International Scholars Journals

International Journal of Agricultural Sciences ISSN: 2167-0447 Vol. 11 (8), pp. 001-007, August, 2021. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Impact of CCC with nutrients on growth, physiological traits and yield of little millet (*Panicum sumatrense*) under rainfed condition

Sivakumar, R.

Regional Research Station, Tamil Nadu Agricultural University, Paiyur, Tamil Nadu, India.
Author Email: sivatnau14@gmail.com

Accepted 07 June, 2021

Abstract

A field experiment was conducted to study the impact of chloro choline chloride (CCC) with potassium sulphate and boric acid on growth, physiological traits and yield of little millet under rainfed condition. Combination of CCC (250 ppm) with K_2SO_4 (1%) and boric acid (0.3%) registered highest total chlorophyll content (1.61 mg) and soluble protein content (14.2 mg). The moderate plant height (120.8 cm) and number of leaves (77) recorded by CCC (250 ppm) with K_2SO_4 (1%) and boric acid (0.3%) compared to other treatments. However, the highest plant height of 133.2 cm registered by water sprayed control and lowest plant height of 109.2 cm recorded by foliar spray of 250 ppm CCC. The Highest number of leaves was recorded by control (82.3) and lowest in CCC alone (67.3). Lowest number of days to flowering (44.7) recorded in foliar spray of CCC (250 ppm) followed by CCC (150 ppm). However, these treatments are significantly on par with each other. The crop growth rate increased by the application of CCC and not supported by addition of potassium and boron. CCC 250 ppm with K_2SO_4 and boric acid spray recorded higher grain yield of 897 kg ha^{-1} compared to control (783 kg ha^{-1}).

Keywords*:* Little millet, CCC, potassium sulphate, CGR, chlorophyll, soluble protein, grain yield.

INTRODUCTION

Little millet is a traditional crop considered as appropriate food for the people of all age groups and grown all over India. It is one among the nutri-cereals gaining lot of importance with low carbohydrate and water soluble gum. It provides the essential nutraceutical ingredients include phenols, tannins and phytates with essential micro and macronutrients. It contains healthy polyunsaturated fatty acids, fibers and iron. Little millet also contains flavonoids which are good antioxidants. These antioxidants play a key role in increasing the immune system of the human body (Sarita and Singh, 2016).

The biggest challenge for agriculture in the present and future is to meet out the food security for increasing world population. Increasing the production of cereals and millets is first importance to meet the challenge. The rainfed zones of India makeup 2/3rd of the net area grown and as much as half of the net agricultural output is generated by it. Out of the 300 million people in this area, 40% is poor and totally depend on the rainfed cultivation (Yadav et al., 2015). It is highly essential to improve the yield of rainfed crops due to maintain the food security and to increase the livelihood of people living under the line of poverty.

The potentiality of little millet has not been exploited due to the following reasons. 1. Mainly growing in rainfed situation, 2. Not recommended potash fertilizers and 3. Not altered the source to sink relation by using plant growth regulators and nutrients. Greater proportion of photo-assimilates is diverted for production and maintenance of vegetative parts rather than reproductive parts lead to more plant height (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 parts. Reduced plant height is also advantage for reduce the lodging especially in millets.

Chloro ethyl trimethyl ammonium chloride (CCC) has been most widely used to reduce plant height, to increase tiller numbers, distribution of assimilates, grain yield, harvest index and limits risk of lodging (Singh et al., 2019). Anosheh et al. (2014) reported that foliar application of cycocel improved the growth and yield of wheat and maize. Reduction in plant height is considered as the most important morphological outcome of cycocel application. According to Shekoofa and Emam (2008), cycocel was associated with reduced elongation of the internodes, rather than lowering the number of internodes. And also they reported that cycocel application increased the grain yield of winter wheat. Latifkar et al. (2014) found that the application of chlormequat chloride significantly increased the number of spikes, thousand grain weight and grain yield in wheat. Potassium is an important primary nutrient and foliar spray of 3% potassium was more efficient for increasing growth and yield of maize crop as compared to soil application under rainfed condition (Ali et al., 2016).

Khan et al. (2016) registered that the foliar application of boron increased the seed yield attributed to modification of source sink relationship and possible mechanisms may be sugar and assimilate translocation and partitioning for seed setting.

