Response of Bidi Tobacco (*Nicotiana Tabacum L.*) to Different Drought Mitigation Measures

S. Jaffar Basha[1]*, P.Pulli Bai[2] and C.Chandrasekhara Rao[3]

[1]Associate Professor of Agronomy and Technical officer to Dean of Agriculture, Acharya N G Ranga Agricultural University, Lam, Guntur-522034, Andhra Pradesh, India

[2] P.Pulli Bai, Scientist (Plant Breeding), Regional Agricultural Research Station, Acharya N G Ranga Agricultural University, Nandyal, -518502, Andhra Pradesh, Indi.

[3]C.Chandrasekhara Rao, Nodal Officer, All India Network Research Project on Tobacco, Central Tobacco Research Institute, Rajamahendravaram, Andhra Pradesh, India

Abstract

A field experiment was undertaken at Regional Agriculture Research Station, Nandyal, Andhra Pradesh during kharif 2019-20 on vertisols under rainfed condition to study the effect of different drought mitigation measures on performance of bidi tobacco (Nicotiana tabacum L.). The nine treatments are i.e., No foliar Spray; Foliar spray with water at early growth stage ; Foliar spray with water at early growth stage and grand growth stage; Foliar spray with KNO_3@ 2.5 % at early growth stage ; Foliar spray with KNO_3@ 2.5 % at early growth stage and grand growth stage ; Foliar spray with Gibberellic acid @ 20 ppm at early growth stage; Foliar spray with Gibberellic acid @ 20 ppm at early growth stage and grand growth stag; Foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and Foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and grand growth stage are designed in RBD and replicated thrice. The data results revealed that Higher leaf length (51.5 cm), leaf width (25.2 cm) spangle score (8.6) and cured leaf yield (2789 kg/ha) was observed with application of foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and grand growth stage. Higher relative water content (92.6%) at 90 DAP and dry wt/unit leaf area (12.9 mg/ cm^2) was observed with application of foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and grand growth stage.

Key words: Bidi tobacco, Drought, Triacontanol (TRIA), KNO_3, Gibberellic acid, Cured Leaf Yield.

1. Introduction

Drought is a major environmental factor that limits crop growth and productivity. Flue-cured tobacco (*Nicotiana tabacum*) is one of the most important commercial crops worldwide and its productivity is vulnerable to drought. Moreover, drought occurred at the vigorous growing stage has the most impact on yield and quality of tobacco leaf. During this stage, drought stress resulted in decreases of the biomass and reducing sugar content, and increases of total nitrogen and nicotine contents (Wu, 1998). Photosynthesis is an important metabolic process in higher plants and photosynthetic apparatus is susceptible to be impaired during drought stress (Chaves *et al.,* 2009). Alterations in photosynthetic parameters under drought stress are good indicators of drought tolerance for plants. Thus, drought is becoming a very important limiting factor for flue-cured tobacco production in the world. Drought is a major environmental stress factor influencing crop growth, development and yield (Luo, 2010). Drought stress affects tobacco growth at the rosette, vigorous growth, flowering, and maturing stages (Shang *et al.,* 2010). Thus, water deficit has become a severe threat to sustainable agriculture (Castroluna *et al.,* 2014). Tobacco is an important economic crop with the leaf representing the primary product, and its productivity is vulnerable to drought. Uneven and low rainfall, dry winds, and temperature dynamics are common factors that promote the development of drought conditions Drought stress play a notorious role in decreasing crops productivity because water shares 80–95% of the fresh biomass of any plant (Furuhashi *et al.,* 2016). This drastic reduction in fresh biomass is mainly due to the disruption of plant's photosynthetic capacity by limiting its physiological and biochemical attributes under the water deficit environment (Furuhashi *et al.,* 2016 and Gilani *et al.,* 2020).

Potassium nitrate (KNO_3)

The water deficiency causes lipid peroxidation (measured as MDA) in leaves. Applying KNO_3 to plants maintains or even reduces MDA contents, thus suggesting a crucial role of K+ in improving the antioxidant system and ameliorating drought stress conditions (Fayez *et al.,* 2014). Exogenous application of KNO_3 as treatment can increase multiple physiological and biochemical mechanisms (Moaaz Ali *et al.,* 2020). Additional KNO_3 increases the photosynthetic pigment contents, potassium content, and enhances plant growth and decreases sodium in moisture-stressed plants.

