Environment and Ecology 39 (4) : 980—984, October—December 2021
ISSN 0970-0420

Influence of Plant Growth Regulators on Yield, Juice Quality and Nutrient Uptake bySugarcane Grown under Waterlogged Situation of North Bihar

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Received 22 April 2021, Accepted 16 September 2021, Published on 6 October 2021

ABSTRACT

A field experiment was conducted to evaluate the effect of growth regulator on productivity and juice quality of sugarcane (cv BO 154) grown under waterlogged condition during the year 2015-16. The different dose of bio-chemicals treatments viz., gibralic acid (GA), cytokinin and indole acidic acid (IAA) were applied as seed treatment and foliar spray at grand growth stage of sugarcane along with control (100% NPK) in RBD. The mean germination varied from 22.86 -30.44%, plant height 251.70 - 271.67 cm and millable cane 74.01-90.41× 10^3 ha^{-1} due to different bio-chemical treatments. The soaking of cane sets and its foliar spray applied @100 ppm GA and IAA at grand growth stage of sugarcane significantly increased the number of millable canes,cane yield,cane diameter, cane weight and yield of sugarcane over control. The mean cane yield (60.72 - 72.46 t ha^{-1}) and sugar yield (6.98-9.17 ha^{-1}) varied significantly-being highest in plots receiving 100 ppm IAA. The juice quality parametersviz. brix, sucroseand purity coefficient increased significantly due to application of IAA. Pol in juice (16.65-17.45%) and commercial cane sugar (11-50-12.65 %) varied significantly due to different treatments. However, effect of cytokinin was non-significant. The uptake of NPK by sugarcane plant also increased and varied significantly for N (142.41- 178.83 kg ha^{-1}), P (14.25- 16.43 kg ha^{-1}) K (152.78- 184.07 kg ha^{-1}) due to application of IAA/ GA and followed the similar trend of cane yield. Our findings suggest that soaking cane sets over night before planting and its two foliar spray with GA or IAA @ 100 ppm at grand growth stage at one month intervals was found beneficial for enhancing nutrient uptake, cane and sugar yieldof sugarcane grown under waterlogged condition.

Keywords Growth regulator, Yield, Juice quality, Sugarcane.

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INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is an important sugar crops in the world and widely grown as cash crop in 5.0 mha area in India. It faces different vagaries of nature including biotic/ abiotic stress during its active growth stages. Several reasons can be assigned to this low productivity and low recovery but one of the major reasons is water logging due to flooding

which come nearly 50 % of the sugarcane growing area in Bihar. The state of Bihar is known for the net work of rivers flowing through the State. These net works of rivers create havoc of floods during monsoon every year affecting over 60% of the catchment area. The problem of flood is severe especially in North Bihar due to different rivers originating from Nepal. All the eleven sugar factories, operative at present, are located in North Bihar. Farmers of North Bihar in different reserve areas of sugar factories are forced to take sugarcane crop in waterlogged and flood affected areas because this crop yields something and there is no case of total loss of the crop. Surface drainage facilities are poor and inadequate in sugarcane growing area of Bihar causing serious and acute problem of water-logging.

The water-logging affects root aeration, resulting in significant morphological and physiological changes, besides limiting the nutrition of plant. About 40% of the sugarcane growing area in Bihar fall under waterlog condition resulted in about 30% reduction in cane yield. Losses due to water-logging mainly depend up on depth and duration of water-logging and sugarcane genotypes grown. As the soil is saturated with water for a long period, anaerobic soil environment is created. Depletion of O_2 in soils create unfavorable soil chemical, physical and biological environment for the growth of sugarcane crop. Further, root respiration is adversely affected which leads to reduced uptake of nutrients and water by the plant. As such, water-logging causes not only decrease in yield but also lower down the sucrose percentage. Higher rate of stalk mortality, low relative growth rate and reduced cane yield are major effects of water-logging. Cane yield and juice quality loss due to water-logging depends upon genotype, environmental conditions, stage of development and duration of inundation (Orchard and Jessop 1984). The sugarcane growing farmers of Bihar have a tendency to apply frequent and high dose of nitrogenous fertilizer which leads to deterioration in juice quality, damage by insect-pest, lodging of the cane and soil health. Sanyal *et al*.(2014) reported that management of soil fertility status is essential in increasing crop productivity and improving nutritional security, while maintaining soil health and environmental quality. Plant growth regulators are organic compounds, other than nutrients, that modify plant physiological process and yield of crop indirectly (Suman Mahaveer 2017, Morgan 1979). It promote cell division, cell enlargement there by accelerate the growth and development of plant. Several plant hormones have been shown to effect germination of seeds of some plant species and stimulate root initiation (Nickell 1982). Keeping in view the above facts the present experiment was formulated to evaluate the effect of plant growth regulators on yield, juice quality and nutrient uptake by sugarcane grown under waterlogged situation of north Bihar.The plant hormones are extremely important agent in the integration of developmental activities. Environmental factors often exert inductive effects by evoking changes in hormones in metabolism and distribution within the plant. Apart from it, they also regulate expression of intrinsic genetic potential of plants. Plant growth regulators or phytohormones are organic substances produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production and active in minute amounts. Plant growth regulators include auxins, gibberellins, cytokinins, ethylene, growth retardants and growth inhibitors.

