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Effect of Polyhalite Multinutrient fertilizer and Drip Irrigation under different ETc Levels on Growth, Quality of Bt. cotton in Inceptisol

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ABSTRACT: Increasing complexity in crop nutrient requirement in intensive crop production system needs alternative multi-nutrient sources. The field investigation entitled, "Effect of Polyhalite multinutrient fertilizer and drip irrigation at different ETc levels on growth, quality and water use efficiency of Bt. cotton in Inceptisol" conducted during the years 2020 and 2021 at AICRP on Irrigation Water Management Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra). The present investigation was laid out in Split plot design with three replications. Total fifty four treatment combinations comprising three irrigation regimes as main plot treatment *viz.*, I_1-0.8 ETc, I_2-1.0 ETc and I_3-1.2 ETc and six fertilizer doses as sub plot treatments. *viz.*, T_1- Absolute control, T_2 - 100% GRDF (125:65:65 N: P_2O_5: K_2O kg ha^{-1}), Mg, S as per recommendation, T_3- 100 % N: P_2O_5 + 100% K_2O through polyhalite, T_4-100 % N: P_2O_5: 25 % K_2O through muriate of potash + 75% K_2O through polyhalite, T_5-100 % N: P_2O_5: 50 % K_2O through muriate of potash + 50 % K_2O through polyhalite, T_6- 100 % N: P_2O_5: 75 % K_2O through muriate of potash + 25% K_2O through polyhalite. The data revealed that scheduling of irrigation at I_2-1.0 ETc irrigation regime registered significantly higher growth attributing characters of Bt. cotton *viz.*, plant height (147.36 cm), number of sympodial branches $plant^{-1}$(21.67), leaf area $plant^{-1}$ (282.16 dm^2), Number of bolls $plant^{-1}$ (34.53) is at par with 0.8 ETc irrigation regime than rest of irrigation methods at harvest during pooled mean of two years. While in case of fertilizer treatment F_4-100% N: P_2O_5: 25% K_2O through MOP + 75% K_2O through Polyhalite showed highest plant height (146.30 cm), number of monopodial branches $plant^{-1}$ (1.41) number of sympodial branches $plant^{-1}$ (20.33), leaf area $plant^{-1}$ (280.16), Number of bolls $plant^{-1}$ (28.94). Other quality traits, *viz.*, ginning percentage, upper half mean length, uniformity index and micronaire ratio were not influenced by the both irrigation regimes and fertilizer treatments. Study concluded that polyhalite shows potential as a commercial fertilizer to supply K, Ca, Mg, and S nutrients. However, the availability of polyhalite will remain a challage and its location and crop specific response needs to be studied for its advocation as a complete K nutrient source for soil.

Keywords: Polyhalite, cotton, Drip irrigation, quality.

INTRODUCTION

Multinutrient fertilizers have been attractive for couple of years, mainly for soils with sufficient levels of fertility. Polyhalite is a hydrated sulphate evaporate mineral containing potassium, calcium, magnesium and sulphur with chemical formula $K_2Ca_2Mg(SO_4)_4.2H_2O$ (Tiwari *et al.*, 2015). Polyhalite is a single complex crystal (triclinic, pseudo-orthorhombic). It is water soluble with precipitation of gypsum and syngenite which is also soluble, leaving behind a precipitate of gypsum. Polyhalite serves as a suitable fertilizer to supply four nutrient, is less water soluble than the more conventional sources and may conceivably provide a slower release of nutrients (Yermiyahu *et al.*, 2017). The polyhalite generally include K_2O: 14%, SO_4: 48%, MgO: 6% and CaO: 17%. As a fertilizer supplying four important plant nutrients polyhalite offers attractive solutions to crop nutrition. An important benefit of using polyhalite as a fertilizer, when compared to the equivalent salts, is the rate at which it releases minerals to soil profile. The leaching of calcium, magnesium, potassium as well as sulphur from polyhalite appears to be slower than the leaching of these ions from the commonly used soluble salts (Vale, 2016). In this regard, polyhalite has the efficiency for extended period effects compared to commercial fertilizers.

