (biocane 2.5 l ha^{-1}) gave the minimum number of internodes (14.89). Similarly, in cases of internodal length, maximum internodal length (14.03 cm) was recorded in T_3 (biocane 2.5 l ha^{-1} + N: P: K -170:85:85 kg ha^{-1}), followed by T_5 treatment where biocane 1.25 l ha^{-1} + N: P: K - 170: 85: 85 kg ha^{-1} were applied. The minimum internodal length (10.76 cm) was produced in the plots where only biocane 2.5 l ha^{-1} (T_2) was applied. Furthermore, treatments T_3, T_4 and T_5 were statistically at par with each other.

Tops weight (tha^{-1}), weight per stripped cane (kg) and trash weight (tha^{-1})

Data shown in Table 1 revealed that the effects of N.P.K fertilizer and biocane treatments on tops weight per hectare were highly significant. However, the tops weight on an average varied from 10.76 to 14.63 tons per hectare in all treatments. The maximum tops weight (14.63 tha^{-1}) was observed in T_3 (biocane 2.5 l ha^{-1} + N: P: K -170:85:85 kg ha^{-1}) treatment followed by T_5 where biocane 1.25 l ha^{-1} and N: P: K -170: 85: 85 kg ha^{-1} were applied. The minimum (10.76 tha^{-1}) tops weight was observed in T_2 (biocane 2.5 l ha^{-1}). Similar results were obtained by Mui et al. (1997). While weight per stripped cane and trash weight had significant effect giving the maximum weight per stripped cane (0.87 kg) and trash weight (8.42 tha^{-1}) were obtained in T_3 treatment where, biocane 2.5 l ha^{-1} + N: P: K -170:85:85 kg ha^{-1} followed by T_5 (0.78 kg) (08.01 tha^{-1}) respectively and minimum weight per stripped cane (0.51 kg) and trash weight (0.6.07 tha^{-1}) were recorded in T_2 (biocane 2.5 l ha^{-1}) treatment. Furthermore, in case of trash weight T_1, T_4 and T_5 were statistically at par with each other and T_3 and T_5, were also at par with each other. Similarly, in cases of weight per stripped, T_5 were statistically similar with T_4.

Stripped cane yield (tha^{-1}) and sucrose contents (%)

Data regarding to the cane yield per hectare showed significant difference among fertilizer treatments by increasing the cane yield progress-sively with the increase of N.P.K. fertilizer and biocane. Similarly, the sucrose in cane juice also showed significant difference among the treatments and on an average, ranged between 16.90 and 17.78%. The maximum cane yield (109.5 tha^{-1}) and sucrose content (17.78% more sucrose content than T_1) was observed in T_3 treatment where recommended doses of N.P.K fertilizers and biocane (that is, biocane 2.5 l ha^{-1} + N: P: K - 170:85:85 kg ha^{-1}) were applied, followed by T_5 (104.6 tha^{-1}) treatment where biocane 1.25 l ha^{-1} and N: P: K - 170: 85: 85 kg ha^{-1} (17.67%) was applied. The minimum stripped cane yield (86.7 tha^{-1}) was observed in treatment T_2 where only recommended dose of biocane (2.5 l ha^{-1}) was applied and T_4 and T_5 did not statistically differ significantly, while in the case of sucrose content, the minimum (16.90%) was recorded in T_1 treatment where only doses of N.P.K. (170: 85: 85 kg ha^{-1}) were recommended. Furthermore, sucrose contents of T_4 treatment (biocane 2.5 l ha^{-1} and N: P: K - 170:85:85 kg ha^{-1}) was statistically at par with T_5 treatment which received biocane 1.25 l ha^{-1} and N: P: K - 85: 42: 42 kg ha^{-1}.

DISCUSSION

The results of the study showed that addition of biocane with recommended dose of NPK fertilizer had significant effect on the growth parameter (which are, number of internodes per cane, internodal length, tops weight, trash weight and sucrose contents) and yield components (number of millable canes, cane length, cane diameter, weight per stripped cane and stripped cane yield) of the research. Our results are in line with findings of previous study which reported that, the number of millable canes m^{-2} was affected significantly by the combination of NPK fertilizer and biocane (Gill and Sing, 1976, Patil et al., 1984; Sirvastava et al., 2006). The higher number of millable canes in biocane treatment (with recommended dose of NPK fertilizer) was due to availability of sufficient amount of required nutrients to the crop (Zulfiqar, 1984).

