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Research Paper

Stress management in rainfed Bt. cotton (*Gossypium hirsutum*) through foliar sprays

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ABSTRACT

In India, Bt cotton is grown on 122 Lakh ha area with production of 361 lakh bales and productivity is of 501 kg lint/ha. In Maharashtra it is grown on 41 lakh ha area with productivity of 81 lakh bales and productivity is 334 kg lint/ha. Cotton is grown on large scale under rainfed condition in Marathwada region of Maharashtra State and is a preferred cash crop in *Kharif* season by marginal as well as large farmers. The productivity of rainfed cotton particularly in Marathwada region is uncertain due to occurrence of frequent dry spells particularly during July to September. Hence to overcome the moisture stress under such dry spells condition and to obtain the sustainability in productivity, the measures like foliar application of potassium nitrate, water spray and other micronutrients are essential for reducing the rate of evapotranspiration. The experiment was conducted during 2017 to 2019 on experimental farm of All India Coordinated Research Project on Dryland Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. Study resulted that application of foliar spray of KNO_3 (30 and 60 days after sowing) was significantly superior in respect of increase in cotton yield as well as Net Returns as compared to the other treatments. Similarly, application of foliar spray during dry spell was also found superior than application of foliar spray after release of dry spells. The chlorophyll content, percent RWC and NDVI were also found higher under application of foliar spray which reflected in enhancing Bt. cotton productivity.

Key words: Chlorophyll, Dry spell, Potassium nitrate, Normalized difference vegetative index, Relative water content

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a cash crop grown in diverse soil types across the globe, including India. More than 100 countries of the world produce cotton over an area of 33.2 million hectare with an average annual cotton production of 18.9 million tonnes. Cotton productivity is highly influenced by several biotic and abiotic factors (drought, heat, waterlogging and salinity), leading to significant losses in the targeted productivity. Nutrients are not only help in better plant growth and development but also help to alleviate different kinds of abiotic stresses like drought. Leaf feeding is the use of foliar fertilizers to enhance overall nutrient level in the plants and increase sugar production during stress period. (Srinivasarao and Gopinath, 2016). Jyothi and Hebsur (2018) conducted study on effect of soil and foliar applied potassium fertilizers on yield, quality and economics of Bt cotton in vertisol and found that higher seed cotton yield was received in the treatment of 100:50:75 NPK kg/ha 2 % KNO_3 foliar spry at 70, 90 and 110 days after sowing. Similarly, Santosh et al., (2016) conducted study on soil and foliar nutrition on Bt cotton and found that $MgSO_4$ + three foliar application of KNO_3 (2%) recorded maximum seed cotton yield. Kulvir Singh *et al*,. (2016). and Harphool Meena *et al*,. (2018) conducted study on foliar application using micronutrients. This particular experiment was conducted to test the various foliar application like water soluble complex fertilizers, water spray, urea spray and spray of micronutrient to reduce water stress during dryspell condition.

Rainfed cotton is cultivated on 17lakh ha area in Marathwada region of Maharashtra state. Majority of the farmers are preferring to grow cotton during *kharif* season. The average productivity of rainfed cotton varies depending of monsoon behavior. The events like rising in temperature, declining rainfall followed by occurrence of frequent dryspells affects the productivity of cotton in the region.

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Marathwada region of Maharashtra state comprises 8 districts with average annual precipitation of 807 mm. The region is dominated by medium black cotton soils (60 %) and majority area falls under assured rainfall zone. In Marathwada region, receipt of deficit rainfall in last decade aggravated the situation of dryland agriculture and resulted in low productivity.

It is known that the most important factors limiting crop productivity are environmental stresses. The most serious among them is the lack of water. This lack of water occurs when the rate of transpiration exceeds water uptake and is a component of several different stresses including drought, salinity and low temperature. Plants have different mechanisms to avoid water deficit. Among them, stomatal conductance is reduced as a part of the systemic response triggered by a signal that originates in the root system (Mata and Lamattina.2001). In this context, the study on various applications of foliar spray to cope with drought situations for attaining sustainable productivity under rainfed cotton was undertaken for standardizing the specific composition of foliar application suited to this region.