MATERIALS AND METHODS

The present investigation was carried out during 2015-16 in a State Govt funded research project by Cane Industry Department, Govt of Bihar to evaluate the effect of growth regulator on productivity and quality of sugarcane (cv BO 154) grown under waterlogged condition at sugarcane research farm, Pusa Bihar. The farm is situated at 25°98' N latitude, 85°67' E longitude and at an altitude of 52.0 m above mean sea level. The climate of study area was sub-tropical with mean annual rainfall of about 1200 mm out of which 75% received during the monsoon period (mid June - mid September). The experimental soil was sandy -loam in texture with high in free calcium carbonate (> 22%) with moderate in fertility. The pH of initial soil was 8.35, EC 0.44 dS/m and 0.44 % organic carbon. The available N, P and K content of initial surface soil was 228.93, 19.78 and 105.08 kg/ha, respectively. The depth of water varied from 50 -150cm during the crop growth stages. The different dose of bio-chemicals

Table 1. Effect of growth regulators on growth and yield attributes of sugarcane.

Treatments	Germination (%)	Tiller (× 10^3)	Cane height (cm)	NMC (000/ha)	Single cane weight (g)	Girth (cm)	Cane yield (t/ha)
T_1 : Control	22.86	92.93	251.70	74.01	740	2.60	60.72
T_2 : 50 ppm GA	23.29	95.26	271.67	79.46	752	2.64	65.31
T_3 : 100 ppm GA	25.34	102.06	271.60	88.93	790	2.73	69.31
T_4 : 50 ppmCKN	26.23	112.40	250.03	74.80	752	2.64	61.61
T_5 : 100 ppm CKN	26.83	126.13	253.23	82.40	754	2.62	63.32
T_6 : 50 ppm IAA	28.40	138.53	260.00	87.08	768	2.67	70.34
T_7 : 100 ppm IAA	30.44	142.33	265.33	90.41	805	2.70	72.46
SEm±	1.05	3.20	4.08	3.2	4.79	0.03	1.10
CD (p=0.05)	3.26	10.15	12.71	10.06	15.0	0.09	3.44

treatments viz., gibberellic acid (GA), cytokinine and indole acetic acid (IAA) were applied as seed treatment and foliar spray at grand growth stage of sugarcane along with control (100% NPK) replicated thrice in RBD. The detail of treatments consisted of T_1- Control (RDF: N 150, P_2O_5 85, K_2O 60 kg ha^{-1}), T_2- RDF + 50 ppm GA (Gibberellic acid),T_3- RDF + 100 ppm GA (Gibberellic acid), T_4- RDF + 50 ppm cytokinin, T_5- RDF + 100 ppm cytokinin, T_6- RDF + 50 ppm IAA (Indole acetic acid) and T_7- RDF + 100 ppm IAA (Indole acetic acid). The recommended dose of fertilizer 150–85–60 kg N–P_2O_5–K_2O /ha were applied through Urea, DAP and MOP. The half dose of the nitrogen was applied as basal and remaining half dose in two equal splits. The different plant growth regulators i.e. gibralic acid (GA), cytokinine and indole acidic acid (IAA) were used as sett treatment and foliar spray. The growth regulators treatments were applied on sugarcane setts with soaking of plat growth regulators before planting and as foliar spray for two times during grand growth stage of crop (150 days after planting) at one month intervals. Initial soil sample were analyzed for pH and EC in 1:2 soils: water ratios (Jackson 1973). The organic carbon was estimated by chromic acid digestion method (Walkey and Black 1934) The available N was estimated using alkaline permanganate method (Subbiah and Asijia 1956), available P by double beam spectrophotometer (Olsen *et al*.1954) and available K was determined by flame photometrically (Jackson 1967). Whole plant was analyzed for N, P and Kusing standard procedure and their uptake was calculated. The cane juice quality viz. brix, pol and purity were determined as per method given by Spencer and Meade (1964). The data were analyzed statistically.

RESULTS AND DISCUSSION

Growth, yield attributes and cane yield

The mean germination (22.86 -30.44%), tillers (92.93 -142.33×10^3 ha^{-1}) and cane height (251.70 - 271.67 cm) varied significantly due to different treatments. The set treatment with cytokinin/ IAA significantly increased germination of cane. The application of either GA @ 100 ppm/ cytokinin and IAA significantly increased number of tillers at 120 days after planting where as cane height at maturity stage was significant for T_2 and T_3 treatments receiving GA.