Cane length, cane diameter and number of internodes per cane were directly co-related with nutrients availability. Biocane enhanced the mineralogy and reduced the immobilization which ultimately provided maximum amount of mineral nutrients from the exchange sites of clay particles; those otherwise are not available to crop plants and are also lower down the pH of the soil providing suitable conditions for the microbial activity. Similar result was observed by Shukla (2007), Pande and Tilak (1970, Ricaud (1969) and Elt et al. (2004) that higher fertility level gave higher cane length, cane diameter and number of internodes per cane while Yadao and Sharma (1978) observed that cane length was strongly dependant on the fertilizer application and availability of other beneficial nutrients. Furthermore, cane diameter and number of internodes per cane was also affected by potassium application (Elt et al., 2004).

Internodal length was also significant in our study and concluded that genetic internodal length was achieved with increased nutrients availability, but our results are contradictory with Munoz et al. (1984) who reported that the effect of various levels of nitrogen and phosphorus on the length of internodes was non significant. This might be due to the application of only nitrogen and phosphorus fertilizer without addition of biocane which surely gave the significant increase in the internodal length of sugarcane.

Biological yield of any plant, showing its response towards any applied treatment, and directly interlinked with total plant response towards the final yield (cane yield), by increasing the surface area for the food factory (photosynthesis) and ultimately gave good economic benefit. Tops weight and trash weight is totally dependant on the application and availability of nutrients which can be ensured by the application of biocane. Our results are confirmed by the findings of Mui et al. (1997), Wood (1990), Zambello (1977), Tentango and Rosario (1977) and Ramalinga et al. (1999) who reported that yield of edible biomass (stalk, tops and green leaves) and trash weight increased with the sufficient availability of nutrients. Cane yield was also more in the biocane treatments which is indirectly due to more biological growth of the plant, producing and accumulation of more photosynthates into the plant body (khan et al., 2005; Shukla, 2003).

Stripped cane yield is a function of the combined effects of various yield components (number of canes per unit area, cane length, cane girth, weight per stripped cane and number of millable canes at harvest) which are significantly affected by different fertilizer and biocane combinations. Data in the Table 1 showed clearly that cane yield increased progressively with the increase of NPK fertilizer and biocane. Cane yield was more in the biocane treatment with recommended dose of NPK fertilizers because the nutrients demand might be fulfilled by good nourishment of plants with both organic and inorganic sources of nutrients, ultimately, plants showed better response and produced more yield. The results are in line with Ramalinga et al. (1999) and Thakur et al. (1978) that, more nitrogen and phosphorous availability increased cane yield. Similarly, Pannu et al. (1985) concluded that combined application of NPK and organic matter increased sugarcane yield by 5.1 to 29.5%. Cane yield had significantly increased with the combined application of NPK each at the rate of 120 kg ha^{-1} (Yusuf and Muhammad, 1954a; Saini, 1965; Tse et al., 1969; Ricaud, 1969). Moreover, there was very high significant correlation found among biocane, soil moisture and soil microbial biomass (Torabi et al., 2008).

With respect to industrial point of view, the sucrose content is very important because they only concerned with sucrose percentage for the production of Sugar. Cane quality is generally determined by sucrose content. Those varieties which have less sucrose contents are less familiar among the farming community due to their lower price in the market. In the above conducted study, sucrose content in cane juice was not influenced significantly by fertilizer application and biocane treatments. However, the sucrose content in cane juice averaged between 16.90 to 17.78%. The results of the experiment are in close agreement with the finding obtained by Lakshmikantham (1974), Ali and Ahmad (1967) and Mathur (1972) who reported that the application of NPK, individually or in combination, did not result in a significant increase in juice sucrose contents.

Conclusion

It is concluded from the above results that in the case of sugarcane variety SPSG-26, when fertilizer application was at N: P: K - 170:85:85 kg ha^{-1} + biocane 2.5 l ha^{-1} proved to be sufficient for getting higher cane growth, yield and sucrose contents.

ACKNOWLEDGEMENT

High appreciation to the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan for the provision of necessary facilities in conducting this experiment.

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