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Management of phosphorus and potassium in *bidi* tobacco (*Nicotiana tabacum* L.) under rainfed conditions

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ABSTRACT

A field experiment was undertaken at Regional Agriculture Research Station, Nandyal, Andhra Pradesh for four consecutive seasons from 2015-16 to 2018-19 on Vertisols under rainfed condition to find out the economics and management of phosphorus and potassium in bidi tobacco (Nicotiana tabacum L.) for higher cured leaf yield and quality. The experiment was laid out in a randomized block design with 8 treatments and replicated thrice. The data pooled over four seasons revealed that significantly higher leaf length (42.8 cm) and leaf width (17.3 cm) was recorded with 100% RDF (110 kg N + 70 kg P_2O_5+ 50 kg K_2O ha^{-1}) every year. Significantly higher cured leaf yield (1551 kg ha^{-1}) and net returns (Rs 63,375 ha^{-1}) were recorded with application of 110 kg N + 70 kg P_2O_5+ 50 kg K_2O ha^{-1}every year and on par with 100% RDN (110 kg N ha^{-1}) +PK (70 kg P_2O_5+ 50 kg K_2O ha^{-1}) once in two years (1408 kg $ha^{-1}$and net returns of Rs 59,275 ha^{-1}). Leaf chemical constituents namely nicotine, reducing sugars and chlorides did not differ significantly due to different treatments and were in permissible limit. Post harvest soil analysis indicated that soil available N, P_2O_5 and K_2O differed significantly due to different treatments and maximum amounts of available N (158.9 kg ha^{-1}), available P_2O_5 (56.3 kg ha^{-1}) and available K_2O (537.3 kg ha^{-1}) were recorded under treatment T5, T3 and T5, respectively. Soil pH and EC values were not affected significantly with the various treatments.

Keywords: Bidi tobacco, phosphorus, potassium, cured leaf yield, soil fertility

INTRODUCTION

The *bidi* tobacco (*Nicotiana tabacum* L.) plant requires large quantities of primary nutrients such as nitrogen (N), phosphorous (P), and potassium (K) in order to attain high leaf yield and good quality. Soil depletion of macronutrients is plausible because of the large input requirement to the tobacco crop (Hoyos *et al.,* 2015). Optimum tobacco growth can only be achieved with adequate and well timed nutrient supply under favorable environments. Recently, investigators have reported a decline in soil macronutrients such as K, P, and S after tobacco cultivation (Moula *et al.,* 2018). The release of nicotine into the rhizosphere was considered to have a major impact on the increase or decrease of these nutrients. Thus, nicotine ($C_{10}H_{14}N_2$) released in the soil could be mineralized and increase N in the soils, however, since nicotine is acidic, when mineralized could also influence solubilization of P and K to be readily available to the plant and reduce their levels in the soil. The nutrient P is essential for hastening tobacco root development as well as improvement of the color and quality of leaves.Maintaining an adequate P concentration in the soil solution is necessary for improved yield and quality of tobacco. The nutrient K influences leaf yield and quality of the tobacco (Yang *et al.,* 2007). However, Vann *et al.* (2013) indicated that the residual soil K and soil texture make it challenging to establish the actual amount of K to be supplied to optimize yields especially for the new cultivars bred as higher yielding. Standard bidi tobacco production requires 110 kg N, 70 kg P_2O_5 and 50 kg K_2O ha^{-1} which is closely dependent on mineral nutrient supply. Fertilization also plays a key role in influencing the most important quality parameters such as leaf colour, texture, hygroscopic properties, combustibility, nicotine, reducing sugars and chlorides contents. Keeping these observations in view, the present *[1]ICAR-*

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investigation was designed to manage the application of phosphorus and potassium fertilizers for higher cured leaf yield and quality in rainfed Vertisols of Andhra Pradesh.