Bt. cotton (*Gossypium hirsutum* L.) has a pride of place among the cultivated plants that satisfy the material need of man because next to food, clothing is the prime need of life. Cotton have significant impact on national and farmer's economy in terms of both employment generation and foreign exchange earnings. Cotton being prime supplier of unprocessed material for the textile industry, which is the runner-up-in size internationally (Muhammad *et al.*, 2013). Cotton supply basic material not only for the textile industry but also the feed and oil industries with its seed, rich in both oil (18-24 %) and protein (20-40 %) (Cetin and Bilgel 2002). One of the beneficial factor for limiting cotton growth is water. Drought stress can thus significantly reduce the biological yield of cotton and hinder the absorption and accumulation of nitrogen, phosphorous and potassium (Hu *et al*., 2002). In addition, it saves the cost of inter cultivation, improves the fertilizer use efficiency, hasten the maturity of crop and improves the quality of the produce. Tang *et al*. (2005) suggested that the alternative drip irrigation could be applied in arid areas to save irrigation water. The present study hypothesizes that, owing to low release properties of polyhalite, if integrated in to the fertilization program, a more balance and stable flow of nutrients can be achieve. Secondly, polyhalite is at least as effective as MOP as a K source.

MATERIAL AND METHODS

The present investigation was conducted during *kharif* season in the year 2020-2021 at AICRP on Irrigation Water Management Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, 413722, Dist. Ahmednagar, Maharashtra, India. Geographically the Central Campus of Mahatma Phule Krishi Vidyapeeth, Rahuri is lies between $19^0$48' N and $19^0$57'N latitude and $74^0$19' E and $74^0$32' E longitude. The altitude varies from 495 to 569 metres above mean sea level. This tract is lying on the eastern side of Western Ghat Zone and falls under rain shadow area. Agro climatically it falls in semi-arid tropics with annual rainfall varying from 307 to 619 mm. The average annual rainfall is 520 mm. Out of the total annual rainfall, about 80 per cent rains received from South-West monsoon in 15-45 rainy days.

The soil of the experimental field was clay in texture. Before laying out the experiment, soil samples were collected from 0-30 cm depth at random spots covering experimental area, a composite soil sample was prepared and analyzed for various physical and chemical properties by using standard analytical methods which indicates that the soil of the experimental field was clay in texture. The seed material of Bt. cotton hybrid Bhakti (BG-II) was procured from the local market of Rahuri. The dibbling method was used for sowing of cotton. The irrigation was scheduled to alternate days for cotton crop. The treatment wise water requirement of cotton crop was worked out on the basis of class 'A' open pan evaporation. The value of pan coefficient was taken as 0.8.

The present investigation was laid out in Split Plot Design with three replications. Data obtained on various variables were analysed by 'Analysis of Variance' method (Panse and Sukhatme 1985).

RESULT AND DISCCUSION

Effect of polyhalite multinutrient fertilizer and irrigation levels on Growth attributing characters:

The data collected on different growth parameters of Bt. cotton are summarizes in Table 1.

A. Plant height

The plant height is simple indicator of development of any crop. The periodical (i.e. 30, 60, 90, 120 DAS and Harvest) data related to the plant height of cotton as significantly influenced by the different treatments are presented in Table 1. The plant height was increased progressively with the advancement of age of the plant owing to indeterminate growth habit of cotton which ultimately resulted in higher growth and development of cotton (Mane *et al*., 2018).

Irrigation regimes. The plant height of Bt cotton was influenced significantly due to the different irrigation regimes are presented in Table 1. Significantly maximum plant height was recorded where crop was irrigated at 1.0 ETc through drip at all the stages of crop growth during pooled mean (41.60, 79.75, 122.64, 140.63 and 145.23 cm). Significantly minimum plant height was registered at 1.2 ETc at all the crop growth stages during pooled means of both years *i.e kharif* 2020-2021. Our results were in line with Mane *et al*. (2018) who reported that the 1.0 ETc irrigation recorded significantly higher growth attributed because it create favorable environment at root rhizosphere for increasing the soil moisture and nutrient absorbtion which leads to increase the cell elongation and multiplication.

Fertilizer Treatments. Treatment F_4-100% N: P_2O_5:25% K_2O through MOP + 75% K_2O through Polyhalite was reported significantly highest plant height at all stages of crop growth during pooled mean of both years (45.83, 87.51, 130.28, 148.16 and 152.84 cm) whereas, treatment F_3-100% N:P_2O_5:100% K_2O through Polyhalite is at par over rest of the treatments during pooled mean (44.22, 84.17, 127.03, 144.56 and 150.79), whereas treatment F_5-100% N:P_2O_5:50% K_2O through MOP + 50% K_2O through Polyhalite is at par during 60 DAS at pooled mean (79.21, 146.30 cm). This might be due to the improvement in growth characteristics of cotton can be attributed to the comparatively lower salt index (SI) of poyhalite fertilizers (68.5 ± 10.8) than other K fertilizers such as the sulphate of potash (SOP), the muriate of potash (MOP). The lower the SI, the higher the seed germination and plant growth as higher salt contents increase the osmotic potential of soil solutions which affects seed and plant germination and overall growth characteristics of plant. Herrera and Ferney *et al.* (2019) observed in there study showed that higher soil K contents increase sugarcane growth parameters, yield mainly when is used polyhalite as a source, in commercial field conditions.