Proper nutrient management is also a key issue in achieving higher harvest index of any crop. Especially potassium and boron are directly linked with transport of photo-assimilates to the economic part. However, these two nutrients are not recommended to little millet so far. Hence, 1% of potassium sulphate and 0.3% boric acid are included in the present study along with CCC for achieving better yield. Keeping this in view, the field experiment was conducted to investigate the impact of plant growth retardant - CCC with potassium and boron on growth parameters like plant height, number of leaves, days to flowering and its consequent effect on grain yield of little millet. The growth and yield parameters are evidenced with physiological traits *viz.* total chlorophyll and soluble protein content.

MATERIALS AND METHODS

The study was conducted at Regional Research Station, Tamil Nadu Agricultural University, Paiyur, Tamil Nadu during Kharif seasons of 2018-2020. The experiment was carried out by using little millet variety Paiyur 2 seeds, sown directly to the field with the spacing of 25 x 10 cm after the receipt of sufficient rainfall. CCC with nutrient solutions were prepared separately and combinations includes CCC (150 ppm), CCC (250 ppm), CCC (150 ppm) + K_2SO_4 (1%), CCC (250 ppm) + K_2SO_4 (1%), CCC (150 ppm) + K_2SO_4 (1%) + boric acid (0.3%), CCC (250 ppm) + K_2SO_4 (1%) + boric acid (0.3%) and applied as foliar spray at 35 days after sowing along with control was maintained with water spray and absolute control with no spray. The experiment was carried out with one variety imposed with eight treatments, replicated thrice and adopted statistics of randomized block design.

Plant height was measured from the ground level to the tip of the growing point. Numbers 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. Number of days to flowering was taken at which the plant started flowering.

Crop growth rate (CGR) was calculated by using the following formula as suggested by Watson (1958).

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

Where, W_2 and W_1 = Whole plant dry weight at t_2 & t_1 respectively; $t_2 - t_1$ = Time interval; P = spacing in m^2.

The physiological parameters were estimated at 65 days after sowing by using standard protocols. Chlorophyll content was estimated by using 80% acetone by adopting the procedure of Arnon (1949) and the content was expressed as mg g^{-1} of fresh weight. 500 mg leaf sample was macerated with 10 mL of 80% acetone and centrifuged the contents at 3000 rpm for 10 minutes. The supernatant was collected and made up the volume to 25 mL by using 80% acetone. The optical density was measured at 652 nm in spectrophotometer and the total chlorophyll content was estimated by using following formula.

$$\text{Total chlorophyll} = \frac{\text{OD at } 652 \times 1000}{34.5} \times \frac{V}{1000 \times W}$$

Where, W is weight of the sample in gram and V is final volume made up in mL.

Soluble protein content of leaf was estimated as per the method of Lowry et al. (1951). 250 mg of leaf sample was weighed and macerated with 10 mL of phosphate buffer solution. The content was centrifuged at 3000 rpm for 10 minutes and the supernatant was collected and made up to 25 mL. 1 mL of the supernatant was pipette out to a test tube and 5 mL of alkaline copper tartarate reagent and 0.5 ml of folin reagent were added. The colour intensity was measured at 660 nm in spectrophotometer and the amount of soluble protein present in the sample was calculated by using bovine serum albumin as standard and expressed as mg g^{-1} fresh weight. The grain yield was recorded after harvest and expressed in terms of kilogram per hectare. The data on various parameters were analyzed statistically as per the procedure suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant height is an important parameter that determines the growth and development of a plant. Increased plant height also an undesirable trait causes lodging and more assimilates are utilized for the increased plant height and number of leaves. More number of leaves cause higher leaf area which ultimately creates shading effect leads to poor yield. Hence, optimum plant height is desirable for higher productivity especially in millets. In the present study, highest plant height was recorded in water spray control (133.2 cm) while lowest (109.2 cm) was registered in foliar spray of 250 ppm of CCC (Table 1).

CCC and paclobutrazole are plant growth retardants mainly used to retard the plant height. This has been achieved by reducing cell elongation and also by lowering the rate of cell division and regulating the plant height physiologically (Asgarian et al., 2013).

