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Impact of Foliar Spray of Plant Growth Retardants with Potassium on Growth Traits, Gas Exchange Parameters and Grain Yield in Foxtail Millet (*Panicum italicum* L.)

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ABSTRACT

Background: Foxtail millet is one of the nutri-cereal foods for the people of semi arid regions. Proper nutrient management and source-sink alteration are major keys for achieving higher productivity in millets. However, potassium is not recommended to foxtail millet and the potential yield is not exploited. And also the study of source-sink alteration in foxtail millet by using plant growth regulators is meager.

Methods: An experiment was conducted to study the impact of plant growth retardants *viz.,* chlormequat chloride (CCC) and mepiquat chloride (MC) with the nutrient potassium (K_2SO_4 - 1%) on growth, gas exchange parameters and grain yield of foxtail millet under rainfed condition. Plant growth retardants with potassium consortium were used as foliar spray at flower initiation stage under field condition. Standard methods were used to measure the plant height, root length, number of leaves, LAD, CGR and grain yield. The photosynthetic rate, transpiration rate and leaf temperature were measured by using the instrument PPS.

Result: Foliar spray of CCC (250 ppm) with 1% K_2SO_4 showed supremacy to enhance crop growth rate, leaf area duration, photosynthetic rate, transpiration rate and grain yield compared to other treatments. However, lowest plant height (100.7 cm) and number of leaves were observed by CCC (250 ppm) alone. Highest photosynthetic rate (26.84) and transpiration rate (17.94) were registered by CCC + K_2SO_4. Lowest leaf temperature of 34.1°C was registered by 1% K_2SO_4 compared to control (35.6°C). CCC with K_2SO_4 recorded highest LAD value of 46.1 which is on par with K_2SO_4 alone (45.9). CCC with K_2SO_4 registered highest grain yield of 2.13 t ha^{-1} with increased yield of 18.3% over control. However, highest benefit cost ratio of ratio of 2.75 was recorded by 1% K_2SO_4 alone.

Key words: CCC, CGR, Foxtail millet, Grain yield, K_2SO_4, Leaf temperature, Photosynthetic rate.

INTRODUCTION

Small millets hold great potential in contributing food and nutritional security of the country which are called as powerhouse of nutrients and climate resilient crops. They have high fiber, quality protein and minerals composition being called as “nutri-cereals” (Durgad *et al.,* 2019). Among the millets, foxtail millet is mostly grown to meet the domestic needs of the rural people and used as an energy source for pregnant women, sick people and children. Recently, the importance of foxtail millet is recognized as diabetic food (Hariprasanna, 2016).

The biggest challenge for agriculture is to meet the food with nutritional security for increasing world population. Increasing the production of millets is first importance because of nutri-cereals. Improving crop yield under rainfed condition is important, to maintain food security and improve the livelihoods of the poor (Yadav *et al.,* 2015). The potentiality of foxtail millet has not been exploited in India due to mainly growing in rainfed condition, not recommended potash fertilizers and not altered the source-sink relation by using PGRs. Greater proportion of photo-assimilates is diverted for production and maintenance of vegetative plant parts rather than translocation to reproductive parts and hence, the plant puts on more plant height and higher biomass (Secondo and Reddy, 2018). Therefore, any attempts to reduce plant height would be expected to improve the yield by diverting the photo-assimilates to reproductive structures. CCC has been most widely used to reduce plant height, stimulate tillering, distribution of assimilates to sink and limits risk of lodging (Emam, 2011). Anosheh *et al.* (2016) reported that foliar application of cycocel improved the grain yield of wheat and maize. Latifkar *et al.* (2014) also reported that the application of cycocel increased the thousand grain weight and grain yield significantly in wheat. Foliar application of mepiquat chloride significantly increased the photosynthetic rate and seed yield in greengram (Rajesh *et al.,* 2014).

Potassium is an important primary nutrient and foliar spray of potassium increased the growth and yield of maize

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crop has been reported by Ali *et al.* (2016) under rainfed condition. Proper nutrient management especially potassium is also a key issue in achieving higher productivity of any crop. Keeping this in view, a field experiment was conducted to investigate the impact of plant growth retardants like CCC and MC with potassium on growth traits, gas exchange parameters and grain yield in foxtail millet.