Interaction. The interaction between irrigation regimes and fertilizer treatments were found non significant in respect of plant height at pooled mean of two years.

B. Number of Monopodial Branches plant^{-1}

The number of monopodial branches plant^{-1} in Bt. cotton did not differed significantly due to different irrigation regimes and fertilizer treatments during pooled mean of both years. This data shows that mean number of monopodial branches remains identical in all treatments throughout crop growth. These findings show similarity with Maitra *et al.* (2000).

C. Number of sympodial branches plant^{-1}

The number of sympodial branches plant^{-1} in Bt. cotton as influenced by different irrigation regimes and fertilizer treatments are presented in Table 1.

Irrigation regimes. The number of sympodial branches plant^{-1} in Bt. cotton was influenced significantly due to the different irrigation regimes. Scheduling of irrigation at 1.0 ETc through drip (pooled mean- 9.83,15.39, 20.19 and 21.67) recorded significantly more number of sympodial branches plant^{-1} than 1.2 ETc irrigation regime through drip irrigation method at all the stages of crop growth during pooled mean of both the years. However, it was at par with 0.8 ETc irrigation regime during pooled mean (9.28, 14.27, 19.81 and 21.28) Significantly minimum number of sympodial branches plant^{-1} were registered under 1.2 ETc at all the crop growth stages during pooled mean both the years. This might be due to better availability of irrigation water during early stage which helped to maintain the favorable microclimate for the plant growth and development. These results in agreement with those reported by Roopashree *et al.* (2016) and Bhalerao and Gaikwad *et al*. (2011).

Fertilizer treatments. The number of sympodial branches plant^{-1} in Bt. cotton was influenced significantly due to fertilizer treatments through drip irrigation during both the years and pooled mean. Treatment F_4-100% N: P_2O_5: 25% K_2O through MOP + 75% K_2O through Polyhalite registered significantly higher number of sympodial branches at all growth stages during pooled mean of two years (10.44, 16.44, 21.61 and 23.89) whereas, treatment F_3-100% N: P_2O_5:100% K_2O through Polyhalite is at par over all other treatments during pooled mean (9.78, 15.78, 20.72 and 22.11). This might be due to increasing primary and secondary nutrient contents in leaves might have increased the production of metabolites synthesized and thus plant had the chance to bear more fruiting branches also increased availability and absorption of necessary elements like Ca, K, Mg, and S present in polyhalite. These results are in accordance with Aziz *et al*. (2023).

Interaction: The interaction between irrigation regimes and fertilizer treatments were found non significant in respect of Sympodial branches during pooled mean of two years.

D. Number of bolls plant^{-1}

Bolls are the major sink for potassium. The number of bolls plant^{-1} in Bt. cotton as influenced by different irrigation regimes, fertilizer treatments are presented in Table 1.

Irrigation regimes. The number of bolls plant^{-1} in Bt. cotton was influenced significantly due to the different irrigation regimes. Scheduling of irrigation at 1.0 ETc through drip (pooled mean- 23.97, 34.53) recorded significantly more number of bolls plant^{-1} than 1.2 ETc irrigation regime through drip irrigation method at all the stages of crop growth during both the years. However, it was at par with 0.8 ETc irrigation regime at during pooled mean (22.58, 31.17). This might be due to drip irrigation which further helped in increasing moisture adsorption, photosynthesis and translocation of photosynthates towards reproductive parts helped in increasing developing bolls.

The results are resembled with those reported by Mane *et al*. (2018) and Dateshwa *et al.* (2010).

Fertilizer level. The number of bolls plant^{-1} in Bt. cotton was influenced significantly due to fertilizer treatment through drip irrigation during both the years and pooled mean. treatment F_4-100% N:P_2O_5:25% K_2O through MOP + 75% K_2O through Polyhalite registered significantly higher number of bolls during pooled mean of two years (27.34, 39.00) whereas, treatment F_3-100% N: P_2O_5:100% K_2O through Polyhalite is at par over all other treatments during pooled mean (25.36, 35.83). Bolls are major sink for potassium whereas bolls are highly sensitive to low soil water potential and K involve in stomatal regulation in addition with this as polyhalite contains Ca, Mg, K, S and there application might be fulfil the need of cotton crop. In addition, the physiological activities which translocate more photosynthates toward reproductive organs resulted in increase the yield attributes of Bt. Cotton.