Mansuroglu et al. (2009) stated that the plant growth retardants inhibit the formation of active gibberellins and can be used to reduce unwanted shoot elongation. Present study corroborated with earlier findings. However, moderate plant height of 120.8 cm was observed in CCC (250 ppm) along with 1% K_2SO_4 and 0.3% boric acid spray. This might be due to the application of potassium and boron which are act as growth nutrients and enzyme activators. Compared to water spray control, 10.3% reduction in plant height was registered in CCC with potassium and boron treatment. Application of CCC has been shown to reduce the plant height in number of plant species such as Poinsettia (Lodeta et al., 2010).

Number of leaves is an ideal physiological trait which mainly contributes photosynthates to all the parts of the plant for growth, development and yield. However, more number of leaves per plant causes mutual shading to the lower leaves which reduces economic yield. Maintenance of ideal leaf number is essential for higher harvest index. In the present study, application of CCC reduced the number of leaves per plant and maintained optimum number with potassium and boron. Among the treatments, highest number of leaves was recorded by water spray control (82.3) and lowest in 250 ppm CCC alone (67.3) (Table 1).

The reduction of leaf number by the application of CCC might be due to reduced plant height. However, number of leaves was increased with increased in concentration of CCC was observed by Mandal et al. (2012) in okra. Present study is not agreement with early study. However, the plant height and number of trifoliate leaves were significantly reduced by the application of CCC was reported by Vishal et al. (2016). This recent earlier study coincided with the present investigation. More number of leaves was recorded in absolute control and water spray control might cause mutual shading which reflect on the yield. In other way, foliar spray of CCC reduced the leaf number up to 22.3% is not an advantage effect which causes source limitation also reflected on the yield showed later in this paper.

Days to flowering was negatively correlated with grain yield under rainfed condition. Delayed flowering under rainfed is a strong indication of susceptibility to any stress (Hanamaratti and Salimath, 2012). Induction of early flowering is an important physiological trait which directly correlated with the grain yield especially under rainfed condition. In the present study, lowest number of days to flowering (44.7) was recorded in foliar spray of CCC (250 ppm) followed by CCC (150 ppm) and CCC (250 ppm) with potassium sulphate (1%) and boric acid (0.3%). However, these treatments are significantly on par with each other (Table 1).

The higher number of days to flowering (49) was observed in water spray control followed by absolute control (48.7). Application of CCC along with potassium and boron induce earlier flowering by three days compared to control. Qureshi et al. (2018) reported that foliar application of cycocel induced early emergence of buds and inflorescences in chrysanthemum. The present study agreed with earlier finding. The early flowering by the application of CCC may be due to the fact that such plants build up sufficient food reserves at initial stages. These reserve foods could have been utilized for the reproductive growth with restriction in vegetative growth (Kumar et al., 2019). CCC treated plants showed earlier flowering because of the anti-gibberellin action of CCC. A reduction in the level of endogenous gibberellins might be a prerequisite for floral induction.

Chlorophyll content is a key factor affecting the photosynthesis through efficient light absorption. Among the photosynthetic pigments, chlorophyll is major pigment which directly involves photosynthesis and related to assimilates production and ultimately yield. In the present study, foliar spray of 250 ppm CCC with 1% K_2SO_4 and 0.3% boric acid registered higher chlorophyll content of 1.61 mg g^{-1} which is on par with 250 ppm CCC with 1% K_2SO_4 (1.58 mg g^{-1}) while lower recorded in absolute control (1.31 mg g^{-1}). An increment of 22.9% chlorophyll content was observed by the application of CCC with K_2SO_4 and boric acid compared to control (Figure 1). Kahar (2008) reported that the growth retardants enhance the green colour of the foliage, stimulate flowering and promote resistance against environmental stresses. The positive effect of CCC on chlorophyll content might be due to the ability to delay senescence of leaf and arresting the chlorophyll degradation in okra (Bhagure and Tamble, 2013). Devi et al. (2011) obtained maximum chlorophyll content by foliar application of 500 ppm CCC in soybean. Bora and Sarma (2004) stated that the effect of cycocel in increasing

Table 1. Impact of CCC with nutrients on growth parameters in little millet under rainfed condition.