MATERIALS AND METHODS

The study was conducted at Regional Research Station, Tamil Nadu Agricultural University, Paiyur during the *kharif* season of 2019-2021. The seeds of ATL 1 variety were directly sown to field with the spacing of 30 × 10 cm. As per the recommendations of TNAU Crop Production Guide, 44 kg of nitrogen and 22 kg of phosphorus per hectare were applied as basal. Plant growth retardants *viz.* CCC and MC and nutrient potassium sulphate solutions alone and combinations includes CCC (250 ppm), MC (250 ppm), K_2SO_4 (1%), CCC (250 ppm) + K_2SO_4 (1%) and MC (250 ppm) + K_2SO_4 (1%) were prepared and applied as foliar spray at 35 days after sowing. The control was maintained with water spray and an absolute control maintained without any spray. The experiment was imposed with seven treatments replicated thrice and adopted statistics of randomized block design.

Measurement of growth parameters

Plant height was measured from the ground level to the tip of the growing point. The plant was uprooted and the root was taken with minimum damage and the length from the cotyledonary node to the root tip was measured and expressed as cm. Number of leaves was determined by counting the leaves from the base to tip of the plant in each replication and mean value expressed in numbers.

Leaf area duration (LAD) was determined by using the formula of Power *et al.* (1967) as follows and expressed in days.

$$LAD = \frac{L_1 + L_2}{2} \times t_2 - t_1$$

Where,

L_1= Leaf area index at first stage.

L_2= Leaf area index at second stage.

$t_2 - t_1$ = Time interval in days.

Crop growth rate (CGR) was calculated based on the formula designed by Watson (1958) and the value is expressed as g m^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{P\ (t_2 - t_1)}$$

Where,

W_2 and W_1 are whole plant dry weight at time t_2 and t_1 respectively.

$t_2 - t_1$ is time interval.

P is spacing in m^2.

Measurement of gas exchange parameters and grain yield

Measurement of gas exchange parameters was performed by using Portable Photosynthesis System (PPS) (Model LC*pro*-SD., ADC BioScientific Ltd., Hoddesdon, UK) equipped with a halogen lamp (6400-02B LED) positioned on the cuvette. Third leaf from top was used for the measurements with replicated thrice. The photosynthetic rate, transpiration rate and leaf temperature were measured between 9 AM and 11.30 AM. The grain yield was recorded after harvest and expressed in terms of tonnes per hectare. The data on various parameters were analyzed statistically as per the procedure suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Impact of plant growth retardants and potassium on growth traits

Optimum plant height is desirable for higher productivity especially in millets. In the present study, control plants recorded highest plant height of 116.7 cm while foliar spray of CCC recorded lowest plant height (100.7 cm). However, moderate plant height of 110.4 cm was observed in K_2SO_4 spray followed by CCC + K_2SO_4 (Table 1). The reduction in the plant height by the application of CCC might be due to the growth retardant action by reducing cell elongation and cell division. Mansuroglu *et al.* (2009) stated that the plant growth retardants inhibit the formation of active gibberellins and reduce the plant height. However, moderate plant height by CCC with K_2SO_4 might be due to potassium which acts as growth nutrient and enzyme activator. Potassium increased the plant height, tiller numbers and yield in berseem (Akshit *et al.,* 2020).

Highest root length was recorded by 1% K_2SO_4 which is on par with CCC + K_2SO_4 and MC + K_2SO_4 while lowest length in absolute control (Table 1). In the present study, root length increased up to 18.4% by potassium sulphate spray alone. Increment of root length by potassium might be due to the effective translocation of photo-assimilates to root growth and its action of compatible osmolyte keeps the leaf water potential lower than that of root water potential which ultimately induces the root growth. Root length increased significantly by the application of potassium in tobacco (Rad and Boland, 2017). Interestingly, growth retardants CCC and MC also increased the root length by foliar spray alone and also along with potassium. Anosheh *et al.* (2016) reported that the application of cycocel increased the root length by the enhancement of IAA content.

