Influence of nutrient application on growth and productivity of spring planted sugarcane (*Saccharum officinarum L.) in sub- tropical North India*

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ABSTRACT: To study the effects of macro and micro nutrients application on sugarcane yield, an experiment was conducted in spring season for two consecutive years i.e. 2011-12 and 2012-13 at the Norman E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand. The experiment consisted of twelve treatments viz. control (no fertilizer), N, NP, NPK, NPKS, NPKZn, NPKFe, NPKMn, NPKSZn, NPKSZnFe, NPKSZnFeMn and FYM was laid out in Randomized Block Design with three replications. The experimental findings revealed that the crop fertilized with NPKSZn (120+60+40+40+25 kg/ha) recorded better growth and the highest cane yield (108.7 t/ha and 109.4 t/ha, respectively) during both the years but remained at par with NPKSZnFe and NPKSZnFeMn. The increase in cane yield under NPKSZn over control was 39.1 and 38.8 %, respectively during both the years. Yield attributes viz. number of millable canes, cane girth and cane length were also found higher under this treatment. Alone application of FYM was not effective in improving growth and cane yield.

Key words: Cane yield, nutrients, sugarcane

The analysis of sugarcane productivity trend during recent years revealed that cane productivity throughout the country is almost stagnant. Besides biotic and abiotic stresses, non availability of suitable varieties, late planting of sugarcane and intensive cultivation coupled with imbalanced fertilization are major cause of its low productivity. Sugarcane- ratoon-wheat is the most dominant cropping system in western Uttar Pradesh and *tarai* region of Uttarakhand. This crop sequence being typical monoculture is very exhaustive. On an average, the sugarcane crop yielding 100 tonnes cane removes 208 kg N, 52 kg P, 280 kg K, 3.4 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2 kg Cu/ha from soil (Yaduvanshi and Singh, 1995). Hence, the nutrient removal by this crop is more than addition; resulting the negative nutrient balance. As a result most of the Indian soil has turned deficient in nitrogen, phosphorus, potassium and sulphur. The deficiency of several micronutrients such as Fe, Zn and Mn are emerging in soils on a large scale. Analysis of soil in India has indicated that 48 % of soils are deficient in Zn, 12 % in Fe, 5% in Mn and 41 % in sulphur (Singh, 2009).

Both macro and micro nutrients are essential for plant growth and development and have unique roles. Nitrogen is essential for the production of amino acids, proteins, enzymes, hormones, phytoalexins and phenolics. N is important to meristematic activity and in this way stimulates vegetative growth and tillering in sugarcane crop. P is essential for energy transfer and required especially in establishing a healthy root system. K plays an important role in controlling the moisture economy of the plant through osmo-regulation in stomata, helps in starch formation in the stalk and stimulates translocation of sugars in the phloem. The role of sulphur in sugarcane is vital and complex as that of nitrogen. It is essential for the formation of plant carbohydrates and protein. Intensive cropping, prolonged use of S free fertilizers and lack of inadvertent addition of organic matter have depleted the soils of their sulphur reserves leading to an adverse effect on cane yield.

Indo-gangetic alluvial plains are generally deficient in micro nutrient such as Zn, Fe and Mn due to inorganic farming. The intensive cultivation also resulted in micro nutrient deficiency and it is one of the yield limiting factors. In fact with the cultivation of high yielding varieties grown year to year irrigated crop rotation with libral use of input, the need for use of micro nutrient along with major and secondary nutrient came in a big way to improve sugarcane tonnage. The micronutrients have great role in sugarcane in the synthesis and translocation of sugar and also in the catalytic and other metabolic activities. Chlorosis in sugarcane is attributed to the deficiency of iron which results in considerably yield losses. Zinc is a necessary component of many enzymes regulating metabolic activities. Manganese helps in certain oxidation process in plant metabolism, development of meristematic tissues as well as synthesis and breakdown of proteins through increased enzyme activity.

Organic manures provide many nutrients in addition improving the physical, chemical and biological properties of soils. Organic manures further facilitate growth of micro organisms, assist in the better uptake of nutrients and counteract the adverse effect of agro-chemicals.