Treatments	Plant height (cm)	Number of leaves	Days to flowering
Absolute control	130.90	80.0	48.7
Control (Water spray)	133.2	82.3	49.0
CCC (150 ppm)	114.7	68.2	46.0
CCC (250 ppm)	109.2	67.3	44.7
CCC (150 ppm) + K_2SO_4	117.6	72.0	46.7
CCC (250 ppm) + K_2SO_4	112.9	71.3	46.3
CCC (150 ppm) + K_2SO_4 + boric acid	121.7	77.0	46.3
CCC (250 ppm) + K_2SO_4 + boric acid	120.8	77.0	46.0
SEd	2.12	1.51	0.87
CD (P=0.05)	4.40	3.20	1.76

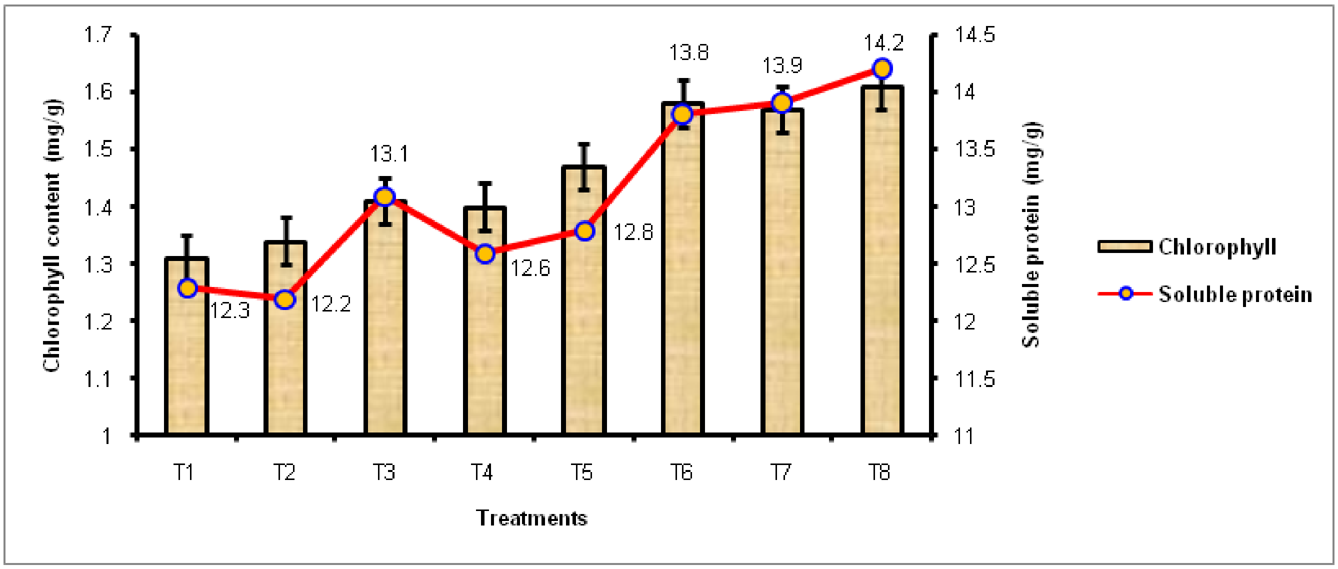

Figure 1. Impact of CCC with nutrients on chlorophyll and soluble protein content in little millet under rainfed condition.

chlorophyll contents may be due to the reduction in cell size resulting in dense cytoplasm. The positive effect of CCC on chlorophyll content was enhanced by the addition of potassium might be due to enzyme activator of chlorophyll synthesis and protect the chloroplast through osmolytic water balance. Adhikari et al. (2019) registered that the foliar application of 2.5% potassium sulphate increased the chlorophyll content in soybean. Potassium facilitates a well-structured organization of grana and stroma lamellae which support chloroplast integrity and efficient light absorption (Tranknera et al., 2018).

Treatment details: T_1 - Absolute Control, T_2 - Control (Water spray), T_3 - CCC (150 ppm), T_4 - CCC (250 ppm), T_5 - CCC (150 ppm) + K_2SO_4, T_6 - CCC (250 ppm) + K_2SO_4, T_7 - CCC (150 ppm) + K_2SO_4 + Boric acid, T_8 - CCC (250 ppm) + K_2SO_4 + Boric acid.