These results in agreement with those reported by Basavanneppa and Biradar (2003), Nalayini *et al.* (2012), Roopashree *et al.* (2016).

Interaction: The interaction between irrigation regimes and fertilizer treatments were found non significant in respect of number of bolls.

E. Leaf area plant^{-1}

The cotton plant is unique because it is a perennial with an indeterminate growth habit, it will continue growing until environmental conditions become unfavorable. The leaf area plant^{-1} in Bt. cotton as influenced by different irrigation regimes, fertilizer treatments are presented in Table 1.

Scheduling of irrigation at I_2-1.0 ETc irrigation regime coupled with fertilizer treatment F_4-100% N:P_2O_5:25% K_2O through MOP + 75% K_2O through Polyhalite registered significantly higher leaf area plant^{-1}. This might be due to potassium integrally involved is in photosynthesis by directly increasing leaf growth and leaf area index and therefore CO_2 assimilation thus K increase the outward translocation of photosynthates from the leaf.

The results obtained are in close anomaly with the findings of Kumar *et al*. (2012).

Table 1: **Effect of polyhalite multinutrient fertilizer and irrigation levels on Growth parameters of Bt. cotton (pooled mean of two years 2020-2021).**

Treatment	**Plant height (cm)**					**Monopodial branches plant^{-1}**		**Sympodial branches plant^{-1}**				**Number of Bolls plant^{-1}**		**Leaf area plant^{-1} (dm^2)**				
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**	**90 DAS**	**120 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
Irrigation Levels-I																		
I_1 : 0.8 ETc	41.60	79.75	122.64	140.63	145.23	1.13	1.44	9.28	14.27	19.81	21.28	22.58	31.17	30.35	123.16	207.12	261.53	284.31
I_2 : 1.0 ETc	43.58	81.95	125.38	142.95	147.36	1.18	1.51	9.83	15.39	20.19	21.67	23.97	34.53	33.06	126.87	213.84	268.23	282.16
I_3 : 1.2 ETc	39.79	74.72	118.31	135.89	140.63	1.04	1.36	8.17	13.50	18.00	17.97	19.99	23.97	27.67	121.54	199.06	244.42	277.89
S.Em (±)	0.87	1.43	1.14	1.62	1.92	0.07	0.09	0.49	0.34	0.40	0.47	0.62	1.69	1.27	1.33	2.70	3.38	4.04
C.D. at 5%	2.86	4.69	3.73	5.31	6.26	NS	NS	1.60	1.13	1.31	1.55	2.04	5.53	4.17	4.36	8.81	11.02	NS
Fertilizer treatments-F																		
F_1 : Absolute control	35.90	65.69	113.36	130.86	131.23	0.82	1.02	7.78	12.00	17.00	16.61	15.28	19.40	21.62	108.41	185.65	228.90	269.46
F_2 : 100% GRDF	40.38	72.45	119.29	136.71	141.94	1.08	1.34	8.72	13.61	18.67	19.44	20.69	27.26	26.41	127.17	207.72	263.03	282.83
F_3 : 100% N:P_2O_5:100% K_2O through Polyhalite	44.22	84.17	127.03	144.56	150.79	1.23	1.60	9.78	15.78	20.72	22.11	25.36	35.83	34.91	131.08	216.69	265.10	287.95
F_4 : 100% N:P_2O_5:25% K_2O through MOP + 75% K_2O through Polyhalite	45.83	87.51	130.28	148.16	152.84	1.39	1.77	10.44	16.44	21.61	23.89	27.34	39.00	37.05	133.05	223.33	278.38	293.58
F_5 : 100% N:P_2O_5:50% K_2O through MOP + 50% K_2O through Polyhalite	42.28	79.21	122.86	139.82	146.30	1.12	1.41	8.94	14.44	19.06	20.33	23.04	28.94	31.35	123.74	204.66	256.44	280.16
F_6 : 100% N:P_2O_5:75% K_2O through MOP + 25% K_2O through Polyhalite	41.30	75.70	119.84	138.83	143.34	1.06	1.36	8.89	13.89	18.94	19.44	21.31	28.91	30.82	119.67	201.99	256.50	274.76
S.Em (±)	1.04	3.68	2.52	2.16	2.46	0.1	1.14	0.54	0.65	0.75	0.93	1.21	3.52	1.86	3.09	4.65	6.03	5.60
C.D. at 5%	2.96	10.42	7.13	6.13	6.96	NS	0.40	1.53	1.84	2.13	2.64	3.44	9.96	5.28	8.76	13.15	17.08	NS
Interactions																		
I x F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Interaction: The interaction between irrigation regimes and fertilizer treatments were found non significant in respect of leaf area plant^{-1}.