Largely, it has been observed that the application of various nutrients to sugarcane crop is limited. The stagnation in crop productivity can't be boosted without the balanced use of macro and micronutrients to overcome the existing deficiencies. To compensate deficiencies of the nutrients, supplementing of these nutrients is of utmost importance. Keeping the above facts in view, the experiment was conducted with the objective to study the effect of macro and micro nutrients on yield of sugarcane.

MATERIALS AND METHODS

A field experiment at Norman E. Borlaug crop research centre of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India was conducted for two consecutive years *i.e.* 2011-12 and 2012-13. Research centre is situated 29^0 N latitude, $79.5\ ^0$ E longitude and 243.84 meter above above mean sea level altitude. Climate of the Pantnagar is classified as humid sub-tropical with hot summer and cold winter. Experiment was conducted in Randomized Block Design with twelve treatments *i.e.* Control, N, NP, NPK, NPKS, NPKZn, NPKFe, NPKMn, NPKSZn, NPKSZn,Fe, NPKSZnFeMn and FYM. All the treatments were replicated three times. Nitrogen (120 kg/ha), P_2O_5 (60 kg/ha), K_2O (40 kg/ha), S (40 kg/ha), Zn (25 kg/ha), Mn (50 Kg/ha), Fe (1 % spray of ferrous sulphate thrice at weekly interval was done at vegetative stage, FYM (20 ton/ha). Full dose of Phosphorus, Potash and other nutrients and half dose of N were applied as basal and remaining half dose of N was given in two splits before June (onset of monsoon). Experimental soil was clay loam in texture, rich in organic carbon (1.11 %), low in available N (224.1 kg N/ha), rich in Phosphorus (42.8 kg P_2O_5/ha), medium in Potassium (258.6 kg K_2O). Sulphur was 47 kg S/ha. The level of other nutrients in soil were (Zn 2.0 mg/ kg, Fe 36.2 mg/kg, Mn 35.8 mg/kg). Sugarcane seed (3 budded) setts of the variety Co Pant 90223 were planted end to end per meter row in 15 cm deep furrows open at 75 cm apart. Before planting setts were treated with fungicide Emessan 0.25 % to prevent the crop from infection if any. Before, preparation the land one pre sowing irrigation was given to ensure good moisture for proper germination. The crop was planted on February 16 during 2011 and February 27, during 2012 and crop was harvested after maturity in the month of February during both the years. Crop was raised with recommended package & practices. Nutrients were applied as per treatment.

RESULTS AND DISCUSSION

Growth

Nutrient application resulted significant variations in growth parameters viz. bud emergence and shoot population (Table 1). Application of NPKSZn being at par with NPKS, NPKZn, NPKSZnFe and NPKSZnFeMn recorded higher emergence percentage (57.8 %) at 45 days after planting than remaining treatments during both the years and was also at par with NPKFe and NPKMn during 2012-13. Crop grown without fertilizers had the lowest emergence. The higher emergence under nutrient combination treatments clearly indicate requirement of micro nutrients along with NPK for bud germination.

Crop nourished with NPKSZn attained significantly more shoot population than rest of the treatments but remained at par with NPKSZn+Fe and NPKSZnFe+Mn during both the years. Minimum shoot population was obtained in control treatment that was at par with FYM. Since shoot population of sugarcane crop depends on germination percentage and tillering, hence higher shoot population in NPKSZn may be attributed to better germination and higher emergence under this treatment. Bokhtiar and Sakurai (2005) also observed better growth with the application of sulphur and zinc over recommended NPK.

Yield attributes

The data revealed that yield attributes viz. cane length, cane girth, individual cane weight and number of millable canes varied significantly due to different nutrient treatments but number of inter nodes per cane remained non significant (Table 1 & 2).

