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CYCOCEL PRIMING AND FOLIAR APPLICATION AFFECT YIELD COMPONENTS OF RAPESEED (*BRASSICA NAPUS* L.)

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ABSTRACT. A factorial based on RCBD experiment was conducted to evaluate the effects of priming and foliar spray of cycocel on rapeseed yield components. Treatments were included; seed priming (0, 600, 900, 1200, 1500 μM) and foliar spray (0, 600, 1200 μM) with cycocel at development stage of flower buds. The results revealed that seed priming with cycocel significantly increased emerged plant number per plot, silique dry weight in the main stems and branches, plant dry weight, branches number, silique number in the main stems and branches, seed number in branches, 1000 seeds weight, and seed yield in non-stress conditions. Foliar application with cycocel also increased plant dry weight, 1000 seeds weight in branches, harvest index and seed yield. Moreover, interaction effect of priming and foliar application of cycocel increased plant dry weight and 1000 seeds weight with branches. CCC foliar application during the early stages of reproductive stage went to elevated plant dry weight and 1000 seeds weight in auxiliary branches and, also increased harvest index and grain yield. Mean comparison and interaction effects of traits also revealed that, appropriate levels of CCC had the meaningful effects on any agronomic and physiological trait. However, the most meaningful impact in most traits was traced in case with primed seed with 900 and 1500 μM CCC. Overall, owing to the present data, CCC priming under both normal and harsh conditions may raise the germination related traits, seedling establishment, plant growth and ultimately may goes to increased yield.

Key words: Rapeseed; Cycocel; Priming; Foliar application; Yield.

INTRODUCTION

Rapeseed ranks the second oilseed bearing crop with the global production of more than 42 million tones. The worldwide cultivation area and mean unit area production of rapeseed were 31 million/ha and about 20 thousands kg/ha during 2009, respectively (F.A.O., 2009). The main restraint for rapeseed production in third-world countries has been well-defined to be the soil heterogeneity and unsuitable structure. This in main part leads to

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several problem such as; reduced germination potential, heterogeneous emergence, and furthermore, subsequent resources shortage goes to competition for light, nutrients and water that eventually impact plant growth, development and final yield. Seed priming alleviates most the problems faced with germination process (Omidi *et al.,* 2005). Priming consists providing the conditions of sufficient water absorption for germination onset accompanied with later speedy seedling emergence and establishment. Various procedures and agents have been employed for the priming (Peltonen and Peltonen-Sainio, 1997). These include hydro-priming, osmo-priming, matri-priming, thermo-priming, bio-priming and hormonal-priming (Ashraf and Foolad, 2005; Dearman *et al.*, 1987; Khan, 1992). Priming with appropriate concentrations of phyto-hormones had ameliorative effects on germination, seedling growth and yield in various species particularly under salt stress conditions (Kaur *et al.,* 2002). Some hormones and PGRs promote the crop resistance with stressful aggressive environments (Haroun *et al.,*1991*;* Hoque and Haque, 2002). Sharma and Saran (1992) reported that priming with 40 mg/l GA_3 increased germination rate and seedling emergence of *Vigna mungo* seeds with normal and stressful conditions. Overall, PGRs have been shown to potentially affect the plant growth and development specially when applied during and till the flowering time. In contrast, GA_3 application had no promotive effect on seed number and weight of carrot inflorescence (Prat *et al.,* 2008). Eisvand *et al.* (2010) also reported that hormonal priming with 100 ppm GA_3 improved the seed vigor in *Agropyron elongatum* under normal and stressful conditions.

Cycocel (2-Chloro ethyl three methyl ammonium chloride) is the most usual anionic plant growth regulator (Emam and Moaied, 2000; Ma and Smith, 1991). There are reports that anionic compounds treated plants were tolerant to drought conditions compared to untreated plants. Moreover, they had higher net photosynthesis potential (Bauer *et al.,* 1984). Furthermore, cycocel increased the seed yield mainly due to increased root growth and more drought resistance under water deficit conditions (De *et al.,* 1982). These researchers noted that the promotive effects of CCC were more pronounced with the increased root growth, as well as elevated leaf water potential. From biochemical point of view, CCC prevents ent-kaurene synthesis in GA_3 biosynthetic cycle leading to GA_3 deficiency and the subsequent reduced vegetative growth potential (Hoque and Haque, 2002). Hambris *et al.* (1960) reported that any yield increase by CCC was related to the enhanced dry matter accumulation. Cycocell foliar application increased cytokinin translocation from roots to shoots, leading to prolonged aboveground parts life-span and hence increased yield (Omidi *et al.,* 2005).