In general number of millable cane (NMC), cane weight and single cane girth increased significantly in treatments T3, T_6 and T_7. The cane yield varied from 60.72- 72.46 t/ha among treatments. The treatments receiving either GA (T_3) or IAA (T_6 and T_7) increased cane yield significantly. The highest cane yield was recorded in treatment T_7 receiving 100 ppm IAA which was at par with T_3 and T_6 receiving 100 ppm GA and 50 ppm IAA, respectively. The mortality of tiller was less and yield attributing characterises was more pronounced in plots treated with GA/IAA resulted in higher cane yield.The data indicated that application of IAA and GA significantly enhanced yield attributing characteristics of sugarcane viz., cane diameter; single cane weight resulted in higher yield of sugarcane. Plant growth regulators are organic compounds, other than nutrients, that modify plant physiological process and yield of crop indirectly (Morgan 1979).

Table 2. Effect of growth regulators on sugarcane juice quality.

Treatments	Juice quality (%)				Sugar yield
	Brix	Sucrose	Purity	CCS (%)	(t/ha)
T_1 : Control	18.90	16.65	88.10	11.50	6.98
T_2 : 50 ppm GA	19.20	17.01	88.59	11.78	7.69
T_3 : 100 ppm GA	19.50	17.15	87.95	12.43	8.62
T_4 : 50 ppm CKN	19.00	17.00	89.47	12.35	7.61
T_5 : 100 ppm CKN	19.60	17.10	57.24	12.41	7.86
T_6: 50 ppm IAA	19.90	17.20	86.43	12.48	8.78
T_7 :100 ppm IAA	20.40	17.45	85.54	12.65	9.17
SE m±	0.20	0.16	0.60	0.07	0.20
CD (=0.05)	0.79	0.51	1.89	0.22	0.81

Juice quality and sugar yield

The juice quality parameters viz. brix and sucrose content increased significantly due to application of IAA applied @100 ppm, however purity coefficient increased in plots treated with IAA. Brix (18.90 -20.40%) Pol (16.65-17.45%) and commercial cane sugar (11-50-12.65 %) varied significantly due to application of different growth regulators. However, the effect of cytokinin was non-significant. Brix indicates the total dissolved solids in the cane juice and pol is directly related to sucrose content in cane juice. The results indicated that application of IAA (T_7) recorded maximum increase in juice quality in terms of brix and pol percent.The purity of cane juice varied (86.43 -89.47%) and influenced by different treatments. The highest purity (89.47%) was recorded in T_4 receiving 50 ppm cytokinin. The sugar yield increased and varied significantly from 6.98- 9.17t ha^{-1} due to application of growth hormones. The application of GA and IAA resulted in significant increase in sugar yield over control. The application of IAA (T_7) recorded maximum increase in sugar yield. Sugar yield is the function of juice quality and cane yield. The improved juice quality parameters and higher cane yield resulted in maximum sugar yield.

Nutrients uptake

The uptake of nutrients (NPK) by sugarcane plant at harvest stage increased significantly due to application of IAA/ GA (Table 3). The uptake of N (142.41 to 178.83 kg ha^{-1}), P (14.25 to 16.43 kg ha^{-1}) K (152.78 to 184.07 kg ha^{-1}). The maximum nutrient uptake for N, P and K has been recorded in T_7 receiving 100 ppm IAA and the lowest in T_1 (Control).The application of IAA improved the nutrient concentration in plant by accelerating the growth characteristics during tillering and grand growth stage of plant. Moreover, higher yield resulted in more uptakes of NPK by plant. The waterlogged condition prevails after 180 days after planting of spring sugarcane. The cane sets treatment and foliar spray of growth regulator accelerates the plant growth by root proliferation and enhanced nutrient uptake by crop under water logging condition. Several plant hormones have been shown to effect germination of seeds of some plant species and stimulate root initiation (Nickell 1982).

Our findings suggest that soaking cane sets over night before planting and its two foliar spray with GA or IAA @ 100 ppm at grand growth stage at one month intervals was found beneficial for enhancing

Table 3. Effect of growth regulators on nutrient uptakes by sugarcane plant at harvest stage. Note: RDF (N150, P_2O_5 85; K_2O 60 kg/ha) applied in all the treatments. GA; Gibberellic acid CKN; Cytokinin and IAA; Indole acetic acid.

Treatments	Uptake of macro nutrients (kg/ha)		
	N	P	K
T_1: Control	142.41	14.25	152.78
T_2 : 50 ppm GA	154.24	15.35	176.98
T_3: 100 ppm GA	163.64	16.23	177.10
T_4: 50 ppmCKN	145.58	14.53	156.62
T_5: 100 ppm CKN	149.57	14.81	160.95
$T_{6:}$ 50 ppm IAA	171.05	16.42	178.56
T_7:100 ppm IAA	178.83	19.43	184.07
SEm±	3.20	0.40	3.27
CD (p=0.05)	10.03	1.25	10.17

nutrient uptake, cane and sugar yield of sugarcane grown under waterlogged condition.

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