Effect of polyhalite multinutrient fertilizer and irrigation levels on Quality parameters of seed cotton

The data regarding quality parameters namely ginning percentage, Upper half mean length (mm), uniformity ratio (%), micronaire value and Tanacity (g tex^{-1}) are presented in Table 2.

Irrigation regimes. The quality parameters *viz.*, Ginning percentage, Upper half mean length (mm), uniformity ratio (%), micronaire value and tanacity (g tex^{-1}) were not influenced significantly due to different irrigation regimes during both the years. The quality parameters are the genetic characteristic of Bt. Hybrid, they were not affected by irrigation regimes. These results are in close agreement with the finding of Waggins *et al.* (2014) and Mane *et al*. (2018).

Fertilizer treatment. The quality parameters *viz.*, Ginning percentage, Upper half mean length (mm), uniformity ratio (%), micronaire value and tenacity (g tex^{-1}) were not influenced significantly due to different fertilizer treatments during both the years.

Interaction. The interaction between irrigation regimes, fertilizer treatments through fertigation was found not significant in respect of quality parameters *viz.*, ginning percentage, Upper half mean length (mm), uniformity ratio (%), micronaire value, tenacity (g tex^{-1}) of Bt cotton during both the years of experimentation.

Table 2: Quality parameters of seed cotton as influenced by different treatments (Pooled mean).

Treatment	Quality parameters of cotton				
	UHML (mm)	UI (%)	MIC	Tanacity (g/tex)**	Ginning percentage
Irrigation Levels-I					
I_1 : 0.8 ETc	29.15	86.00	3.80	27.97	33.50
I_2 : 1.0 ETc	29.12	86.14	3.87	28.25	33.83
I_3 : 1.2 ETc	29.29	85.67	3.83	27.88	33.43
S.Em (±)	0.06	0.08	0.08	0.07	0.50
C.D. at 5%	NS	NS	NS	NS	NS
Fertilizer treatments-F					
F_1 : Absolute control	29.24	85.17	3.78	28.08	30.51
F_2 : 100% GRDF	29.21	86.11	3.82	27.03	33.65
F_3 : 100% N:P_2O_5:100% K_2O through Polyhalite	29.23	85.89	3.84	29.01	34.57
F_4 : 100% N:P_2O_5:25% K_2O through MOP + 75% K_2O through Polyhalite	29.27	86.56	3.89	28.18	34.76
F_5 : 100% N:P_2O_5:50% K_2O through MOP + 50% K_2O through Polyhalite	28.85	85.78	3.83	27.97	34.75
F_6 : 100% N:P_2O_5:75% K_2O through MOP + 25% K_2O through Polyhalite	29.32	86.11	3.84	27.93	33.29
S.Em (±)	0.27	0.15	0.04	0.104	0.37
C.D. at 5%	NS	NS	NS	NS	NS
Interactions					
I x F	NS	NS	NS	NS	NS
Optimum Range	26.7	81	3.6	26.6	35- 36 %

CONCLUSIONS

Irrigation regimes with scheduling of deficit irrigation at 0.8 ETc is significant among other irrigation levels with 20 percentage of saving cost coupled with application of 100% N: P_2O_5: 25% K_2O through MOP + 75% K_2O through polyhalite recorded significantly highest growth contributing characters. The quality parameters viz. ginning percentage, 2.5 % span length, uniformity ratio, micronaire value, elongation and bundle strength were not influenced significantly due to different irrigation regimes and fertilizer treatments during both the years. overall, this research contributes to sustainable agriculture practices, a balanced and prolonged supply of a nutrients with polyhalite to crop in sustained manner can be maintained.

FUTURE SCOPE

1. Investigate the long term effects of polyhalite multinutrient fertilizer on soil health.
2. Investigate the environmental sustainability of these practices, considering factors like water use efficiency, nutrient runoff and overall ecological impact. 3. Future trial should be conducted at summer season to see the interaction effect of irrigation levels and fertilizer treatments.

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