The present experiment was conducted to evaluate the effects of priming and foliar application with CCC on yield and yield components of rapeseed plants.

MATERIALS AND METHODS

The experiment was conducted in the Research Field of Agronomy and Plant Breeding Department, at the University of Maragheh during autumn 2009. Experimental design was factorial based on RCBD, with three replicates. The treatments were seed priming with cycocel (0, 600, 900, 1200 and 1500 μM) and cycocel foliar application (0, 600 and 1200 μM). Growth stages of plants were assigned and recorded based on the growth degree days from planting till harvest time (Bauer *et al.,* 1984).

At the time of seed maturity and commercial harvest time (GDD 2410), several traits were recorded as; number of plants per plot, branches number, silique number in the main stems and branches, seed numbers in the main and secondary siliques, 1000 seeds weight in the main and secondary siliques, seed yield, harvest index and seed oil content.

Data were analyzed by SPSS and MSTATC softwares, and graphs were draw by Excel. Mean comparisons were carried out by Duncan's multiple range test at P<0.01.

RESULTS AND DISCUSSION

The results showed that cycocel priming had significant effects on the number of emerged plants per plot. Mean comparison revealed that priming with 900 and 600 μM cycocel led to more emerged plants per plot (*Fig. 1*). Hussain *et al.* (2006) reported the same results. Those researchers noted that hydro-priming and NaCl osmo-priming had the most promising impact on sunflower germination traits. Cycocel priming had prominent effect on branch numbers as well (*Table 1*). Mean comparison showed that all the cycocel levels were different (P≤0.01) from control, and 900 and 1200 μM treatments had the greater number for branches. Child *et al.* (1988) reported that cycocel application was associated with the increased cytokinin biosynthesis and in parallel prolonged the developmental life-span of tiller producing buds. Several reports demonstrate that growth retardants such as CCC affect the plant height, increase the shoots diameter and standing, reduce seed yield loss and hence may go to increased seed yield per plant and plot (Emam and Karimi, 1996; Emam and Moaied, 2000). In the present experiment, cycocel level had meaningful influence on the branch numbers.

The results showed that priming and foliar spray with cycocel had no significant effect on seed number in main silique, but, the main effects of cycocel priming was significant on seed number in secondary silique (*Fig. 2*). Variance analysis showed that cycocel priming and foliar spray had no significant effect on silique number in the main stems and branches, but, the main effects of cycocel priming were significant on silique number in branches (*Tab. 1*). Mean comparison for the main effects of priming showed that 900 and 1500 μM treatments had the highest silique number in plant (*Fig. 3*). Harris *et al.* (2001) reported that in rapeseed, osmo-priming remarkably increased the silique number of plants. It seems that cycocel priming positively affects tillering and also in most cases goes to elevated number of fertile tillers per unit area (Woodward and Marshall, 1987).

In line, CCC treatment significantly increased tillering in barley and triticale (Woodward and Marshall, 1987). Several scientists reported that PGRs such as CCC linearly increased the spike number of plants. The reason may be more tillering induction and correspondingly more fertile spikes per plant. Moreover, cycocel treatments increased the number and longevity of tillers, and branches leaf area and eventually went to elevated photosynthesis (Cox and Otis, 1989; Waddington and Cartwright, 1988).

Knapp *et al.* (1987) reported that different levels of cycocel increased the soluble carbohydrates accumulation and stream in the phloem sap. At the same time, several reports verified that stem reservoirs i.e. excess photoassimilates mobilization before the grain filling period have the preponderant role in grain yield. This situation is worthy of special attention under high temperature and drought stress conditions mainly during the filling stage (Ntui *et al.,* 2007). Sharma and Saran (1992) and Bora and Sarma (2006) reported that 250 μg/ml GA_3 and 100 μg/ml cycocel increased silique number in bean plants.

Mean comparison for the priming main effect showed that, seed priming with 900, 1200 and 1500 μM cycocel gained the highest seed number with secondary siliques (*Fig. 4*). Omidi *et al.* (2005) reported that cycocel treatment led to increased seed row numbers in corn plant.