MATERIALS AND METHODS

The field experiment was conducted at All India Coordinated Research Project on Dryland Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* seasons of 2017 to 2019. The district has been classified as rainfed agro ecosystem and soybean-based production system with an average rainfall of 892 mm. The cultivated fields in the Parbhani district are normally having slope in the range of 0.5 to 1 % with good surface drainage conditions. The experimental soil was medium black with *p*H 8.1, organic carbon 0.50 % and contained low nitrogen (150 kg/ha), low phosphorous (12.1 kg/ha) and high potassium (498 kg/ha). The experiment was laid out in split plot with three replications. The cotton hybrid Ajit-155 was used for sowing. Bt. Cotton was sown at recommended spacing of 120 cm x 45 cm and recommended dose of fertilizers (120:60:60, N:P:K Kg/ha) was applied. The nitrogen dose was applied in three splits. The full dose of phosphorous and potassium was applied at the time of sowing. The foliar sprays were undertaken as per the treatments. The experiment was executed with two main plot treatments viz. T1- Foliar spray during dryspell and T2- Foliar spray after relieving of stress /dry spell with sub plot treatments as F_1 : Urea @ 1%, F_2: Urea @ 2%, F_3:Water soluble complex Fertilizer (19:19:19) @ 0.5%, F_4 :Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient, F5:Recommended dose of micronutrients, F6-Water Spray, F7: KNO_3 and F8, Control (No spray of any material/water)

Chlorophyll Content was determined using SPAD meter, Normalized Difference Vegetative Index (NDVI) was determined using Hand Held Green Seeker and percent Relative Water Content (% RWC) was determined by using the method of Mata and Lamattina (2001). RWC was determined for seedlings, and leaves after different period of drought/ dryspells according to formula

$$\text{RWC (\%)} = \frac{\text{(FW-DW)}}{\text{(TW-DW)}} \times 100$$

Fresh weight (FW) was measured at the end of the drought period and dry weight (DW) was obtained after drying the samples at 75^0C for at least 24 hours. Turgor weight (TW) was determined by subjecting leaves to rehydration for 2 hrs. after drought treatments.

The data on Bt. cotton seed yield was collected and accordingly the Net Monetary Returns (NMR) and Benefit Cost ratio (B:C) were worked out using standard statistical methodology (Panse and Sukhatme 1967). All the data obtained in the experiment for three consecutive years of investigation was statistically analyzed using the F-test, the procedure given by Gomez and Gomez (1984), critical difference values at P=0.05 were used to determine the significance of differences between means.

RESULTS AND DISCUSSIONS

The crop seasonal rainfall and dryspells observed during the *kharif* seasons of 2017 to 2019 are presented in Table

Table 1. Crop seasonal rainfall and Dryspells observed during 2017 to 2019

Crop seasonal rainfall, mm					
2017		2018		2019	
886		802.4		859.4	
Dry spells					
Duration (Days)	Dates & Months	Duration (Days)	Dates & Months	Duration (Days)	Dates & Months
16	Jun 25 to Jul 10	9	Jun 12 to Jun 20	10	Jul 01 to Jul 10
13	Jul 26 to Aug.7	25	Jul. 22 to Aug. 15	13	Jul 14 to Jul 26
09	Aug. 31 to Sep. 8	33	Aug. 28 to Sep. 30	16	Aug 15 to Aug 30
16	Sep. 17 to Oct. 2	—	—	18	Oct 02 to Oct 19

1. The mean crop seasonal rainfall of the area is 859.4 mm. The crop seasonal rainfall during 2017 to 2019 was observed in the range of 800 to 900 mm which was found nearer to mean crop seasonal rainfall. Data presented in Table 1 indicated that four dryspells were observed during the month of June to September during the year 2017. During the year 2018, three dryspells were observed out of which 2 dryspells were observed as at critical dryspells of duration 25 days and 33 days respectively. Similarly, four dryspells were observed during the year 2019. The last dryspell observed during October was of terminal type. During all the years, dryspells mostly observed either during vegetative stage of crop or boll forming stage of the cotton crop.

The pooled data over three seasons with respect to soybean seed yield, net returns and benefit: cost ratio is presented in Table 2.

Effect of Foliar sprays on crop yield

The effect of application of foliar spray and types of foliar spray on cotton yield is presented in Table 2. Data indicated that Bt. cotton yield was found significantly superior under the application of foliar spray during dryspell. Similarly, the foliar application of KNO_3 was found significantly superior over rest of the treatment with respect to cotton yield and found at par with the treatment of Water Soluble Complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray (F4).

Various scientists conducted experiments on foliar applications of micro nutrients on cotton (Seyyed and Seyyed, 2014, Shinde *et al*., 2009; Shivamurthhy and Biradar, 2014) and found that cotton productivity was increased due to application of foliar spray of various micronutrients during moisture stress condition. They also reported that along with productivity, the NMR and BC ratio also increased due to application of foliar spray of micronutrients and potassium nitrate. Similarly, Waraich *et al*. 2011 conducted study of foliar application of potassium nitrate (KNO_3) for drought mitigation in cotton and reported that yield enhancement was observed under cotton due to KNO_3 foliar application.

Economics

The data pertaining to net returns and B: C ratio is presented in Table 2. Data revealed that net returns under various time of applications of foliar spray was found significantly superior under the application of foliar spray during dryspell. Similarly, the foliar application of KNO_3 was found significantly superior over rest of the treatments with respect to net returns in Bt. cotton and found at par with the treatment of Water Soluble Complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient (F4).

