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Response of bidi tobacco (*Nicotiana tabacum* L.) to foliar nutrition with nitrogen and potassium under rainfed conditions

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Abstract
A field experiment was undertaken at Regional Agriculture Research Station, Nandyal, Andhra Pradesh during 2017-18 on vertisols under rainfed condition to study the response of bidi tobacco to supplemental nitrogen (N) and potassium (P) nutrient through foliar application. The treatments consisted of ten treatment combinations from three sources of nutrients (i.e. potassium nitrate (KNO_3), ammonium sulphate + sulphate of potash (SOP) and urea + SOP) and three intervals i.e. foliar spray at 45 days after transplanting (DAT), 60 DAT, 45 and 60 DAT. The experiment was laid out in a randomized block design and replicated thrice. Cured leaf yield of bidi tobacco was significantly higher when foliar application of 2.5% Potassium nitrate (KNO_3) twice at 45 and 60 DAT (1713 kg ha^{-1}) was at par with spraying of 2.5% ammonium sulphate + SOP at 45 & 60 DAT (1606 kg ha^{-1}), 2.5% ammonium sulphate + SOP at 60 DAT (1550 kg ha^{-1}), 2.5% ammonium sulphate + sulphate of potash (SOP) at 45 DAT (1512 kg ha^{-1}), 2.5% Urea + SOP at 45 & 60 DAT (1508 kg ha^{-1}) and 2.5% with KNO_3 at 60 DAT (1503 kg ha^{-1}). Higher leaf length (50.4 cm) and leaf width (20.5 cm) was observed with foliar application of 2.5% KNO_3 twice at 45 and 60 DAT. Higher net returns (Rs 89,265/ha) and BCR (2.87) was recorded with foliar application of 2.5% KNO_3 twice at 45 and 60 DAT.

Keywords: Bidi tobacco, foliar nutrition, cured leaf yield, economics, leaf quality

Introduction
Tobacco (*Nicotiana tabacum* L.) is the most important non-food crop cultivated in more than 100 countries. It is one of the most important commercial crops of India, valued for its leaf containing nicotine. It is grown over an area of 0.46 million ha with production of 0.84 million tones with productivity of 1842 kg ha^{-1}(Agriculture statistics at a glance 2016 at www.agricoop.nic.in & http:// eands.dacnet.nic.in) [1]. The role of potassium (K) and nitrogen (N) nutrients is important in crop production. A deficiency of either one or both of these nutrients causes yield loss. They play a key role in controlling important quality parameters such as leaf colour, texture, hygroscopic properties, combustibility, sugar and alkaloid contents. Balanced N-K fertilization enhances tobacco growth and improves the uptake of both nutrients, which in turn reduces the nitrate losses during and after the cropping season. In Andhra Pradesh, bidi tobacco is commercially cultivated under rainfed black soils in late rainy season i.e, September (2nd fortnight) month. Usually, farmers apply recommended fertilizer dose in two split doses i.e one at basal and one as top dressing at 30 days after transplanting (DAT). Several studies were conducted on nutrient management to improve the cured leaf yields and found less response. However, in present day agriculture, foliar fertilization is very frequently applied in agriculture and also recommended in an integrated plant production component because it is environmental friendly and helps to achieve high productivity with good quality. For nutrients which are phloem mobile, the efficiency of this measure is particularly successful. According to Doring and Gericke (1986) [2] and Tukey and Marczyński (1984) [3], a combined soil and foliar fertilization should be recommended in crop production to increase both crop productivity and yield quality. Foliar fertilization should be done under conditions of decreased nutrient availability in soil, dry topsoil and decreased root activity during the reproductive stage (Wójcik, 2004) [4]. However, the efficiency of foliar fertilization depends on nutrient mobility within a plant. However, crop physiologists have recently developed the technique of foliar application to the agricultural crops (Smolen and Sady, 2009) [5]. Foliar application of potassium is more suitable, target oriented and economical technique for increasing the fertilizer use efficiency and grain yield over soil application (Farooqi *et al.*, 2012) [6]. Hence, the present study was conducted to study the response of bidi tobacco to foliar nutrition of nitrogen and potassium and also to find out the effective source and time of application.