Hambris *et al.* (1960) expressed that, CCC treatment created more seeds with individual corn inflorescences, but it had low relationship with final yield increase. Ma and Smith (1991) documented that the principal component for the barley seed number increase beyond CCC application was the increased spike number. Other researchers noted that CCC treatment raised the seed number per plant more likely due to intensified source-power before the time of flowering (Waddington and Cartwright, 1988).

Emam *et al.* (1996) reported that wheat grain yield increased by CCC application in main part due to increased seed number in unit area. Priming and foliar application of CCC had no significant effect on 1000 seeds weight in the main stem, but, the main effects of priming and foliar spray were significant on 1000 seeds weight and yield with branches. Interaction effects of priming*foliar application with CCC on 1000 seeds weight in branch was significant as well (*Tab. 1*). Mean comparison for the main effects of treatments on yield components disclosed that 600 μM CCC priming and foliar spray with 600 and 900 μM CCC had the most remarkable impact on the seed weight (*Figs. 5 and 6*).

Table 1 - The effects of seed priming and foliar spraying by cycocel on rapeseed yield, yield components and growth characters

SOV	df	MS												
		Number of plants per plot	Dry weight of main silique	Dry weight of siliques in branches	Dry weight of plant	Number of branches	Number of silique in main branches	Number of siliques in branches	Number of seeds in main branches	Number of seeds in secondary branches	1000 seed weight in primary branches	1000 seed weight in secondary branches	Harvest index	Seed yield
Priming	4	4119.6	1112.8	2263.53**	56234.5**	16.93**	1689.1	5768.9*	368.48	734.689**	5038.1	1.31**	0.677	34.15**
Spraying	2	461.6	333.4	160.46	17572.1*	0.14	897.5	1897.7	72.36	27.689	4903	1.44**	2.306*	21.28
Priming × spraying	8	348.2	75.4	152.05	45500.9**	3.36	731.3	1677.8	49.91	73.558	5037	0.86**	0.566	9.01
Block	2	521.2	1.95	149.55	4310.5	7.37	345.3	2993.5	216.29	235.96	4976.5	0.42	0.617	5.17
E	28	238.3	101.71	103.99	4872.6	3.32	1033.8	2070.3	94.44	116.86	4981.1	0.21	0.573	14.23
CV (%)	-	20.73	30.59	24.84	22.14	35.04	67.90	57.83	66.84	63.04	48.71	11.68	44.09	14.42

** Means significant at P≤0.01 based on Duncan's multiple range test

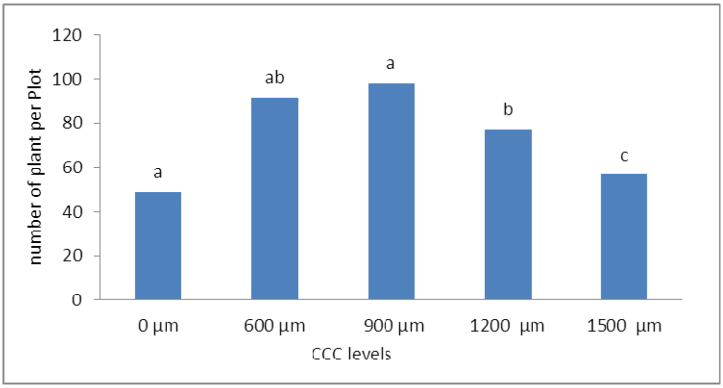

Figure 1 - The effects of seed priming by cycocel levels on number of plant per plot