MATERIALS AND METHODS

A field experiment was undertaken from 2015-16 to 2018-19 at Regional Agriculture Research Station, Nandyal, Andhra Pradesh on Vertisols under rainfed condition. The soil of experimental site was medium deep black, moderately alkaline (pH-8.3), non saline (EC-0.22 dSm^{-1}), low in nitrogen (122 kg ha^{-1}), medium in available P_2O_5 (50.6 kg ha^{-1}) and high in available K_2O (520.6 kg ha^{-1}). The 8 treatments consisted of T_1- Control; T_2- 110 kg N + 70 kg P_2O_5+ 50 kg K_2O ha^{-1} (yearly); T_3- 110 kg N + 70 kg $P_2O_5ha^{-1}$ (yearly); T_4-110 kg N (yearly) + 70 kg $P_2O_5ha^{-1}$ (once in 2 years); T_5-110 kg N + 50 kg K_2ha^{-1} (yearly); T_6- 110 kg N ha^{-1} (yearly) + 50 kg K_2 (once in 2 years); T_7 -110 kg N (yearly) + 70 kg P_2O_5 + 50 kg K_2ha^{-1} (once in 2 years) and T_8- 110 kg N ha^{-1} (yearly). The experiment was laid out in a randomized block design with three replications. The *bidi* tobacco variety (Nandyal Pogaku-1) was planted at planting geometry of 75 cm x 75 cm. The treatments were imposed through application of ammonium sulphate for nitrogen, single superphosphate for phosphorus and sulphate of potash for potassium. Half of the nitrogen, total phosphorus and potassiumwere applied as basal and remaining half of N was applied as top dressing within 30-40 days after planting. There was lower rainfall then the normal values during September – October of four years of experimentation except excess rainfall during September 2015 (78.1%) and October 2017 (66.2%). The total amount of rainfall received during crop growth period (nursery to harvest) was less than the normal during 2015-16 (22.6%), 2016-17 (-6.8%) and 2018-19 (-65.8%). Crop management practices like nursery raising, land preparation, weed control, intercultivation, de-suckering, need based plant protection and sun curing were adopted as per recommended practice. Measurements of the length, width and dry mass of the middle leaf were made at harvest according to Torrecilla *et al.* (1980).The leaf samples were used for estimating chemical quality constituents *viz.,* nicotine, reducing sugars (Harvey *et al.*, 1969) and chlorides (Hanumantha Rao *et al.*, 1980). Post harvest soil samples were analysed for pH, EC and status of available nutrients by adopting standard procedures (Jackson, 1973). The data gathered in each observation were statistically evaluated using analysis of variance (ANOVA) technique (Panse and Sukhatme 1985). The critical difference (CD) was computed to assess the significance of treatment means at 5% level of probability.

RESULTS AND DISCUSSION

Growth parameters and cured leaf yield

The data pooled over four seasons (2015-16 to 2018-19) revealed that the growth parameters and cured leaf yield differed significantly due to different treatments. Significantly higher plant height (76.3 cm) was recorded with 110 kg N (yearly) + 70 kg P_2O_5 + 50 kg K_2O ha^{-1}(once in two years) and minimum in control (53.2 cm). This was due to topping plants and lower growth of plants in control (Table 1). Higher leaf length (42.8 cm) and leaf width (17.3 cm) was recorded in yearly application of 110 kg N + 70 kg P_2O_5+ 50 kg K_2O ha^{-1} and minimum in control (30.1 cm ; 12.4 cm). This increase in these parameters may be attributed to increased availability of nutrients to the plants. Similar results were reported by Moula *et al.* (2018). Higher cured leaf yield (1551 kg ha^{-1}) was observed in yearly application of 110 kg N + 70 kg P_2O_5+ 50 kg K_2O ha^{-1} and was on par with 110 kg N (yearly) + 70 kg P_2O_5 + 50 kg K_2O ha^{-1} (once in 2 years) (1408 kg ha^{-1}). Higher growth parameters lead to higher cured leaf yield. The control recorded lower cured leaf yield (773 kg ha^{-1}). Zhengxiong *et al.* (2010) reported that yield and quality of flue-cured tobacco were greatly affected by fertilization and especially by nitrogen (N) and potassium (K) supplies. The lack of response to applied K_2O to cured leaf yield was likely due to soils having medium to high K levels (Vann *et al.,* 2012). Continuous fertilization of Oriental tobacco grown as monoculture with very large amounts of phosphate fertilizers was not an effective cultural practice (Bozhinova, 2016).

Table 1: Effect of P and K fertilizers on growth, cured leaf yield and economics of bidi tobacco

Treatments	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Cured leaf yield (kg ha^{-1})	Gross returns (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net returns (Rs ha^{-1})	BCR
T_1	53.2	30.1	12.4	773	58050	33450	24600	1.74
T_2	74.4	42.8	17.3	1551	116325	52950	63375	2.20
T_3	71.4	39.9	16.2	1391	104325	44950	59375	2.32
T_4	66.8	39.6	16.2	1293	96975	42700	54275	2.27
T_5	70.7	40.1	16.5	1253	93975	48450	45525	1.94
T_6	68.8	40.5	16.3	1275	95625	44450	51175	2.15
T_7	76.3	42.3	17.0	1408	105975	46700	59275	2.27
T_8	70.0	38.3	16.0	1058	79350	40450	38900	1.96
S.Em±	3.5	1.8	0.8	83				
CD (P=0.05)	10.2	5.3	2.3	249				
CV (%)	9.5	9.0	10.2	12.3				

Economics

Higher net returns higher net returns (Rs 63,375 ha^{-1}) with benefit: cost ratio of 2.20 was recorded with yearly application of 110 kg N + 70 kg P_2O_5+ 50 kg K_2O ha^{-1} followed by yearly application of 110 kg N + 70 kg $P_2O_5ha^{-1}$ (Rs 63,375 $ha^{-1}$with BCR of 2.32) (Table 1). The wide differences in gross returns and net returns due to various treatments were owing to differences in their performance towards growth and yield of cured leaf. Thus, the differences in yield obtained from the various treatments were responsible to finalise the ultimate net income. Lower net returns of Rs 24,600 ha^{-1} with BCR of 1.74 was observed with control. This may be attributed to lower production of cured leaf under control.