Gibberellic Acid

Gibberellic acids (Gibberellins) are naturally occurring plant hormones that are used as plant growth regulators to stimulate both cell division and elongation that affects leaves and stems. Exogenous application of GA_3 improved the water stress tolerance in maize plants by maintaining membrane permeability, enhancing chlorophyll concentration, leaf relative water content (LRWC) and some macro-nutrient concentrations in leaves (Cingiz Kaya *et al.,* 2006). Exogenous application of gibberellic acid not only improved the drought tolerance in maize, but also increased the crop yield under normal condition (Sarwar *et al.,* 2017). Exogenous GA helped the seedlings to survive by upregulating antioxidant defense mechanisms and the glyoxalase system in spring wheat (Moumita *et al.,* 2019).

Triacontanol (TRAI)

Among the environmental factors affecting crop growth and yield, drought invariably stands as the dominant one. Drought adversely affects the growth of crops and consequently reduces crop yield globally. Under severe conditions of drought, the resistance mechanisms in plants may fail. To counteract this problem, different strategies for drought stress tolerance are being explored; one such strategy is the application of plant growth regulators (PGRs), which have acquired significant attention recently. Triacontanol (TRIA), a relatively new PGR, enhances plant growth, stress tolerance, and productivity of different crops (Elham Asadi Karam *et al.,* 2017). TRIA is a naturally occurring PGR, comprising a long-chain C primary alcohol that is found in the epicuticular waxes of plant upper surfaces. TRIA's effectiveness depends on its applied concentration (Shaistul Islam and Firoz Mohammad, 2020). Foliar spray of 20 µM Triacontanol (TRIA) was more operative in reducing the negative impact of drought stress in Brassica juncea by regulating the antioxidant system, calcium, and lignifications (Javed Ahmad *et al.,* 2021).

Hence, the present investigation was conducted with the objective of finding out the effect of different drought mitigation measures on growth, cured leaf yield, economics and leaf chemical constituents of bidi tobacco.

2. Material and Methods

The experiment was carried out during 2019-20. The soil of experimental site was medium deep black, moderately alkaline (pH-8.2), non saline (EC- 0.11 ds m^{-1}), low in nitrogen (152.3 kg ha^{-1}), medium in available P2O5 (32.5 kg ha^{-1}) and high in available K_2O (350.9 kg ha^{-1}). The nine treatments are i.e., No foliar Spray; Foliar spray with water at early growth stage ; Foliar spray with water at early growth stage and grand growth stage; Foliar spray with KNO_3@ 2.5 % at early growth stage ; Foliar spray with KNO_3@ 2.5 % at early growth stage and grand growth stage ; Foliar spray with Gibberellic acid @ 20 ppm at early growth stage; Foliar spray with Gibberellic acid @ 20 ppm at early growth stage and grand growth stag; Foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and Foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and grand growth stage are designed in RBD and replicated thrice. The variety used for xperimentation is Nandyal Pogaku -1. The nursery was sown on 27th July 2019 and the seedlings were transplanted at planting geometry of 75 cm x 75 cm on 27th September. The plot size is 5.25 m x 4.5 m. The recommended dose of fertilizers RDF (110 N + 70 P_2O_5 + 50 K_2O) was applied through ammonium sulphate for nitrogen, single superphosphate for phosphorus and sulphate of potash for potassium. Half of the nitrogen, total phosphorus and total potassium were applied as basal and remaining half was applied as top dressing within 30-40 days after planting. Crop management practices like land preparation, weed control, intercultivation, need based plant protection, de-suckering and sun curing were followed as recommended for local area. The data at regular intervals were recorded for available soil moisture, relative water content, dry weight per unit leaf area, plant height, leaf length, leaf width and cured leaf yield, Benefit Cost Ratio at harvest. The crop was harvested on 14th Febrauary 2020. 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). 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.

3. Results and Discussion

3.1 Weather during experiment

Tobacco nurseries were sown during last week of July and transplanting was done last week of September and crop was harvested first FN of February. The rainfall distribution was not uniform throughout the experimental period. An amount of 856.0 mm rainfall was received in 39 rain days with 45.1% excess rainfall (Table 1). Excess rains (166.7%) received during September affected transplanted seedlings and suitable measures were taken to survive the plants by removing excess water through drains. Maximum temperature ranges from 30.1^{0}C to 35.8^{0}C, Minimum temperature ranges from 19.6^{0}C to 25.6^{0}C, Relative humidity ranges from 84.7% to 90.% at 8.30 hrs and 50.5% to 71.3% at 17.30 hrs. Evaporation ranges from 2.0 to 6.3 mm/day. Bright sunshine hours ranges from 2.9 to 9.6 per day.