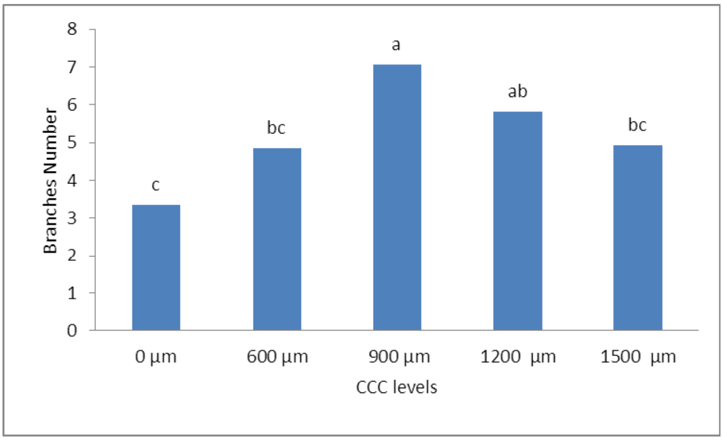

Figure 2 - The effects of seed priming on branches number

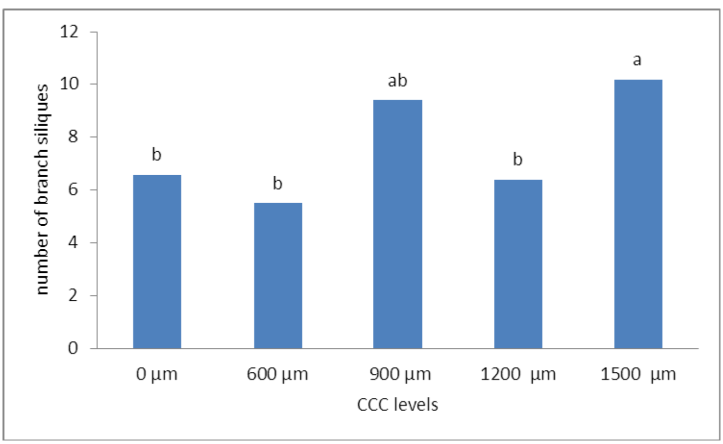

Figure 3 - The effects of seed priming by cycocel levels on number of branch siliques