Material and methods

A field experiment was conducted at Regional Agricultural Research Station, Nandyal under rainfed conditions during *kharif* 2017-18. The soil of experimental site was medium deep black, moderately alkaline (pH-8.2), non saline (EC- 0.1 ds/m), low in nitrogen (158.4 kg ha^{-1}), medium in available P_2O_5 (31.1 kg ha^{-1}) and high in available K_2O (354.7 kg ha^{-1}). Experiment comprised of ten treatments, viz., (T_1) Control (No foliar nutrition), (T_2)2.5% Potassium nitrate (KNO_3) at 45 DAT, (T_3) 2.5% KNO_3 at 60 DAT, (T4) 2.5% KNO_3 at 45 and 60 DAT, (T_5) 2.5% ammonium sulphate (A.S) + Sulphate of potash (SOP) at 45 DAT, (T_6) 2.5% A.S +SOP at 60 DAT, (T_7) 2.5% A.S +SOP at 45 and 60 DAT, (T_8) 2.5% Urea +SOP at 45 DAT, (T_9) 2.5% Urea +SOP at 60 DAT and (T_{10}) 2.5% Urea +SOP at 45 and 60 DAT. The experiment was carried out in randomized block design (RBD) with three replications. The row-to-row and plant to spacing was 75 cm. Crop management practices like land preparation, N, P and K fertilizer application, weed control, intercultivation, need based plant protection, de suckering and sun curing were followed as recommended for local area. The nursery was raised during 26-07-17 and healthy seedlings were transplanted on 09-09-17. For foliar nutrition,2.5% potassium nitrate, 2.5% ammonium sulphate + sulphate of potash, 2.5% urea + sulphate of potash was prepared at spraying time and used at 45 and 60 DAT at the rate of 500 liters per hectare by using hand operated knapsack sprayer. The experiment was conducted under rainfed condition. An amount of 519.6 mm of rainfall was received during crop season (July to December) during 2017. Rainfall distribution was highly erratic coupled with prolonged dry spells i.e. 307 mm in 17 rainy days in nursery and 212.6 mm in 13 rainy days in standing crop after transplanting. The data were recorded on ten randomly selected plants of each treatment in replication for plant height, leaf length, leaf width and cured leaf yield at harvest were recorded. Leaf quality parameters like nicotine and reducing sugars were also recorded at harvest. The mean values of all the quantitative characters were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984) [7]. The level of significance used in 'F' test was at 5 percent.

Results and discussion

Growth parameters and cured leaf yield

Foliar nutrition significantly influenced the plant height, leaf length and leaf width. Significantly higher plant height was recorded with foliar nutrition of 2.5% KNO_3 at 60 DAT (65.8 cm) which was at par with all foliar nutrition treatments except control (45.6 cm). Significantly higher leaf length (50.4 cm) and leaf width (20.5 cm) was observed with foliar nutrition with 2.5% KNO_3 at 45 and 60 DAT. Leaf area is an important factor determining the dry matter production of a crop and subsequently the yield. Govindan and Thirumurugan (2000) [8] reported that the growth parameters *viz.*, LAI in green gram were significantly higher with the foliar spray of KNO_3 (%) or KCl (1%) and their combinations. Similar results were reported by ICAR-CTRI Rajahmundry (Damodar Reddy, 2014) [9] which revealed that the application of N and K through foliar sprays improved the leaf area in FCV tobacco. Foliar application of NAA 20 ppm + KNO_3 0.5 percent significantly increased the dry matter production in red gram (Jayarani Reddy *et al.* (2004) [10]. Significantly lower leaf length (32.9 cm) and leaf width (14.9 cm) was observed with control. Significantly higher cured leaf yield (1713 kg ha^{-1}) were recorded with foliar nutrition of 2.5% KNO_3 at 45 and 60 DAT which was on par with 2.5% A.S +SOP at 45 and 60 DAT (1606 kg ha^{-1}), 2.5% A.S +SOP at 60 DAT (1550 kg ha^{-1}), 2.5% Ammonium sulphate (AS) + Sulphate of potash (SOP) at 45 DAT(1512 kg ha^{-1}), 2.5% Urea +SOP at 45 and 60 DAT (1508 kg ha^{-1}) and 2.5% KNO_3 at 60 DAT (1503 kg ha^{-1}). Significantly lower cured leaf yield (1263 kg ha^{-1}) was recorded with control. However, two times foliar nutrition with KNO_3 or ammonium sulphate + sulphate of potash was found significantly superior to one time spray. For foliar nutrition, potassium nitrate and ammonium sulphate are superior which might be due to low salt index (Steve Curley, 1994) [11]. The results confirmed that increased N and K concentration in the foliar spray solution up to six percent affects and increases N and K concentration in the leaves, which in turn increase yields. Moreover, leaf parameters also contributed for increase in cured leaf yield. The similar results were reported by Marchand (2010) [12] where foliar nutrition of SOP increased the concentration of leaf K content and increased tobacco leaf yield. The foliar application of nitrogen alone was more effective than NPK in producing higher number of seeds per pod in lentil (Humayun *et al.*, 2011) [13]. Experimental results on foliar nutrition on FCV tobacco by All India Net work project on Tobacco (AINPT) indicated that the foliar application of N and K at 45 and 55 DAT @ 2.5% concentration increased the cured leaf productivity by 13-14% and there is no difference between the two sources potassium nitrate or ammonium sulphate + SOP (Damodar Reddy 2015) [14]. Foliar spray of potassium 3% concentration was more efficient for increasing growth and yield of maize crop as compared to soil application and fertilization of potassium fertilizer (Abid ali, 2016) [15].

