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Naveen Kumar Ranga
Department of Soil science, CCS Haryana Agricultural University, Hisar, Haryana, India

Sanjeev
Department of Soil science, CCS Haryana Agricultural University, Hisar, Haryana, India

Vijay Kumar
Department of Soil science, CCS Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Naveen Kumar Ranga
Department of Soil science, CCS Haryana Agricultural University, Hisar, Haryana, India

Effect of foliar application of NPK on sugarcane yield and its parameters

Naveen Kumar Ranga, Sanjeev and Vijay Kumar

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Abstract
Sugarcane is important cash crop of India as well as Haryana. Haryana is 7th largest producer of sugarcane in the country. In India sugarcane is cultivated all over the country from latitude 8^0 N to 33^0 N, except cold hilly areas like Kashmir valley, Himachal Pradesh and Arunachal Pradesh. The experiment was conducted at Regional Research Station, Uchani (Karnal) of CCS Haryana Agricultural University. The study was conducted to evaluate the effect of foliar application of NPK on cane yield, yield attributes (NMC (number of millable canes) (000 ha^{-1}), cane girth (cm), and cane length (m) of sugarcane variety CoH119. The experiment included 14 treatments of RDF (recommended dose of fertilizers) plus different combination of foliar spray which were used in RBD design of plot size of 6m x 6m. The highest number of cane yield (78.60 t/ha), NMC (92010/ha), cane length (1.51m) and cane girth (2.60cm) was found in RDF + 3% urea + 3% DAP + 3% MOP over control i.e. 67.8 t/ha, 82942/ha, 1.20m and 2.16cm and followed by the treatment RDF + 2% urea + 2% DAP + 2% MOP i.e. 78.00/ha, 91274/ha, 1.45m and 2.58 cm respectively. The results suggest a need for revision of already recommended NPK rates to get maximum output and its foliar application in sugarcane growing areas of India and possible other areas of the world.

Keywords: Sugarcane, NMC, cane yield, cane length, cane girth, RDF, DAP, urea, and MOP

Introduction
Sugarcane is a tropical plant (Humbert, 1968) and a warm humid climate is good for growth of sugarcane. However it is well grown in subtropical region of earth i.e. latitude 30^0 N and 35^0 S. Sugarcane occupy an important position in agrarian economy of India. Sugarcane is an exhaustive crop, which removes nitrogen, phosphorus and potash heavily from the soil. In past, sugarcane was mainly grown with the sole application of N fertilizers in Haryana. Excessive use of Nitrogen or exclusive use of N without use of balanced fertilizer has led soils deficient in phosphorus, potash and micronutrients like iron and zinc (Sagwal and Kumar, 1998) [12]. Foliar spray of phosphorus is advantageous because it can be done as and when the requirement of phosphorus is shown by the plant. This can increase the fertilizer use efficiency (Silbertstein and Wittwer 1951; Dixon 2003; Girma *et al.* 2007) [13, 4, 5]. Foliar applied urea solutions being highly permeable and the resultant N metabolites are easily transported from mature leaves to sink organs (Bondada *et al.*, 2001 and Stiegler *et al.*, 2011) [2, 15]. A crop of sugarcane producing one tonne of sugarcane resulted into removal of 5 kg nitrogen, 1.15 kg of P_2O_5 and 5.25 kg of K_2O on an average basis (Keshavaiah *et al.*, 2012) [7]. For achieving the higher cane yield, balanced use of fertilizers is most important. The use of phosphorus in sugarcane increased the cane yield and available P in the soil (Kumar *et al.*, 2005) [10]. The large quantity of NPK is mainly met through Urea, DAP and MOP. Nitrogen deficiency may decrease cane yields, while excess N availability during the ripening period reduces juice quality (Tabayoyong and Robeniol, 1962) [16]. The use of phosphorus in sugarcane increased the cane yield and available P in the soil (Kumar *et al.*, 2005) [10]. Khan *et al.* (2005) [8] reported that with increase in the NPK per hectare, there is decrease in the sugar yield and commercial cane sugar per cent. In Haryana, the fertilizer recommendation for sugarcane crop is nitrogen @150 kg N per hectare, phosphorus @ 50 kg P_2O_5 per hectare, potash @ 50 kg K_2O per hectare. Nitrogen is generally applied in three splits, one third at planting (through urea and DAP), one third at about 6 to10 weeks after planting and one third at before the onset of monsoon. Phosphorus and potash are applied at the time of planting.