Table 2. Effect of foliar spray on Bt. cotton yield, net returns and B : C ratio (pooled data of 2 years)

Treatment	Pooled data		
	Bt. cotton yield (t/ha)	Net returns ($\times 10^3$ /ha)	Benefit: cost ratio
2017	1.73	29.54	1.77
2018	1.44	42.13	2.13
2019	1.31	36.07	1.98
Mainplot			
T_1, Foliar spray during dry spell	1.58	40.54	2.21
T_2, Foliar spray after relieving of stress /dry spell	1.40	31.29	1.70
SEm±	0.038	1.78	0.13
CD (P=0.05)	0.117	5.17	0.39
Subplot			
F_1, Urea @ 1%	1.41	31.55	1.77
F_2, Urea @ 2%	1.44	34.29	1.92
F_3, Water soluble complex Fertilizer (19:19:19) @ 0.5%	1.52	37.41	2.06
F_4, Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient	1.57	38.42	2.03
F_5, Recommended dose of micronutrient	1.55	37.94	2.03
F_6, Water Spray	1.46	35.16	1.97
F_7, KNO_3	1.65	43.00	2.33
F_8, Control (No spray of any material/water)	1.32	29.54	1.61
SEm±	0.031	1.26	0.15
CD (P=0.05)	0.091	3.67	0.44
Interaction (T X F)			
SEm±	0.044	1.79	0.16
CD (P=0.05)	0.129	5.20	0.45

Roberts *et al*. 1999, Ravikiran *et al.* 2012 and Shinde *et al.* 1994 studied economics of cotton crop due to foliar application micronutrients and foliar application of potassium nitrate and reported that foliar application during drought enhances the cotton yield. Similar results were observed in the present study.

The data on mean percent Relative Water Content (% RWC), Mean Chlorophyll Content and Mean Normalized Difference Vegetative Index (NDVI) for 30 and 60 days after sowing during the years 2017 to 2019 are presented in Table 3 and Table 4, respectively.

Foliar applications after 30 days resulted that the higher values of % RWC, Chlorophyll and NDVI were observed under the treatment foliar application of KNO_3 (F7) followed by under the treatment Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient which also reflected the higher yield of cotton.

Foliar applications after 60 days resulted that the higher values of % RWC, Chlorophyll and NDVI were observed under the treatment foliar application of KNO_{3}-(F_7) followed by under the treatment recommended dose of micronutrient (F_5) which also reflected the higher yield of cotton.

It is also concluded that all foliar applications resulted in increase in % RWC, Chlorophyll and NDVI under dryspell / moisture stress condition due to application of foliar applications of KNO_3 and micro nutrients. Similarly, foliar application during the dryspells resulted in enhancing cotton yield as compared to foliar application after relieving the dryspell. Matin *et. al.* (1989) stated that the ability to maintain high water status can be considered as an indication of drought tolerance and also mention that relative water content plays greater role under moisture stress and receding soil moisture situation. Similarly, Barrs and Weatherly (1962) reported that relative turgidity for estimating water deficits in leaves is also important for screening drought tolerant varieties. Similar results are observed in the present study.

CONCLUSION

This study clearly indicated the advantage of foliar application of KNO_3 during the dryspell for higher yield of Bt. cotton. The results hold promise for improvement in production potential of dryland crops with better and efficient nutrient management and enhancing % RWC and chlorophyll content which can be effectively make crops resilient towards recurring drought events. Hence foliar spray of KNO_3 is recommended in rainfed Bt. cotton of Marathwada region to ensure higher returns.

REFERENCES

Barrs, H.D. and Weatherly, P.E. 1962. A re-examination of relative turgidity for estimating water deficits in leaves. *Australian Journal of Biological Sciences* **15**: 413–428.

Table 3. Mean RWC, Chlorophyll content and NDVI 30 days after sowing under various treatments

Treatment	% RWC		Chlorophyll content		NDVI	
	T_1	T_2	T_1	T_2	T_1	T_2
F_1, Urea @ 1%	100.80	129.50	42.32	42.38	0.785	0.835
F_2, Urea @ 2%	102.80	128.72	42.19	42.49	0.781	0.826
F_3, Water soluble complex Fertilizer (19:19:19) @ 0.5%	117.2	136.54	43.22	43.38	0.812	0.825
F_4, Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient	160.20	159.20	44.48	43.01	0.801	0.838
F_5, Recommended dose of micronutrient	148.52	152.30	42.42	42.38	0.842	0.819
F_6, Water Spray	102.50	120.72	41.53	42.01	0.777	0.778
F_7, KNO_3	179.32	159.70	45.35	43.28	0.825	0.866
F_8, Control (No spray of any material/water)	92.42	88.10	41.47	41.62	0.783	0.756