Leaf chemical constituents

The leaf chemical parameters viz., nicotine, reducing sugars and chlorides did not differ significantly due to different topping crop stage and leaf number (Table 2). The leaf chemical parameters were in permissible limits with nicotine ranging from 5.07 to 5.35 % whereas reducing sugars was from 2.94 to 3.45 % and chlorides from 1.24 to 1.49 per cent. Nicotine content tended to decrease with treatments and maximum value (5.32%) was recorded under control. On the other hand the maximum values of reducing sugars (3.45%) and chlorides (1.49%) were recorded with yearly application of 110 kg N + 70 kg P_2O_5 + 50 kg K_2O ha^{-1}. Reducing sugar content was not affected by K_2O application. Reducing sugar levels were not typically correlated with K_2O rate within a rate range where no yield effect was observed (Vann *et al.,* 2012).

Table 2: Effect of P and K fertilizers on leaf chemical constituents of bidi tobacco

Treatments	Nicotine (%)	Reducing sugars (%)	Chlorides (%)
T_1- Control	5.32	3.39	1.24
T_2- 110 kg N + 70 kg P_2O_5+ 50 kg K_2O ha^{-1} (yrly)	5.13	3.45	1.49
T_3- 110 kg N + 70 kg $P_2O_5ha^{-1}$(yrly)	5.27	3.15	1.45
T_4-110 kg N (yrly) + 70 kg $P_2O_5ha^{-1}$ (once in 2 yrs)	5.17	3.12	1.22
T_5- 110 kg N + 50 kg K_2O ha^{-1} (yrly)	5.15	3.15	1.26
T_6- 110 kg N (yrly) + 50 kg K_2O ha^{-1} (once in 2 yrs)	5.25	3.26	1.27
110 kg N (yrly) + 70 kg P_2O_5 + 50 kg K_2O ha^{-1} (once in 2 yrs)	5.35	3.19	1.22
T_8- 110 kg N ha^{-1} (yrly)	5.07	2.94	1.38
S.Em±	0.35	0.25	0.14
CD (P=0.05)	NS	NS	NS
CV (%)	11.7	13.2	17.2

Soil fertility

The values of soil chemical properties of post harvest soil were compared with initial values. There was no significant change in pH and EC due to different treatments (Table 3). The effect of various treatments was statistically at par with each other including initial values. There was an improvement in available nitrogen with various treatments (133.8 - 158.9 kg ha^{-1}) compared to initial value (122.4 kg ha^{-1}). The increase in soil N could have been caused by the mineralization, nitrification, and nicotine released in the soils, that inhibited soil bacteria with a role of converting nitrate into the inorganic form and hence N mineralization rate reduced causing an increase of soil total N (Farooq *et al.,* 2014). It is likely that the tobacco plant creates a favorable environment for increasing N in the rhizosphere as this nutrient is required for nicotine synthesis. Available P content in soil ranged from 31.7 to 56.3 kg $ha^{-1}$and maximum value was recorded with yearly application of 110 kg N + 70 kg $P_2O_5ha^{-1}$.Therefore, these findings indicated that cultivation of tobacco caused a decrease in P (Lisuma *et al.,* 2020). Available K content in soil ranged from 370.1 to 537.1 kg $ha^{-1}$and maximum value was recorded with yearly application of 110 kg N + 50 kg $P_2O_5ha^{-1}$ Application of fertilizer did not increase K levels in soil due to the genetic nature of tobacco plants requiring K for increasing leaf yield and quality (Yang *et al.,* 2007).