Foliar application of CCC reduced the number of leaves per plant and maintained optimum number along with potassium. Among the treatments, highest number of leaves (11.3) was recorded by absolute control and CCC alone registered lowest number (Table 1). Vishal *et al.* (2016) found that the plant height and number of leaves were significantly reduced by CCC. The optimum number of leaves (9.0) was recorded by CCC with potassium which is on par with potassium alone (9.7). The enhancement of leaf number by the addition of potassium with CCC might be due to the role of potassium on turgor maintenance leads to increased plant height. Potassium increased the plant height and number of leaves in *Brassica rapa* through increased protein synthesis (Truong, 2017).

The highest LAD value of 46.10 days was recorded by CCC with potassium which is on par values with K_2SO_4 alone (45.90 days). The increment of LAD by CCC might be due to maintaining leaf area and LAI through increased retention capacity. The present study revealed that the increment of leaf area by CCC and MC might be the reason for the improvement of LAD. Sivakumar and Surendar (2020) reported that the foliar application of brassinolide along with potassium showed superior LAD value might be due to maintaining leaf area in finger millet.

CGR explains that the dry matter accumulation per unit land area and unit time. Foliar spray of 1% K_2SO_4 recorded superior CGR value of 14.10 followed by CCC with potassium (13.92). Absolute control recorded least value (11.69) of CGR (Table 1). There was an increment of 20.6% and 19.1% CGR values by the application of K_2SO_4 alone and CCC with K_2SO_4 respectively. The positive role of potassium on CGR might be due to the effective transport of photo-assimilates to various parts of plants. Mumtaz *et al.* (2012) found that the increasing rate of potassium increased the LAI and CGR in canola cultivars. Foliar application of CCC increased the CGR value in mustard (Banerjee *et al.,* 2012).

Impact of plant growth retardants and potassium on gas exchange parameters

Application of K_2SO_4 alone and CCC with K_2SO_4 increased the photosynthetic rate and transpiration rate. Among the treatments, CCC + K_2SO_4 recorded higher photosynthetic rate of 26.84 which is on par with potassium alone (26.45) and the lower was recorded in absolute control (Fig 1). The beneficial effect of CCC and MC on photosynthetic rate is due to the increment of CO_2 conductance through stomatal movement in cotton (Kumar *et al.,* 2005).

CCC with potassium increased the photosynthetic rate up to 14.2% and potassium alone 12.5% over control. Increased photosynthetic rate by potassium might be due to its action on stomatal opening. Rad and Boland (2017) noticed that the addition of potassium increased the photosynthetic rate under drought condition in tobacco.

Foliar spray of CCC with potassium increased the transpiration rate and reduced the leaf temperature compared to unsprayed one. The highest transpiration rate of 17.94 was registered by CCC + potassium which is on par with MC + potassium (17.56) and potassium alone (17.42). An increment of 15.6% transpiration rate was observed by CCC with potassium (Fig 2). Foliar spray of CCC and MC increased the transpiration rate was associated with increased stomatal conductance in soybean genotypes (Kumar *et al.,* 2002). Potassium plays a major role on stomatal opening through its compatible osmolyte nature thus increased the transpiration rate. Zaina and Ismail (2016) reported that enhancement of transpiration rate was observed by the application of potassium in rice.

Absolute control registered higher leaf temperature of 30.6°C followed by water spray control (30.4°C). However,

Table 1: Impact of plant growth retardants with potassium on growth parameters in foxtail millet.

Treatments	Plant height (cm)	Root length (cm)	Number of leaves	LAD (Days)	CGR (g m^{-2} day^{-1})	BC ratio
Absolute control	116.6	18.4	11.3	41.03	11.69	-
Control	116.7	18.8	11.0	40.97	11.91	-
CCC (250 ppm)	100.7	19.2	08.7	43.37	13.15	1.56
MC (250 ppm)	105.8	18.8	09.3	42.73	13.04	1.78
K_2SO_4 (1%)	110.4	20.6	09.7	45.90	14.10	2.75
CCC (250 ppm) + K_2SO_4 (1%)	106.4	19.5	09.0	46.10	13.92	2.32
MC (250 ppm) + K_2SO_4 (1%)	109.3	19.0	10.0	44.03	13.83	2.33
SEd	2.33	0.79	0.48	1.25	0.57	-
CD (P=0.05)	4.78	1.64	1.02	2.68	1.19	-