3.2 Available Soil moisture, Relative leaf water content, Spangle score

The data on available soil moisture is not significant among the treatments as well as at different intervals (Table 2). The available soil moisture ranges initially from 25.3% at 20 DAP and reduced to 11.3 % at 80 DAP. The relative water content in the leaf is not significant among the treatments at 30 DAP and 60 DAP. Whereas it varied at 90 DAP ranging from 77.1% (No foliar spray) to 92.6 % (foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and grand growth stage). Significantly higher dry wt/unit leaf area (12.9 mg/ cm^2) and spangle score of 8.6 were observed with application of foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and grand growth stage. This might be due to the foliar application of Triacontanol 0.1%EW @ 2ml /L at early growth stage and grand growth stages.

3.3 Growth, Yield parameters and Economics

The plant height did not showed significant variation due to topping in all the treatments (Table 3). Significantly higher leaf length (51.5 cm), leaf width (25.2 cm), cured leaf yield (2789 kg/ha) and Benefit Cost Ratio of 3.10 were observed with application of foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage and grand growth stage. The wide differences in Benefit Cost ration was due to various treatments were owing to differences in their performance towards growth and yield of cured leaf. Thus, the differences in cured leaf yield obtained from the various treatments were responsible to finalise the ultimate BCR. Lower BCR of 2.39 was observed with no foliar spray. This may be attributed to lower production of cured leaf under no foliar spray. The findings are corroborated with results of Basha *et al.,* (2020).

3.4 Leaf chemical constituents

The leaf chemical parameters viz., nicotine, reducing sugars and chlorides did not differ significantly due to different drought mitigation measures (Table 3). The leaf chemical parameters were in permissible limits with nicotine ranging from 5.26 to 7.12 % whereas reducing sugars was from 1.80 to 2.45 % and chlorides from 0.80 to 1.45 per cent.

4. Conclusion

Application of foliar spray with Triacontanol 0.1% EW @ 2ml /L at early growth stage and grand growth stage in bidi tobacco grown under rainfed conditions is economical in realization of optimum cured leaf yield and net returns during drought period.

5. Acknowledgement

The authors are grateful to All India Network Project on Tobacco (AINPT), ICAR-CTRI, Rajahmundry and Regional Agricultural Research Station, Nandyal, ANGRAU, Andhra Pradesh for providing the facilities for smooth conduct of the experiment.

6. References

[1] Wu, X. "The effects of soil moisture on yield and quality of flue-cured tobacco". *Agric. Tech.* Vol. 4, **(1998),** pp. 3-6.

[2] Chaves, M. M., J. Flexas, and C. Pinheiro, "Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell". Ann. Bot. 103, **(2009),** pp. 551–560. doi: 10.1093/aob/mcn125.

[3] Luo, L. J. "Breeding for water-saving and drought-resistance rice (WDR) in China". J. Exp. Bot. Vol. 61, **(2010),** pp. 3509–3517. doi: 10.1093/jxb/erq185

[4] Shang, X., H. Liu, X. Zhang, J. Lin, W. Duan, and Yang, T. "Growth and physiological characteristics of roots in different flue-cured tobacco varieties under drought stress". *Acta Bot. Boreal.-Occident. Sin.* Vol. 30, **(2010),** pp. 357–361.

[5] Castroluna, A., O.M. Ruiz, and A.M. Quiroga, "Effects of salinity and drought stress on germination, biomass and growth in three varieties of Medicagosativa L. Avances invest". Agropec. Vol. 18, **(2014)**, 39–50.

[6] Furuhashi, T. T. Nakamura and K. Iwase, "Analysis of Metabolites in Stem Parasitic Plant Interactions: Interaction of Cuscuta– Momordica versus Cassytha–Ipomoea Plants" Vol.5, (**2016)**, pp. 43.

[7] Gilani, M. S., N. Danish, A.A. Ahmed, A. Rahi, U. Akrem, I. Younis, R.K. Irshad and Iqbal, "Mitigation of drought stress in spinach using individual and combined applications of salicylic acid and potassium". Pak. J. Bot. Vol 52, *(***2020)**, pp. 1505–1513.