Table 3: Effect of P and K fertilizers on post harvest soil chemical properties

Treatment	pH	EC (dSm^{-1})	Available nutrients ($kg\ ha^{-1}$)		
			N	P_2O_5	K_2O
T_1- Control	8.1	0.21	87.8	31.7	370.1
T_2- 110 kg N + 70 kg P_2O_5+ 50 kg K_2O ha^{-1} (yrly)	8.1	0.23	133.8	52.9	508.0
T_3- 110 kg N + 70 kg $P_2O_5ha^{-1}$(yrly)	8.2	0.18	146.3	56.3	410.1
T_4-110 kg N (yrly) + 70 kg P_2O_5 ha^{-1} (once in 2 yrs)	8.2	0.22	150.5	43.1	391.9
T_5- 110 kg N + 50 kg K_2O ha^{-1} (yrly)	8.1	0.18	158.9	32.9	537.1
T_6- 110 kg N (yrly) + 50 kg K_2O ha^{-1} (once in 2 yrs)	8.3	0.22	158.9	35.9	446.3
T_7 -110 kg N (yrly) + 70 kg P_2O_5 + 50 kg K_2O ha^{-1} (once in 2 yrs)	8.2	0.19	154.7	42.3	435.5
T_8- 110 kg N ha^{-1} (yrly)	8.3	0.22	150.5	36.3	384.7
S.Em$\pm$	0.34	0.01	8.00	2.5	23.1
CD (P=0.05)	NS	NS	24.3	7.7	70.0
CV (%)	7.1	11.6	9.7	10.6	9.2
Soil initial properties	8.3	0.22	122.4	50.6	520.6

It may be concluded from the results that the application of 100% RDN (110 kg) +PK (70 kg P_2O_5+ 50 kg K_2O) ha^{-1}once in two years or 100% RDN (110 kg) +P (70 kg P_2O_5) ha^{-1} every year produced higher cured leaf yield and fetched higher net returns and improved soil fertility. The data obtained can be helpful in developing nutrient management plans for *bidi* tobacco grown on Vertisols with medium available soil P_2O_5 and high available soil K_2O.

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REFERENCES

Bozhinova, R. (2016). Effect of long term phosphorus fertilization on the mineral composition of oriental tobacco. *Bulgarian Journal of Agricultural Science* **22**(3): 1-5

Farooq, M., Husssain, T., Wakeel, A. and Cheema, Z.A. (2014) Differential *et al.*response of maize and mungbean to tobacco allelopathy. *Experimental Agriculture* **50**: 611–624

Hanumantha Rao. A., Gopalakrishna C.V.S.S.V. and Satyanarayanamurthy, B.V.V. (1980) Determination of chlorides in tobacco by auto-analyser.*Tobacco Research* **7**: 92-5.

Harvey, W.R., Stahr, H.M. and Smith, W.C. (1969) Automated determination of reducing sugars and alkaloids in the same extract of tobacco.*Tobacco Science* **13**: 13-5.

Hoyos, V. C., Magnitskiy, S. and Plaza, G.T. (2015) Effect of fertilization on the contents of macronutrients and chlorine in tobacco leaves cv. flue-cured (*Nicotiana tabacum* L.) in two municipalities in Huila, Colombia. *Agronomy Colombia* **33**: 174–183.

Jackson, M.L.(1973) Soil Chemical Analysis. Prentice Hall of India Private limited, New Delhi

Lisuma, J., Mbega, E. and Ndakidemi, P. (2020) Influence of tobacco plant on macronutrient levels in sandy soils. *Agronomy* **10**: 1-15

Moula, M.S., Hossain, M. S., Farazi, M.M., Ali, M.H. and Mamun, M.A.A. (2018) Effects of consecutive two years tobacco cultivation on soil fertility status at Bheramara Upazilla in Kushtia District. *Journal of Rice Research* **6**: 190-195.

Panse, V. G. and Sukhatme, P. V. (1985) *Statistical Methods for Agricultural workers*. ICAR, New Delhi .

Torrecilla, G., Pino. A., Alfonso, P. and Barroso.A. (1980).Metodología para las mediciones de los caracteres cualitativos de la planta de tabaco. *Cienc.Téc. Agriculture Tabaco.* **3**(1):21-61.

Vann, M.C., Fisher, L.R., Jordan, D.L., Smith, W.D., Hardy, D.H. and Stewart, A.M. (2013) potassium rate and application effect on flue-cured tobacco (*Nicotiana tabacum* L.). *Agronomy Journal* **105**: 304–310.

Vann, M.C., Fisher, L.R., Jordan, D.L., Smith, W.D., Hardy, D.H. and Stewart, A.M. (2012) The effect of potassium rate on the yield and quality of flue-cured tobacco (*Nicotianatabacum* L.). *Tobacco Science* **49**:14–20.

Yang, T.Z., Lu, L.M., Xia, W. and Fan, J.H. (2007) Characteristics of potassium-enriched, flue-cured tobacco genotype in potassium absorption, accumulation, and in-ward potassium currents of root cortex. *Agricultural Science China.***6**: 1479–1486.

Zhengxiong Z., Chunjian, L., Yuhong, Y. and Fusuo, Z. (2010) Why does potassium concentration in flue-cured tobacco leaves decrease after apex excision? *Field Crops Research* **116** (1): 86 – 91.