Wittwer *et al.* (1957) [18] reported that when urea is applied on the plant foliage, the nitrogen present in it is rapidly absorbed, transported, and metabolized. They observed that when N^{15} labeled urea is applied to sugar cane and tobacco, the absorption and distribution of N^{15} was observed throughout the plant within 24 hours. Burr *et al.* (1957) [3] reported that rapid uptake of N^{15}-labeled urea occurred through the leaves and that within 24 hours and it was transported throughout the plant, even to roots. Anonymous (2016) [1] has reviewed the reasons to use KNO3 in foliar spray, the situations that make KNO3 very beneficial and the recommendations and guidelines for foliar sprayings and reported the crop-specific recommendations for foliar KNO3 sprayings in vegetables, flowers and field crops. With introduction of high yield sugarcane varieties and due to decline in general soil fertility of soils, the recommended dose of NPK may not be sufficient to achieve the potential yield of sugarcane. Kumar and Verma (1999) [9] observed that application of 50 kg P_2O_5 per hectare and above increased the cane yield significantly over the control (37.2 to 56.4 t ha^{-1}). Yadav and Singh (1995) [19] reviewed that the yield response ranged from 0.09 to 1.53 ton millable cane per kg of applied P at 44.8 Kg P/ha in different part of India. There is need to improve the nutrient use efficiency for NPK. but due to decline in general soil fertility of soils, the recommended dose of NPK may not be sufficient to achieve the potential yield of sugarcane. There is need to improve the nutrient use efficiency for NPK. Foliar application of nitrogen, phosphorus and potash can be easily absorbed and utilized by the plant and also increases its use efficiency. Objectives of the study were to evaluate the effect of foliar application of NPK on cane yield, NMC (000 ha^{-1}), yield attributes cane girth (cm), cane length (m).

Study area

The experiment was conducted at Regional Research Station, Uchani (Karnal) of CCS Haryana Agricultural University which is located at latitude of 29º 43'42.19" N, longitude of 76º 58'49.88" E and at an altitude of 253 meters above mean sea level. The climate is sub-tropical with mean maximum temperature ranging between 34-39º C in summer and mean minimum temperature ranging between 6-7º C in winter. Most of the rainfall is received during the months of July to September and few showers during December to late spring.

Determination of physio-chemical properties of the study area

The field selected for conducting the experiment was uniform in fertility gradient. A composite sample of soil from 0-15 cm of soil depth was taken randomly from ten places from the field before preparing layout of the experiment. The soil samples collected were mixed thoroughly, dried and subjected to mechanical and chemical analysis.

One representative soil sample was collected from the experimental site was analyzed for initial chemical and physical properties of the soil such as:

Table 1: Physiochemical properties of soil of the experimental field

Sr. No.	Parameters	Values observed
1.	Soil texture	Clay loam
2.	pH	8.4
3.	EC(dS/m)	0.42
4.	Organic carbon (%)	0.52
5.	Available nitrogen (kg/ha)	123
6.	Available phosphorus (kg/ha)	10.5
7.	Available potassium (kg/ha)	122
8.	$CaCO_3$	NIL

Field preparation

The experimental field was ploughed repeatedly and brought to a fine tilth. The experiment was laid out according to a Randomized Complete Block Design (RCBD) having three replications, denoted as R1, R2 and R3. Each Replication was further divided into 15 equal plots of size 6m x 6m. In each plot of replications R1, R2 and R3 fertilizers were added as per treatments given below

T1: RDF + foliar spray 2% urea
T2: RDF + foliar spray 3% urea
T3: RDF + foliar spray 2% DAP
T4: RDF + foliar spray 3% DAP
T5: RDF + foliar spray 2% MOP
T6: RDF + foliar spray 3% MOP
T7: RDF + foliar spray 2% urea + 2% DAP
T8: RDF + foliar spray 2% urea + 2% MOP
T9: RDF + foliar spray 2% DAP + 2% MOP
T10: RDF + foliar spray 3% urea + 3% DAP
T11: RDF + foliar spray 3% urea + 3% MOP
T12: RDF + foliar spray 3% DAP + 3% MOP
T13: RDF + foliar spray 2% urea + 2% DAP + 2% MOP
T14: RDF + foliar spray3% urea + 3% DAP + 3% MOP
T15: RDF (recommended dose of fertilizer i.e. 150:50:50 N: P_2O_5:K_2O kg/ha)

Nitrogen was applied @150 kg Nha^{-1}, phosphorus @ 50 kg P_2O_5 ha^{-1}, potash @ 50 kg K_2O ha^{-1}. Three sprays of each foliar application of Nitrogen, Phosphorus and Potassium in April, May and June at 15 days' interval were carried out.

Collection of data and recording of observations

Each replication was named and each plot was denoted as per their treatments and observations were taken.

Cane yield (t/h) and Number of millable cane (NMC): After harvesting crop, all the mill able canes were counted for each plot. From this data the NMC per hectare was calculated for each treatment. All the canes were weighted for each plot and cane yield/ha were calculated for each treatment.