Table 1: Effect of nutrients on emergence, shoot population, cane length and cane girth of sugarcane

Treatments	Emergence (%) at 45 DAP		Shoot population (000/ha) at 210 DAP		Cane length (cm)		Cane girth (cm)	
	2011-2012	**2012-2013**	**2011-2012**	**2012-2013**	**2011-2012-**	**2012-2013**	**2011-2012-**	**2012-2013**
T_1 (control)	36.6	35.5	99.4	99.7	160.0	162.7	7.0	6.6
T_2 (N)	50.7	48.8	118.5	119.1	216.7	216.7	7.5	6.9
T_3 (NP)	50.9	49.4	131.1	132.5	226.7	229.0	7.6	7.1
T_4 (NPK)	51.8	50.2	136.6	136.6	230.0	231.7	8.0	7.2
T_5 (NPKS)	54.2	53.0	149.0	150.2	233.3	236.0	8.2	7.4
T_6 (NPKZn)	55.4	54.4	181.1	180.7	240.0	245.6	8.2	7.5
T_7 (NPKFe)	52.8	51.7	168.9	169.2	236.7	239.7	8.2	7.4
T_8 (NPKMn)	52.3	51.2	137.8	138.4	230.0	233.7	8.1	7.3
T_9 (NPKSZn)	57.8	56.2	200.0	199.1	263.3	267.0	8.6	8.5
T_{10} (NPKSZnFe)	57.4	55.0	195.5	194.4	250.0	254.3	8.4	8.2
T_{11} (NPKSZnFeMn)	56.7	53.9	191.8	188.1	246.7	247.7	8.3	7.9
T_{12} (FYM)	46.0	44.4	106.6	106.9	200.0	207.0	7.4	6.7
S.Em.±	1.4	1.9	6.3	6.1	6.9	7.2	0.27	0.21
CD at 5 %	4.3	5.8	18.6	17.9	20.5	21.2	0.81	0.63

Table 2: Effect of nutrients on yield attributes and cane yield

Treatments	No. of internodes per cane		Individual cane weight (kg)		NMC (000/ha)		Cane yield (t/ha)	
	2011-2012	**2012-2013**	**2011-2012**	**2012-2013**	**2011-2012-**	**2012-2013**	**2011-2012-**	**2012-2013**
T_1 (control)	18.3	17.2	0.86	0.85	90.1	91.3	66.2	67.0
T_2 (N)	19.9	18.8	1.03	1.01	101.3	99.5	83.9	84.4
T_3 (NP)	17.3	19.5	1.04	1.03	104.5	102.4	87.3	88.8
T_4 (NPK)	18.9	18.9	1.05	1.03	104.3	103.1	89.4	90.6
T_5 (NPKS)	18.5	19.9	1.09	1.10	110.0	108.5	96.7	98.6
T_6 (NPKZn)	19.0	20.1	1.14	1.13	111.1	110.8	99.8	101.0
T_7 (NPKFe)	20.1	19.5	1.13	1.12	110.6	110.2	99.3	100.3
T_8 (NPKMn)	18.9	19.1	1.06	1.04	105.0	104.1	90.9	90.8
T_9 (NPKSZn)	22.3	21.1	1.20	1.21	121.4	121.5	108.7	109.4
T_{10} (NPKSZnFe)	20.5	20.9	1.18	1.18	119.5	116.4	105.0	106.6
T_{11} (NPKSZnFeMn)	21.6	20.8	1.15	1.17	115.7	115.9	101.9	102.0
T_{12} (FYM)	18.5	17.7	0.96	0.91	100.5	96.6	83.5	80.0
S.Em.±	1.2	1.1	0.48	0.55	5.8	4.4	3.7	2.7
CD at 5 %	NS	NS	0.14	0.16	17.0	13.0	10.9	8.0