[8] Fayez, K.A. and S.A. Bazaid, "Improving drought and salinity tolerance in barley by application of salicylic acid and potassium nitrate". J. Saudi Soc. Agric. Sci. Vol. 13, **(2014),** pp. 45–55.

[9] Moaaz Ali, M, T. Javed, R.P. Mauro, R. Shabbir, I. Afzal and A.F. Yousef, "Effect of seed priming with potassium nitrate on the performance of tomato", Agriculture, Vol. 10, **(2020)** pp.498-502.

[10] Cengiz Kaya, A. Levent Tuna and Alfredo A.C. Alves, "Gibberellic acid improves water deficit tolerance in maize plants", Acta Physiologiae Plantarum, Vol 28, **(2006),** pp 331-337.

[11] Sarwar, N., Atique-Ur-Rehman , O. Farooq , K. Mubeen , A. Wasaya , W. Nouman, M. Zafar Ali and M. Shehzad, "Exogenous Application of Gibberellic Acid Improves The Maize Crop Productivity Under Scarce And Sufficient Soil Moisture Condition, Cercetări Agronomice în Moldova" Vol. L , no. 4 **(2017),** pp. 65-73.

[12] Moumita, Jubayer Al Mahmud, Parimal Kanti Biswas, Kamrun Nahar, Masayuki Fujita, Mirza Hasanuzzaman, "Exogenous application of gibberellic acid mitigates drought-induced damage in spring whea", Acta Agrobotanica, Vol. 72 no.2, **(2019),** DOI: https://doi.org/10.5586/aa.1776

[13] Elham Asadi Karam, Batool Keramat, Zahra Asrar and Hossein Mozafari, "Triacontanol-induced changes in growth, oxidative defense system in Coriander (Coriandrum sativum) under arsenic toxicity", Indian Journal of Plant Physiology, Vol.21, no.2, **(2016),** DOI:10.1007/s40502-016-0213-8

[14] Shaistul Islam and Firoz Mohammad, "Triacontanol as a dynamic growth regulator for plants under diverse environmental conditions", Physiology and Molecular Biology of Plants, Vol.26, no.5, **(2020),** pp. 871–883.

[15] Javed Ahmad, A. Arlene, Ali, A. Asma, Al-Huqail, M. Irfan Qureshi, "Triacontanol attenuates drought-induced oxidative stress in Brassica juncea L. by regulating

lignification genes, calcium metabolism and the antioxidant system”, Plant Physiology and Biochemistry, Vol.166, **(2021),** pp.985-998.

[16] Harvey, W.R., H.M. Stahr, and W.C. Smith, “Automated determination of reducing sugars and alkaloids in the same extract of tobacco”. Tobacco Science *Vol.*13, **(1969),** pp. 13-15.

[17] Hanumantha Rao A., C.V.S.S.V. Gopalakrishna and B.V.V. Satyanarayanamurthy, “Determination of chlorides in tobacco by auto-analyser”, Tobacco Research, Vol. **7, (1980),** pp. 92-95.

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

[19] Basha, S. J., P. Pulli Bai, K. Prabhakar, J. Manjunath, Kasturi Krishna and C. Chandrasekhara Rao, “Management of phosphorus and potassium in *bidi* tobacco (*Nicotiana tabacum* L.) under rainfed conditions”, Annals of Plant and Soil Research, Vol. 22, no. 4 **(2020),** pp. 420-424. https://doi.org/10.47815/apsr.2020.10015

Table 1. Rainfall and weather parameters at RARS, Nandyal during 2019-20

Month	Actual		Deviation from normal (%)	Remarks	Temp (^{0}C)		Relative humidity (%)		Average wind speed (km/hr)	Evaporation (mm/day)	Bright sunshine hours /day
	R.F (mm)	Rainy days			Max	Min	08.30	17.30			
July	139.8	8.0	-9.7	Normal	35.8	25.6	80.5	51.5	9.9	6.3	3.4
August	209.4	10.0	21.9	Excess	33.3	24.9	84.7	61.2	7.0	2.9	2.9
September	407.8	10.0	166.7	Excess	32.1	24.5	87.8	67.9	2.5	2.1	3.9
October	81.4	8.0	11.4	Normal	32.4	24.1	87.3	71.3	10	2.0	5.8
November	11.6	2.0	-59.0	Deficit	32.0	22.3	86.4	63.0	1.3	3.0	7.2
December	6.0	1.0	140.0	Excess	30.1	19.6	90.0	62.1	0.6	2.2	6.1
January	0.0	0.0	-100.0	Scanty	32.1	19.7	90.0	50.5	0.1	3.6	8.3
February	0.0	0.0	-100.0	Scanty	33.7	20.2	81.8	38.4	3.3	5.1	9.6
Total	856.0	39.0									