The soluble protein content of the leaf, being a measure of rubisco activity is considered as an index for photosynthetic efficiency of crop plants. Rubisco enzyme forms nearly 80 per cent of the soluble proteins in leaves of many plants. Diethelm and Shibles (1989) reported that the rubisco content per unit leaf area was positively correlated with that of soluble protein content of the leaf. Among the treatments, foliar spray of 250 ppm CCC with 1% K_2SO_4 and 0.3% boric acid registered higher soluble protein content of 14.2 mg g^{-1} which is on par with 250 ppm CCC with 1% K_2SO_4 (13.8 mg g^{-1}). An increment of 16.4% soluble protein was observed in the present study by the application of CCC with potassium and boron (Figure 1). The positive effect of CCC on soluble protein content might be due to the ability to promoting the synthesis of soluble protein and enzyme (Bhagure and Tamble, 2013).

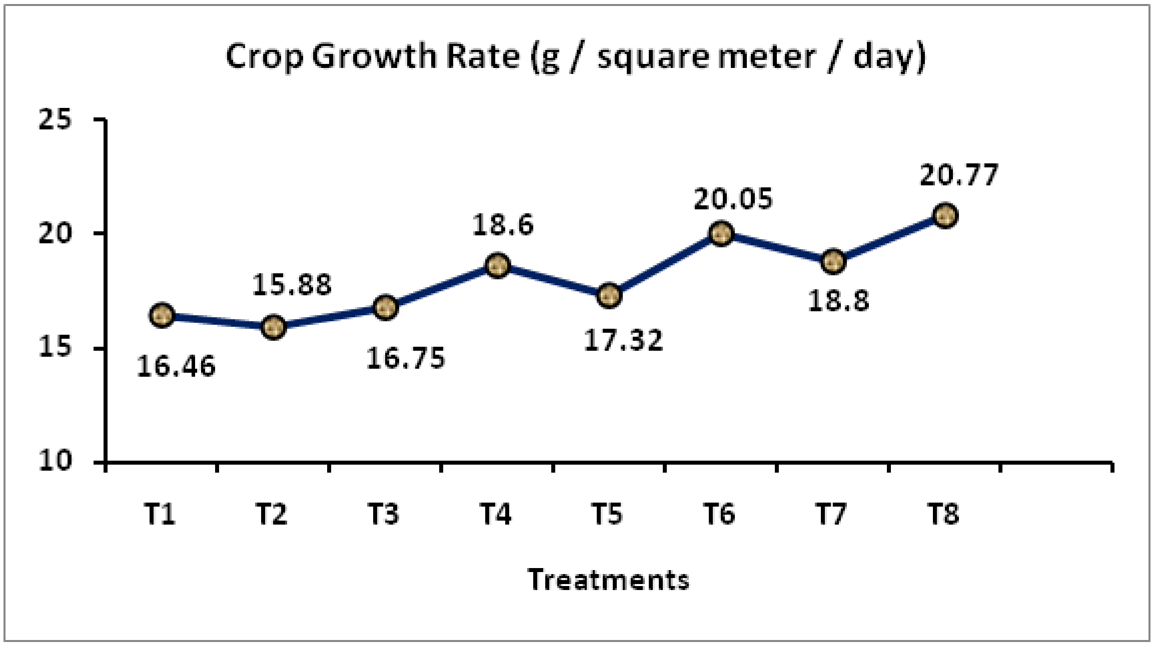

Figure 2. Impact of CCC with nutrients on crop growth rate in little millet under rainfed condition.