Application of NPKSZn resulted in significantly higher cane length (263.3 and 267.0 cm), though at par with that of NPKSZnFe and NPKSZnFeMn, but significantly higher than that rest of the treatments during both the years. However, control plots attained a lowest cane length followed by FYM. Crop fertilized with NPKSZn had a significant higher cane length which may be attributed to involvment of these nutrients in increasing cell division and cell elongation specially Zn in internode elongation. Crop raised with NPKSZn had significant more cane girth than control, N, and FYM, during both the years but was at par with the rest of the treatments during 2011-12 and with NPKSZnFe and NPKSZnFeMn during 2012-13. Whereas, the minimum cane girth was recorded in control treatment followed by FYM. The reason cited for more cane length under NPKSZn treatment also hold true for cane girth. The number of internodes per cane did not significantly influenced by different treatments however, value was maximum in NPKSZn and minimum in control treatment during both the years. Crop fertilized with NPKSZn had the heaviest individual cane weight during both the years (1.20 kg and 1.21 kg, respectively) that significantly higher than rest of the treatments but was at par with that of NPKS, NPKZn, NPKFe, NPKMn, NPKSZnFe and NPKSZnFeMn, except NPKS and NPKMn in 2012-13.

The crop grown without fertilizers had significantly lowest cane weight followed by FYM during both the years. The results indicated that during both the years the application of NPKSZn produced significantly higher number of millable canes (121.4 000/ha and 121.5 000/ha, respectively) than control, N, NP, NPK and FYM but remained at par with NPKS, NPKZn, NPKFe,NPKSZnFe and NPKSZnFeMn, except NPKMn in 2012-13. Significantly lower numbers of millable canes were recorded in control treatment during both crop seasons. The crop receiving NPKSZn, produced the highest number of millable canes owing to more shoot population and higher conversion ratio of shoots into millable canes.

The higher values of yield attributes in treatments having NPKS and micro nutrients might be ascribed to better growth of crop. The results are in the line of findings of Bokhtiar *et al.* (2003) who reported improvement in yield attributes due to integrated supply of micro nutrients along with recommended NPK.

Cane yield

The data revealed that among the different treatments, NPKSZn being at par that of NPKZn, NPKFe, NPKSZnFe and NPKSZnFeMn, recorded significantly higher cane yield (108.7 t/ha) than rest of the treatments during crop season 2011-12 (Table 2). Though the highest cane yield was also recorded under NPKSZn (109.4 t/ha) during 2012-13 but was statistically at par only with that of NPKSZnFe and NPKSZnFeMn. The lowest cane yield was obtained in the control treatment (66.2 and 67.0 t/ha, respectively) in both the year that was significantly inferior to rest of the treatments. The per cent increase in cane yield under NPKSZn compared to control and FYM was 39.1 and 23.2, respectively during 2011-12 while during 2012-13 the values were 38.8 and 26.9, respectively.The cane yield in the treatments in which NPKSZn were supplemented with Mn (50 kg/ha) and Fe (1%) spray of $FeSO_4$ thrice in weekly intervals at vegetative phase could not perform better than NPKZnS during both the years. Thus, no response of crop to Mn and Fe fertilization advocates their application only in deficient areas. No improvement in cane yield under FYM indicates incapability of sole FYM to fulfil high nutrients demand of sugarcane crop. This suggested that sugarcane yield is more responsible to secondary and micro nutrient as compared to only nitrogen application. There is a positive role of sulphur and zinc along with major nutrient in increasing the productivity of sugarcane.

Cane yield is a function of the number of millable cane (NMC) and individual cane weight. The NMC is a unit area depends on initial plant population. Tillering makes shoot population which is the direct effect of emergence and less mortality in the last stage of crop growth.The higher cane yield in NPKSZn may be ascribed to higher NMC which was the result of higher shoot population. Moreover, heavier cane weight under this treatment led to more cane yield. Higher fertility levels had significant impact on growth and yield attributes which ultimately contributed to more cane yield. Similar findings were also reported by Kumar (2012). The positive role of S and Zn in enhancing cane yield was also observed by Singh *et al. (*2003). They also reported that addition of Fe and Mn did not show any effect on yield.

CONCLUSION

The application of 40 kg S and 25 kg $ZnSO_4$ /ha along with recommended dose of N (120 kg/ha), P_2O_5 (60 kg/ha) and K_2O (40 kg/ha) is required to get higher productivity of spring planted sugarcane in sub-tropical North India. Alone application of FYM is not effective in improving the growth and cane yield.

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Received: January 3, 2014
Accepted: July 23, 2016