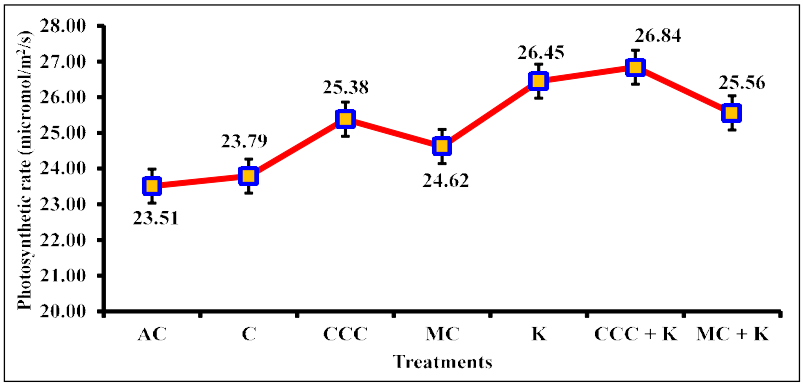

Fig 1: Impact of plant growth retardants with potassium on photosynthetic rate in foxtail millet.

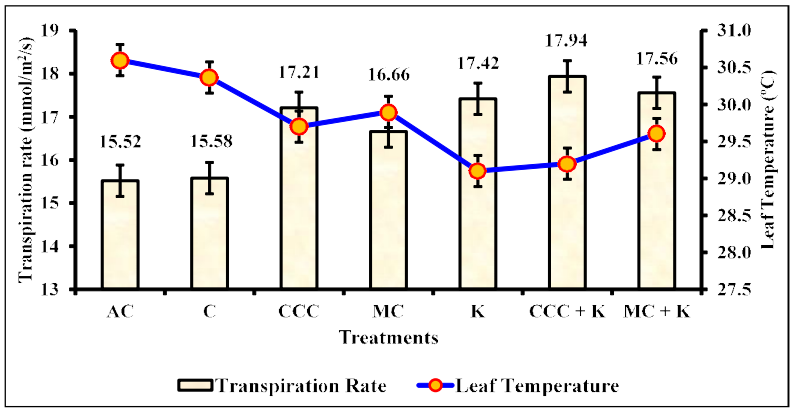

Fig 2: Impact of plant growth retardants with potassium on transpiration rate and leaf temperature in Foxtail millet.

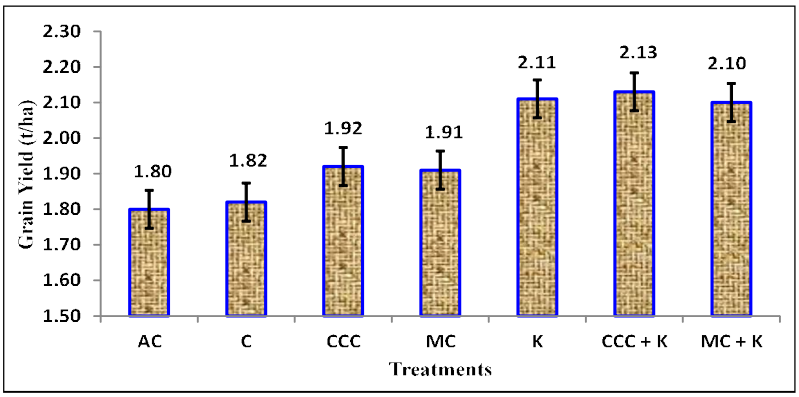

Fig 3: Impact of plant growth retardants with potassium on grain yield in Foxtail millet.

the lowest leaf temperature of 29.1°C was found in 1% K_2SO_4 which is on par with CCC + K_2SO_4 (29.2°C). Maintenance of transpiration rate under rainfed condition is an essential to maintain the photosynthetic rate and leaf temperature. In the present study, leaf temperature was reduced up to 1.5°C and 1.4°C by the application of potassium alone and CCC with potassium respectively compared to absolute control. Foliar application of cycocel reduced the leaf temperature in tuberose (Khondoker *et al.,* 2019). The reduction of leaf temperature by the addition of potassium might be due its stomatal opening function. Athnere *et al.* (2020) found that the foliar spray of 1% potash recorded minimum leaf temperature and higher grain yield in summer greengram.