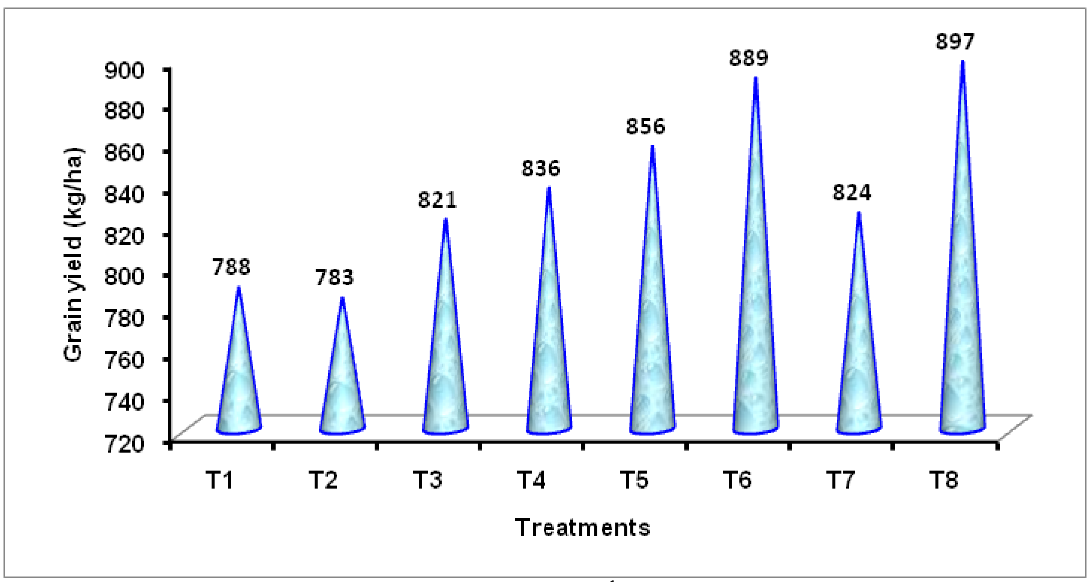

Figure 3. Impact of CCC with nutrients on grain yield (kg ha^{-1}) in little millet under rainfed condition.

The additive effect of potassium with CCC on soluble protein attributed to increased efficiency of abundant enzyme - rubisco and increases rubisco carboxylation activity in chloroplast (Zahoor et al., 2017). On the other hand, Oosterhuis et al. (2013) found that potassium deficiency inhibits the activation of rubisco resulting in reduced rate of RuBP carboxylation ultimately photosynthesis. Potassium facilitates chloroplast integrity and the efficiency of light absorption, rubisco activity and carbon assimilation (Tranknera et al., 2018).

Treatment details: T_1 - Absolute Control, T_2 - Control (Water spray), T_3 - CCC (150 ppm), T_4 - CCC (250 ppm), T_5 - CCC (150 ppm) + K_2SO_4, T_6 - CCC (250 ppm) + K_2SO_4, T_7 - CCC (150 ppm) + K_2SO_4 + Boric acid, T_8 - CCC (250 ppm) + K_2SO_4 + Boric acid.

CGR denotes that dry matter accumulation per unit land area and unit time. Maintenance of CGR under rainfed situation is an essential growth analytical trait which decides the yield of crop plants. CGR is a simple and important index of agricultural productivity on rate of dry matter production. In the present study, foliar spray of 250 ppm CCC with 1% K_2SO_4 and 0.3% boric acid recorded superior CGR value of 20.77 g m^{-2} day^{-1} followed by 250 ppm CCC with 1% K_2SO_4 (20.05). Water sprayed control recorded least value (15.88 g m^{-2} day^{-1}) of CGR (Figure 2). There was an increment of 30.8% CGR by the application of CCC with potassium and boron. The results indicated that the role of potassium and boron on CGR is meager. However, the superior role of CCC on CGR might be due to its role on increase in the per cent distribution of dry matter to the economic part was reported by Gollagi et al. (2009). Foliar application of 200 ppm CCC increased growth analytical traits like LAD, SLW, NAR and CGR was already reported by Banerjee et al. (2012) in mustard.

Treatment details: T_1 - Absolute Control, T_2 - Control (Water spray), T_3 - CCC (150 ppm), T_4 - CCC (250 ppm), T_5 - CCC (150 ppm) + K_2SO_4, T_6 - CCC (250 ppm) + K_2SO_4, T_7 - CCC (150 ppm) + K_2SO_4 + Boric acid, T_8 - CCC (250 ppm) + K_2SO_4 + Boric acid.