Table 4. Mean RWC, Chlorophyll content and NDVI 60 days after sowing under various treatments

Treatment	% RWC		Chlorophyll content		NDVI	
	T_1	T_2	T_1	T_2	T_1	T_2
F_1, Urea @ 1%	33.24	27.98	47.27	51.65	0.83	0.85
F_2, Urea @ 2%	35.68	26.42	48.58	48.92	0.84	0.86
F_3, Water soluble complex Fertilizer (19:19:19) @ 0.5%	47.14	32.39	49.94	51.16	0.85	0.87
F_4, Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient	60.32	40.12	51.86	50.62	0.85	0.85
F_5, Recommended dose of micronutrient	51.38	33.62	48.92	48.38	0.85	0.85
F_6, Water Spray	21.25	19.52	47.52	48.56	0.84	0.86
F_7, KNO_3	66.93	43.69	51.98	51.96	0.87	0.87
F_8, Control (No spray of any material/water)	13.78	18.86	44.94	47.80	0.83	0.83

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research, Edn 2,

John Wiley & Sons, New York. Harphool Meena, Meena PKP and Kumhar BL. 2018. Enhancing productivity of B*t* cotton through foliar fertilization under humid southern plain zone of Rajasthan. *Journal of Cotton Research and Development* **32**(1): 77–83.

Jyothi, T.V. and Hebsur NS. 2018. Effect of soil and foliar applied potassium fertilizers on yield, quality and economics of Bt cotton (*Gossypium, hirsutum*) in vertisol. *Indian Journal of Agronomy* **63**(1): 91–94.

Singh, Kulvir, Malik, Sudeep, Singh, Amandeep and Rathore, Pankaj 2016. Influence of foliar feeding of nutrients on growth yield attributes and seed cotton yield of American cotton. *Journal of Cotton Research and Development* **30**(1): 69–72.

Mata, C., Garcia, L. Lamattina. 2001. Nitric oxide induces stomatal closure and enhances the adaptive plant responses against drought stress. *Plant Physiology* **126**(3): 1,196–1,204.

Matin, MA, Brown, J.H. and Ferguson, H. 1989. Leaf water potential, relative water content and diffusive resistance as screening techniques for drought resistance in Barley. *Agro Journal* **81**: 100–105.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical methods for Agricultural Workers. ICAR, New Delhi.

Ravikiran, S., Halepyati, A.S., Pujari, B.T., Koppalakar, B.G. and Narayanarao, K. 2012. Effect of macro and soluble micronutrients on yield, uptake of nutrients, quality and economics of B*t* cotton (*Gossypium hirsutum* L.) under irrigation. *Karnataka Journal of Agricultural Science* **25**(4): 418–422.

Roberts, R.K., Gersman, J.M. and Howard, D.D. 1999. Economics of using and adjuvant with foliar potassium nitrate (KNO_3) on cotton. *The Journal of Cotton Science* **3**: 116–121.

Santosh, U.N., Satyanarayan, Rao, Biradar, S.A., Desai, B.K., Halepyati, A.S. and Koppalkar B.G. 2016. Response of soil and foliar nutrition on B*t* cotton (*Gossypium hirsutum* L.) *Journal of Cotton Research and Development* **30**(2): 205–209.

Seyyed, M.S. and Seyyed, A.N. 2014. Evaluation of foliar application effects of Zn and Fe on yield and its components of lentil (*Lens culinaris*, Medik), Iran. *Indian Journal of Fundamental and Applied Life Sciences* **4**(2): 220–225.

Shinde, A.K., Birari, S.P. and Jadhav B.B. 1994. Effect of potassium nitrate and urea on growth and yield of cowpea *(Vigna unguiculata) Indian Journal of Agricultural Sciences* **64**(7): 490–491.

Shinde, V.S., Deshmukh, L.S., Shinde, S.A. and Zade, K.K. 2009. Influence of rainwater management through different agrotechniques on yield, yield attributing characters and economics of cotton. *Journal Cotton Research Development* **23**(1): 51–55.

Shivamurthhy, D. and and Biradar, D.P. 2014. Effect of foliar nutrition on growth, yield attributes and seed-cotton yield of Bt cotton. *Karnataka Journal of Agricultural Science* **27**(1): 5–8.

Srinivasarao and Gopinath 2016. Resilient rainfed technologies for drought mitigation and sustainable food security. *Mausam* **67**(1): 169–181.

Waraich, EA, Ahmad, R, Raja GM, Ehsanullah Ahmad, A. and Nasir, M. 2011. Response of foliar application of KNO_3 on yield, yield components and lint quality of cotton (*Gossypium hirsutum* L.). *African Journal of Agricultural Research* **6**(24): 5,457–5,463.