Plant girth (cm), plant height (m) and number of internodes: After harvesting the crop the girth, height and Internodes of canes were recorded. 5 canes from each plot were taken and their girth, height and internodes were recorded. Average of these represented the girth, height and internodes of plants in the plot.

Statistical Analysis

After different experiments and observations statistical

analysis is required and possesses utmost importance. For the calculation of different responses of treatments, their correlation and variability can only be estimated by using statistical techniques.

Various relationships between nutrient levels applied in soil versus yield of cane were determined using different regression models. The responses of different plant nutrient levels on yield and its parameters were determined by using ANOVA and LSD ($P< 50$). Common parameters like mean, range, standard error of means and critical difference were calculated. Analysis of variance of the observations recorded on different treatments was carried out as per the standard procedure suggested by Panse and Sukhatme (1985) [11].

Results and Discussion

Effect of Foliar Application of NPK on Yield and Yield Parameters

Cane yield

The application of RDF + foliar spray of 3% Urea alone resulted into significant increase in cane yield over control (RDF) i.e. 9% (Table 2). The application of RDF + foliar spray of 2% urea or 2 or 3% DAP and RDF + foliar spray of 2% or 3% MOP alone failed to produce any significant increase in cane yield over control. However, the application of RDF + foliar spray of 2% urea +2% DAP and the application of RDF + foliar spray of 3% urea+ 3% DAP it is resulted into significant increase in the cane yield over control (RDF) i.e. 7.08% and 15% respectively. Similar result were observed with the application of RDF + foliar spray of 2% Urea+ 2% MOP and the application of RDF + foliar spray of 3% Urea + 3% MOP resulted into 10.52 and 14.45% increase in cane yield over control (RDF). However, the application of RDF + foliar spray of 2% DAP + 2% MOP failed to produce such results. The application of RDF + foliar spray of 3% DAP + 3% MOP found to increase the cane yield significantly and per cent increase was estimated as 9.56% over control. The application of RDF + foliar spray of 2%Urea, 2%DAP and 2%MOP and The application of RDF + foliar spray of 3%Urea, 3%DAP and 3%MOP resulted into significantly higher cane yield over control (RDF) by 15.04 and 15.93%.

Number of mill able canes (NMC)

The application of RDF + foliar spray of 3% Urea alone resulted into significant increase in NMC over control (RDF) i.e. 3.69%.(Table 2) The application of RDF + foliar spray of 2% urea or 2 or 3% DAP and RDF + foliar spray of 2% or 3% MOP alone failed to produce any significant increase in NMC over control. However, the application of RDF + foliar spray of 2% urea +2% DAP and the application of RDF + foliar spray of 3%urea+ 3% DAP it is resulted into significant increase in the NMC over control (RDF) i.e. 6.36% and 6.32% respectively. Similar result were observed with the application of RDF + foliar spray of 2% Urea+ 2% MOP and the application of RDF + foliar spray of 3% Urea + 3% MOP resulted into 6.56% and 7.84% increase in NMC over control (RDF). However, the application of RDF + foliar spray of 2% DAP + 2% MOP failed to produce such results. The application of RDF + foliar spray of 3% DAP + 3% MOP found to increase the NMC significantly and per cent increase was estimated as 6.24% over control. The application of RDF + foliar spray of 2%Urea, 2%DAP and 2%MOP and The application of RDF + foliar spray of 3%Urea, 3%DAP and 3%MOP resulted into significantly higher NMC over control (RDF) by 10.05 and 10.93%.

Table 2: Effect of different treatments on number of mill able canes (NMC) and cane yield

Treatments		NMC	Yield (t/ha)
T1	RDF + 2% urea	85789	71.08
T2	RDF + 3% urea	85999	73.90
T3	RDF + 2% DAP	83124	68.55
T4	RDF + 3%DAP	83138	69.02
T5	RDF + 2% MOP	83655	69.21
T6	RDF + 3%MOP	84875	70.97
T7	RDF + 2% Urea+2% DAP	88221	72.60
T8	RDF + 2% Urea+2% MOP	88381	74.93
T9	RDF + 2% DAP+2% MOP	85069	70.18
T10	RDF + 3% Urea+3% DAP	88184	77.97
T11	RDF + 3% Urea+3% MOP	89445	77.60
T12	RDF + 3% DAP+3% MOP	88118	74.28
T13	RDF + 2% Urea+2% DAP+2% MOP	91274	78.00
T14	RDF +3% Urea+3% DAP+3% MOP	92010	78.60
T15	Control (RDF)	82942	67.80
CD at 5%		2624	4.49

RDF: Recommended dose of fertilizer i.e. 150:50:50 N: P_2O_5:K_2O kg/ha

Cane length

The application of RDF + foliar spray of 3% Urea alone resulted into significant increase in cane length over control (RDF) i.e. 6.67% (Table 3) respectively. The application of RDF + foliar spray of 2% urea or 2 or 3% DAP and RDF + foliar spray of 2 or 3% MOP alone failed to produce any significant increase in cane length over control. However, the application of RDF + foliar spray of 2% urea +2% DAP and the application of RDF + foliar spray of 3%urea+ 3% DAP it is resulted into significant increase in the cane length over control (RDF) i.e. 8.33% and 15% respectively.