The highest grain yield of 897 kg ha^{-1} was registered by combination of 250 ppm CCC + 1% K_2SO_4 + 0.3% boric acid followed by 150 ppm CCC + 1% K_2SO_4 + 0.3% boric acid (889 kg/ha) while the lowest was recorded in control (783 kg/ha).

The grain yield was increased up to 14.6% by the application of CCC + K_2SO_4 + boric acid under rainfed condition (Figure 3). The yield increment by CCC + K_2SO_4 + boric acid under rainfed might be due to the reduced plant height, increased chlorophyll, soluble protein content, and CGR which are directly contribute to the photosynthesis and ultimately yield. The positive effect of CCC on grain yield might be due to reduced plant height which improves the partitioning efficiency and sink activity. The positive role of CCC on yield components such as greater fertile tillers, spike number, fertile spikelets, grain number and grain weight was reported by Anosheh et al. (2016). Foliar application of chlormequat chloride at 0.2% increased the grain yield and harvest index in wheat attributed to higher translocation to economic part (Singh et al., 2019). Latifkar et al. (2014) also reported that the application of chlormequat chloride significantly increased the grain yield in wheat. The present investigation coincided with these earlier studies. Potassium is known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation ultimately enhance productivity of the crops. Boron can improve flowering ability via pollen germination and pollen tube growth and can also enhance the effective partitioning of assimilates from source and sink.

REFERENCES

Adhikari B, Dhungana SK, Kim D, Shin DH (2019). Effect of foliar application of potassium fertilizers on soybean plants under salinity stress. J. Sau. Soc. Agri. Sci., doi.org/10.1016/j.jssas.2019.02.001.

Ali A, Hussain M, Habib HS, Kiani TT, Anees MA, Rahman MA (2016). Foliar spray surpasses soil application of potassium for maize production under rainfed conditions. Tur. J. Field Crops, 21(1): 36-43.

Anosheh P, Emam H, Ashraf M (2014). Impact of cycocel on seed germination and growth in some commercial crops under osmotic stress conditions. Arch. Agron. Soil Sci., 60: 1277-1289.

Anosheh P, Emam Y, Khaliq A (2016). Response of cereals to cycocel application. Ir. Agri. Res., 35(1): 1-12.

Arnon DI (1949). Copper enzymes in isolated chloroplasts, polyphenoxidase in *Beta vulgaris*. Pl. Physiol., 24: 1-15.

Asgarian H, Nabigol A, Taheri M (2013). Effects of paclobutrazol and cycocel for height conrol of *Zinnia*. Inter. J. Agron. Plant Product., 4: 3824-3827

Banerjee A, Datta JK, Mondal NK (2012). Changes in morpho-physiological traits of mustard under the influence of different fertilizers and plant growth regulator cycocel. J. Sau. Soc. Agri. Sci., 11: 89-97.

Bhagure YL, Tamble TB (2013). Effect of seed soaking and foliar sprays of plant growth regulators on germination, growth and yield of okra (*Abelmoschus esculentus* (L.) Moench) var. Parbhani Kranti. Asian J. Horti. 8(2): 399-402.

Bora RK, Sarma CM (2004). Effect of GA_3 and CCC on growth, yield and protein content of soybean (cv. Ankur). Environ. Conserv. Biol., 9: 59-65.

Devi KN, Vyas AK, Singh MS, Gopimohon N (2011). Effect of bioregulators on growth, yield and chemical constituents of soybean (*Glycine max*). J. Agri. Sci., 3(4): 151-159.

Diethelm R, Shibles R (1989). Relationship of enhanced sink demand with photosynthesis and amount and activity of ribulose 1,5-bisphosphate carboxylase in soybean leaves. J. Pl. Physiol., 134: 70-74

Gollagi SG, Hiremath SM, Chetti MB (2009). Effects of growth regulator and nutrients on growth parameters and yield in chilli cv. Byadagi Kaddi. Inter. J. Agri. Sci., 5: 123-125.

Gomez KA, Gomez AA (1984). Statistical procedures for agricultural research. (2nd Ed.) John Wiley and sons, NewYork, USA.

Hanamaratti NG, Salimath PM (2012). Association of flowering delay under stress and drought tolerance in upland rice (*Oryza sativa* L.). Inter. J. For. Crop Improv., 3(2): 99-104.