Leaf quality parameters and economics

Leaf nicotine and reducing sugars did not differed with control i.e. no foliar nutrition. These results are similar to the finding of research results of Damodar Reddy (2015) [14]. The economic evaluation of the study revealed that the higher net profit of Rs 89,265/ ha and benefit cost ration of 2.87 was observed with foliar nutrition of 2.5% KNO_3 at 45 and 60 DAT. Lower net profit of Rs 58,265/ ha and benefit cost ration of 2.36 was observed with control (no foliar nutrition).

Table 1: Growth, cured leaf yield, economics and leaf quality as influenced by foliar nutrition of nitrogen and potassium in bidi tobacco

Treatments	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Cured leaf yield (kg/ha)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	Benefit cost ratio (BCR)	Nicotine (%)	Reducing sugars (%)
Control (No foliar nutrition)	45.6	32.9	14.9	1263	101040	42775	58265	2.36	5.06	3.31
2.5% KNO_3 at 45 DAT	58.5	46.5	19.0	1465	117200	45275	71925	2.59	4.05	3.01
2.5% KNO_3 at 60 DAT	65.8	49.5	19.7	1503	120240	45275	74965	2.66	5.19	3.67
2.5% KNO_3 at 45 and 60 DAT	52.6	50.4	20.5	1713	137040	47775	89265	2.87	4.84	3.05
2.5% AS +SOP at 45 DAT	58.1	46.9	17.9	1512	120960	44575	76385	2.71	5.51	3.14
2.5% AS +SOP at 60 DAT	64.4	48.5	19.0	1550	124000	44575	79425	2.78	4.54	3.67
2.5% AS +SOP at 45 and 60 DAT	62.2	49.5	19.9	1606	128480	46375	82105	2.77	4.73	3.55
2.5% Urea +SOP at 45 DAT	54.4	46.7	18.5	1447	115760	44475	71285	2.60	5.04	3.25
2.5% Urea +SOP at 60 DAT	62.9	46.7	19.1	1470	117600	44475	73125	2.64	5.15	3.18
2.5% Urea +SOP at 45 and 60 DAT	59.2	49.1	19.8	1508	120640	46175	74465	2.61	6.16	2.77
S.Em±	3.84	2.63	0.87	73					0.44	0.25
C.D.(P=0.05)	11.4	7.8	2.6	217					NS	NS

AS- Ammonium sulphate; SOP- Sulphate of potash: DAT- Days after transplanting

Conclusion

Foliar application of 2.5% KNO_3 or 2.5% AS + SOP twice at 45 and 60 DAT to bidi tobacco is optimum for cured leaf yield and net returns. Leaf quality parameters like nicotine and reducing sugars were slightly altered by foliar nutrition and observed within the acceptable range. Foliar spray can serve a useful purpose in bypassing the soil to ensure optimal supply of nutrients to plants under conditions where nutrients supply to plants became a limiting factor.

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