Impact of plant growth retardants and potassium on grain yield and BC ratio

The highest grain yield of 2.13 tonnes ha^{-1} registered by CCC + K_2SO_4 which is on par with K_2SO_4 alone (2.11) and MC + potassium (2.10) while the lowest was recorded in absolute control (1.80). The grain yield increased up to 18.3% by CCC with potassium and 17.2% by K_2SO_4 alone (Fig 3) compared to absolute control. The yield increment by CCC + K_2SO_4 might be due to the increased root length, CGR, LAD and photosynthetic rate which are directly contribute to the photosynthesis and ultimately yield.

Foliar application of CCC increased the grain yield in wheat up to 13.5% compared to control under water deficit condition (Jiriaie and Sajedii, 2012). Qin *et al.* (2020) reported that the foliar application of CCC reduced the plant height and increased the grain yield in wheat. Split potassium fertilization increased the dry matter content and quality parameters in tomato (Vasileva and Dinev, 2021). The highest benefit cost (BC) ratio of 2.75 was registered by potassium alone followed by MC + potassium (2.33) and CCC + potassium (2.32). Even though, the highest grain yield was recorded by CCC with potassium, lower BC ratio was found due to higher cost of CCC than MC and potassium.

CONCLUSION

Foliar spray of CCC (250 ppm) with K_2SO_4 (1%) at 35 days after sowing recorded higher grain yield of 2.13 tonnes ha^{-1} with the yield increment of 18.3% compared to absolute control. However foliar spray of 1% potassium sulphate alone recorded 2.11 tonnes grain yield per hectare with highest BC ratio of 2.75 in foxtail millet. Therefore, foliar spray of 1% K_2SO_4 may be recommended to increase the grain yield and also attain higher benefit cost ratio in foxtail millet under rainfed condition.

REFERENCES

Akshit, Sheoran, R.S., Harender, Kumar, S. and Kavinder. (2020). Effect of potassium and boron fertilization on growth, forage yield and quality of Berseem (*Trifolium alexandrinum* L.). Legume Research - An International Journal. 43(3): 421-426.

Ali, A., Hussain, M., Habib, H.S., Kiani, T.T., Anees, M.A. and Rahman, M.A. (2016). Foliar spray surpasses soil application of potassium for maize production under rainfed conditions. Turkish Journal of Field Crops. 21(1): 36-43.

Anosheh, P., Emam, Y. and Khaliq, A. (2016). Response of cereals to cycocel application. Iran Agricultural Research. 35(1): 1-12.

Athnere, S., Kolage, A., Gagare, Y. and Gadakh, M. (2020). Effect of potash on physiochemical properties of summer green gram at different irrigation schedules. Chemical Science Review and Letters. 9(35): 660-664.

Banerjee, A., Datta, J.K. and Mondal, N.K. (2012). Changes in morpho-physiological traits of mustard under the influence of different fertilizers and plant growth regulator cycocel. Journal of the Saudi Society of Agricultural Sciences. 11: 89-97.

Durgad, A.G., Amrutha, T.J., Suresh, S.P., Hiremath, G.M., Goudappa, S.B. and Ananda, N. (2019). Economics of foxtail and little millets production in Ballari and Koppal districts of Karnataka, India. International Journal of Current Microbiology and Applied Sciences. 9: 214-222.

Emam, Y. (2011). Cereal Production (4th ed.). Shiraz: Shiraz University Press.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. (2nd Ed.) John Wiley and Sons, New York, USA.

Hariprasanna, K. (2016). Foxtail Millet - Nutritional importance and cultivation aspects. Indian Farming. 65(12): 25-29.

Jiriaie, M. and Sajedii, N.A. (2012). Effect of plant growth regulators on agro physiological traits of wheat [*Triticum aestivum* (L.) var. Shahriar] under water deficit stress. Research on Crops. 13(1): 37-45.

Khondoker, R., Rasal Monir, M.D. and Kabir, M.H. (2019). Influence of anti-transpirant and cycocel on growth and flowering of tuberose under different moisture regimes. International Journal of Natural and Social Sciences. 6(2): 27-43.