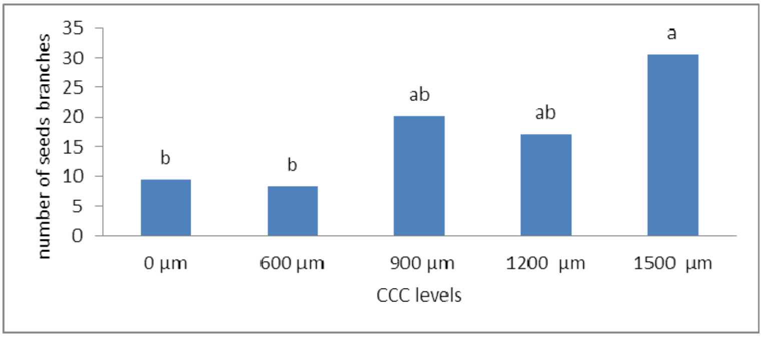

Figure 4 - The effects of seed priming on seeds of branches

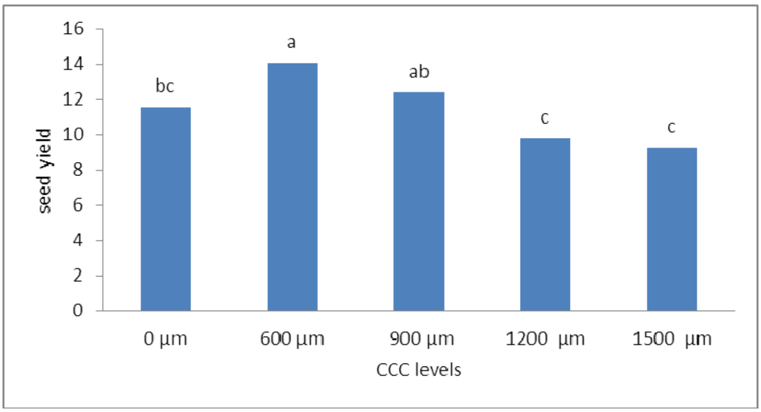

Figure 5 - The effects of seed priming by cycocel levels on rapeseed yield

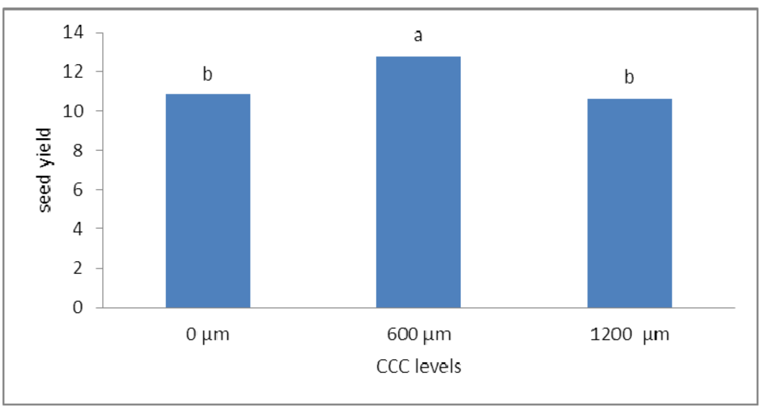

Figure 6 - The effects of cycocel spraying on rapeseed yield

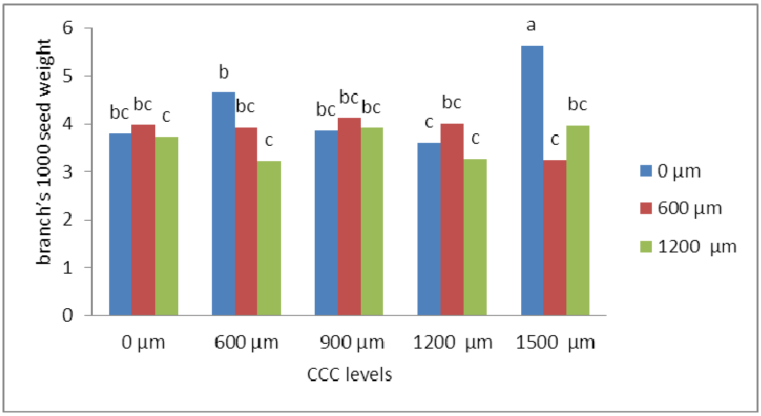

Figure 7 - The effects of seed priming and foliar spraying of cycocel on branch's 1000 seed weight

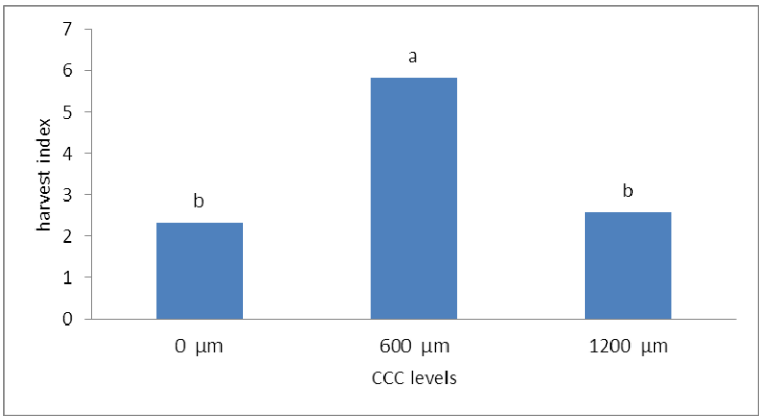

Figure 8 - The effects of cycocel spraying on harvest index

Mean comparisons for the effects of seed priming and foliar application of CCC on 1000 seed weight in branches showed that, interaction of priming*1500 µM and with no CCC application had the highest effect on 1000 seeds weight (*Fig. 7*). Omidi *et al.* (2005) demonstrated that CCC treatment increased the 100 seeds weight compared to control ones. Jeriaei *et al.* (2009) documented that combined SA and CCC application with both normal and drought faced environments resulted in elevated grain and spike weight.

Cox and Otis (1989) reported that CCC treated plants had about 12-18% yield increase. Any increase in plant yield with seed priming might be due to multiplied germination percentage and rate, and also improved establishment of seedling during early growth stages (Emam *et al.,* 1996).

Foliar spray with CCC had significant effect on harvest index (*Tab. 1*). Mean comparison revealed that 600 μM treatment significantly increased the harvest index (*Fig. 8*). Shafi *et al.* (2006) reported the similar results with wheat seeds. Contrarily, priming had no effect on harvest index consistent with Farooq *et al.* (2006) results.

CONCLUSIONS

In conclusion, priming with CCC led to increased plant number per plot, silique dry weight in the main and auxiliary branches, plant dry weight, auxiliary branches number, silique number in the main and auxiliary branches, seed number in auxiliary branches, 1000 seeds weight and grain yield under field conditions. CCC foliar application during the early stages of reproductive stage (GDD=554.5) went to elevated plant dry weight and 1000 seeds weight in auxiliary branches and, also increased harvest index and grain yield. Mean comparison and interaction effects of traits also revealed that, appropriate levels of CCC had the meaningful effects on any agronomic and physiological trait. However, the most meaningful impact in most traits was traced in case with primed seed with 900 and 1500 μM CCC. Overall, owing to the present data, CCC priming under both normal and harsh conditions may raise the germination related traits, seedling establishment, plant growth and ultimately may goes to increased yield.

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