Table 2. Available soil moisture, Relative water content at different growth stages, dry weight and spangle score of bidi tobacco

Treatments	Available soil moisture (%)				Relative water content (%)			Dry wt/ unit leaf area (mg/cm^2)	Spangle score
	20 DAP	40 DAP	60 DAP	80 DAP	30 DAP	60 DAP	90 DAP		
T_1 – No foliar Spray	23.6	24.8	13.9	11.3	88.4	67.1	77.1	9.4	7.2
T_2 – Foliar spray with water at early growth stage	24.6	26.3	14.7	12.2	88.8	67.8	78.3	9.9	7.6
T_3 – Foliar spray with water at early growth stage and grand growth stage	25.0	26.7	15.3	11.8	91.8	69.4	85.4	10.7	8.1
T_4 – Foliar spray with KNO_3@ 2.5 % at early growth stage	25.3	27.0	14.6	12.6	85.8	68.5	78.9	10.0	7.5
T_5 - Foliar spray with KNO_3@ 2.5 % at early growth stage and grand growth stage	22.8	25.5	14.8	11.7	90.9	72.7	90.7	11.9	8.1
T_6 – Foliar spray with Gibberellic acid @ 20 ppm at early growth stage	23.9	26.1	15.2	12.5	87.2	68.9	79.4	10.2	7.6
T_7 – Foliar spray with Gibberellic acid @ 20 ppm at early growth stage and grand growth stage	23.8	25.7	14.9	12.8	87.4	73.2	91.6	12.4	8.2
T_8 - Foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage	23.6	25.6	14.6	11.5	90.2	69.3	79.5	10.4	7.7
T_9 – Foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage) and grand growth stage	24.3	27.5	15.2	12.2	87.5	73.9	92.6	12.9	8.6
S.Em$\pm$	1.41	1.46	0.82	0.72	4.4	3.3	3.9	0.6	0.38
C.D.(P=0.05)	NS	NS	NS	NS	NS	NS	11.8	1.9	NS
C.V. (%)	10.2	9.7	9.6	10.3	8.6	8.2	8.2	10.2	8.3

Table 3. Growth, yield parameters and Leaf chemical constituents as affected by different drought mitigation measures

Treatments	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Cured leaf yield (kg/ha)	BCR	Nicotine (%)	Reducing sugars (%)	Chlorides (%)
T_1 – No foliar Spray	83.4	41.0	16.7	2067	2.39	5.79	1.90	0.86
T_2 – Foliar spray with water at early growth stage	83.8	41.7	17.5	2139	2.47	5.83	1.92	0.92
T_3 – Foliar spray with water at early growth stage and grand growth stage	86.8	43.3	18.7	2282	2.56	5.67	2.01	0.80
T_4 – Foliar spray with KNO_3@ 2.5 % at early growth stage	80.8	42.4	18.2	2155	2.49	5.26	1.92	1.05
T_5 - Foliar spray with KNO_3@ 2.5 % at early growth stage and grand growth stage	85.9	49.6	23.3	2527	2.75	5.56	1.93	0.75
T_6 – Foliar spray with Gibberellic acid @ 20 ppm at early growth stage	82.2	42.8	18.4	2249	2.60	5.66	2.45	1.45
T_7 – Foliar spray with Gibberellic acid @ 20 ppm at early growth stage and grand growth stage	82.4	50.4	24.2	2655	2.94	6.22	1.80	0.83
T_8 - Foliar spray with Triacontanol 0.1% EW @ 2ml /L at early growth stage	85.2	43.2	19.0	2273	2.62	7.12	1.90	1.23
T_9 – Foliar spray with Triacontanol 0.1%EW @ 2ml /L at early growth stage) and grand growth stage	82.5	51.5	25.2	2789	3.10	5.80	1.94	1.14
S.Em$\pm$	4.39	2.39	1.3	120		0.39	0.14	0.15
C.D.(P=0.05)	NS	7.2	3.9	361		NS	NS	NS
C.V. (%)	9.10	9.2	11.1	8.9		11.4	11.9	26.4