Kumar, K.K.A., Patil, B.C. and Chetti, M.B. (2005). Effect of plant growth regulators on physiological components of yield in hybrid cotton. Indian Journal of Plant Physiology. 10(2): 187-190.

Kumar, P., Hiremath, S.M., Deshmukh, P.S. and Kushwaha, S.R. (2002). Effect of growth regulators on growth yield and metabolism in soybean genotypes. Indian Journal of Agricultural Research. 36(4): 254-258.

Latifkar, M., Mojaddam, M. and Nejad, T.S. (2014). The effect of application time of cycocel hormone and plant density on yield and yield components of wheat (Chamran cv.) in Ahvaz weather conditions. International Journal of Biosciences. 4: 234-242.

Mansuroglu, S., Karaguzel, O., Ortacesme, V. and Sayan, M.S. (2009). Effect of paclobutrazol on flowering, leaf and flower colour of *Consolida orientalis*. Pakistan Journal of Botany. 41: 2323-2332.

Mumtaz, A., Cheema, M.A., Sattar, A., Rasul, F. and Saleem, M.F. (2012). Influence of different levels of potassium on growth, yield and quality of canola (*Brassica napus* L.) cultivars. Pakistan Journal of Agricultural Sciences. 49(2): 163-168.

Power, J.E., Wills, W.O., Granes, D.L. and Reichman, G.A. (1967). Effect of soil temperature, phosphorus and plant age on growth analysis of barley. Agronomy Journal. 59: 231-234.

Qin, R., Noulas, C., Wysocki, D., Liang, X., Wang, G. and Lukas, S. (2020). Application of plant growth regulators on soft white winter wheat under different nitrogen fertilizer scenarios in irrigated fields. Agriculture. 10: 305-318.

Rad, S.B. and Boland, R.H. (2017). Effect of potassium application in drought-stressed tobacco (*Nicotiana rustica* L.) plants: Comparison of root with foliar application. Annals of Agricultural Sciences. 62(2): 121-130.

Rajesh, K., Reddy, N.S., Reddy, P.K.A. and Singh, G.B. (2014). Effect of plant growth regulating compounds on chlorophyll, photosynthetic rate and yield of greengram. International Journal of Development Research. 4(5): 1110-1112.

Secondo, A.S.P. and Reddy, Y.A.N. (2018). Plant growth retardants improve sink strength and yield of sunflower. International Journal of Current Microbiology and Applied Sciences. 7(10): 111-119.

Sivakumar, R. and Surendar, K.K. (2020). Effects of plant growth regulators and potassium on growth and yield of finger millet. Bangladesh Journal of Botany. 49(2): 223-228.

Truong, K. (2017). The effects of nitrogen and potassium on the growth of *Brassica rapa*. Best Integrated Writing. 4: 88-99.

Vasileva, V.H. and Dinev, N.S. (2021). Mineral content and quality parameters of tomato fruits as affected by different potassium fertilization treatments and cultivar specifics. Indian Journal of Agricultural Research. 55(2): 169-174.

Vishal, V.C., Thippesha, D., Chethana, K., Maheshgowda, B.M., Veeresha, B.G. and Basavraj, A.K. (2016). Effect of various growth regulators on vegetative parameters of strawberry (*Fragaria* × *Ananassa* Duch.) Cv. Sujatha. Research Journal of Chemical and Environmental Sciences. 4(4): 68-71.

Watson, D.J. (1958). Comparative physiological studies on the growth of field crops. Variation in net assimilation rate and leaf area between species and varieties and within and between years. Annals of Botany. 2: 41-76.

Yadav, A.K., Kumar, A., Singh, J., Jat, R.D., Jat, H.S., Datta, A., Singh, K., Choudhary, R., Choudhary, K.M. and Sutaliya, J.M. (2015). Differential response of pearl millet genotypes to irrigated and rainfed conditions. Ecology, Environment and Conservation. 21(4): 2013-2020.

Zaina, N.M.M. and Ismail, M.R. (2016). Effects of potassium rates and types on growth, leaf gas exchange and biochemical changes in rice (*Oryza sativa*) planted under cyclic water stress. Agricultural Water Management. 164: 83-90.