Similar result were observed with the application of RDF + foliar spray of 2% Urea+ 2% MOP and the application of RDF + foliar spray of 3% Urea + 3% MOP resulted into 16.67 and 17.5% increase in cane length over control (RDF). However, the application of RDF + foliar spray of 2% DAP + 2% MOP failed to produce such results. The application of RDF + foliar spray of 3% DAP + 3% MOP found to increase the cane length significantly and per cent increase was estimated as 5.83% over control.

The application of RDF + foliar spray of 2%Urea, 2%DAP and 2%MOP and The application of RDF + foliar spray of 3%Urea, 3%DAP and 3%MOP resulted into significantly higher cane length over control (RDF) by 20.83 and 25.83%.

Cane girth

The application of RDF + foliar spray of 3% Urea alone resulted into significant increase in cane girth over control (RDF) i.e. 8.33% (Table 3). The application of RDF + foliar spray of 2% urea or 2 or 3% DAP and RDF + foliar spray of 2% or 3% MOP alone failed to produce any significant increase in cane girth over control. However, the application of RDF + foliar spray of 2% urea +2% DAP and the application of RDF + foliar spray of 3%urea+ 3% DAP it is resulted into significant increase in the cane girth over control (RDF) i.e. 10.11% and 11.11% respectively.

Similar result were observed with the application of RDF + foliar spray of 2% Urea+ 2% MOP and the application of RDF + foliar spray of 3% Urea + 3% MOP resulted into 11.11 and 15.74% increase in cane girth over control (RDF). However, the application of RDF + foliar spray of 2% DAP + 2% MOP failed to produce such results. The application of RDF + foliar spray of 3% DAP + 3% MOP found to increase

the cane girth significantly and per cent increase was estimated as 9.26% over control.

The application of RDF + foliar spray of 2%Urea, 2%DAP and 2%MOP and The application of RDF + foliar spray of 3%Urea, 3%DAP and 3%MOP resulted into significantly higher cane girth over control (RDF) by 19.44% and 20.37%.

Table 3: Effect of different treatments on cane girth and cane height

Treatments		Cane length (m)	Cane girth (cm)
T1	RDF + 2% urea	1.24	2.32
T2	RDF + 3% urea	1.28	2.34
T3	RDF + 2% DAP	1.22	2.16
T4	RDF + 3%DAP	1.22	2.19
T5	RDF + 2% MOP	1.23	2.33
T6	RDF + 3%MOP	1.23	2.33
T7	RDF + 2% Urea+2% DAP	1.30	2.38
T8	RDF + 2% Urea+2% MOP	1.40	2.40
T9	RDF + 2% DAP+2% MOP	1.24	2.32
T10	RDF + 3% Urea+3% DAP	1.38	2.40
T11	RDF + 3% Urea+3% MOP	1.41	2.50
T12	RDF + 3% DAP+3% MOP	1.27	2.36
T13	RDF + 2% Urea+2% DAP+2% MOP	1.45	2.58
T14	RDF +3% Urea+3% DAP+3% MOP	1.51	2.60
T15	Control (RDF)	1.20	2.16
CD at 5%		0.057	0.175

RDF: Recommended dose of fertilizer i.e. 150:50:50 N: P_2O_5:K_2O kg/ha

Conclusion

The application of recommended dose of fertilizer (RDF) + 2 or 3% foliar spray of DAP or MOP alone produced cane yield, NMC, cane length and cane girth at par with control (RDF). Similarly the application of RDF + 3%urea, RDF + 2% urea + 2% DAP, RDF + 2% urea +2% MOP, RDF + 3% urea+3% DAP, RDF + 3% urea + 3% MOP and RDF + 3% DAP + 3% MOP also significantly increased the cane yield, NMC, cane length and cane girth as compare to control (RDF). The highest increased in cane yield NMC, cane length, and cane girth was observed in the treatment of the application of RDF + foliar spray of 3% urea + 3% DAP + 3% MOP as compare to control (RDF). There was no significant change in the in soil physic-chemical properties with the foliar application of 2 or 3% urea or DAP or MOP. The highest net return and B:C ratio were obtained in the treatment RDF + foliar spray of 3% urea + 3% DAP + 3% MOP which is closely followed by the treatment RDF + foliar spray of 2% urea + 2% DAP + 2% MOP. Hence for maximum cane yield and its parameters, the treatment application of RDF + 2% urea + 2% DAP + 2% MOP is recommended, since it is more economical to the farmers.

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