Kahar SA (2008). Effects of frequency and concentration of B-9 (Daminozide) on growth, flowering and flower quality of Reagan Sunny chrysanthemum (*Chrysanthemum morifolium* Ramat). Acta Hort., 788: 141-148.

Khan S, Hafeez R, Wahid MA, Saleem MF, Cheema MA, Basra SMA, Nadeem M (2016). Boron fertilization improves seed yield and harvest index of *Camelina*

Sativa L. by affecting source-sink. J. Plant. Nut., 39(12): 1681-1687.

Kumar S, Haripriya K, Kumar S, Muraleedharan A, Kamalakannan S (2019). Effect of cycocel on growth, flowering and yield of nerium (*Nerium odorum* L.). J. Pharm. Phytochem., 8(3): 2226-2228.

Latifkar M, Mojaddam M, Nejad TS (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. Inter. J. Biosci., 4: 234-242.

Lodeta KB, Ban SG, Perica S, Dumicic G, Bucan L (2010). Response of Poinsettia to drench application of growth regulators. J. Food Agri. Environ., 8: 297-301.

Lowry OH, Brought NTR, Farr LA, Randall RJ (1951). Protein measurement with folin phenol reagent. J. Biol. Chem., 193: 265-275.

Mandal PN, Singh KP, Singh VK, Roy RK (2012). Effect of the growth regulators on growth and yield of hybrid okra (*Abelmoschus esculentus* (L.) Moench). Asian J. Hort., 7(1):72-74.

Mansuroglu S, Karaguzel O, Ortacesme V, Sayan MS (2009). Effect of paclobutrazol on flowering, leaf and flower colour of *Consolida orientalis*. Pak. J. Bot., 41: 2323-2332.

Oosterhuis DM, Loka DA, Raper TB (2013). Potassium and stress alleviation: Physiological functions and management of cotton. J. Pl. Nut. Soil Sci., 176: 331-343.

Qureshi IA, Gulzar S, Dar AR, Rehman RU, Tahir I (2018). Effect of growth retardants on the growth and flowering of *Chrysanthemum morifolium* cv. Flirt. Ind. J. Agri. Res., 52(3): 319-322.

Sarita A, Singh E (2016). Millet’s anti-nutrients and their therapeutic effects. The Pharm. Innov. J., 5(8): 42-46.

Secondo ASP, Reddy YAN (2018). Plant growth retardants improve sink strength and yield of sunflower. Inter. J. Curr. Microbiol. App. Sci., 7(10): 111-119

Shekoofa A, Emam Y (2008). Effect of nitrogen fertilization and plant growth regulators (PGRs) on yield of wheat. Shiraz. J. Agri. Sci. Tech., 10: 101-108.

Singh S, Singh T, Singh AK, Sing RK (2019). Effect of nitrogen levels and plant growth regulators on growth, lodging, yield and economics of wheat (*Triticum aestivum* L.) J. Pharmacog. Phytochem., 8(4): 665-671

Tranknera M, Tavakolb E, Jaklic B (2018). Functioning of potassium and magnesium in photosynthesis, photosynthate translocation and photo protection. Physiol. Plant., 163**:** 414-431.

Vishal VC, Thippesha D, Chethana K, Maheshgowda BM, Veeresha BG, Basavraj AK (2016). Effect of various growth regulators on vegetative parameters of strawberry (*Fragaria* x *Ananassa* Duch.) Cv. Sujatha. Res. J. Chem. Environ. Sci., 4(4): 68-71

Watson DJ (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. Ann. Bot., 2: 41-76.

Yadav AK, Kumar A, Singh J, Jat RD, Jat HS, Datta A, Singh K, Choudhary R, Choudhary KM, Sutaliya JM (2015). Differential response of pearl millet genotypes to irrigated and rainfed conditions. Ecol. Environ. Conserv., 21(4): 2013-2020.

Zahoor R, Zhao W, Abid M, Dong H, Zhou Z (2017). Potassium application regulates nitrogen metabolism and osmotic adjustment in cotton (*Gossypium hirsutum* L.) functional leaf under drought stress. J. Pl. Physiol., 215: 30-38.