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Response of Two Wheat Cultivars to Chlormequat (CCC) Application

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Abstract. Two field experiments were conducted at Deirab Agricultural Experiment Station, King Saud University, in the winter seasons of 1985-1986 and 1986-1987 to study the effect of cycocel application (500 ppm) on grain yield, yield components, and lodging of two wheat cultivars, Yecora rojo (semi-dwarf and lodging resistant cultivar) and Sama (tall and lodging susceptible cultivar). For the tall cultivar, Sama, CCC treatment tended to decrease lodging, increase number of spikes/m^2, and kernel number/spike, consequently, increased the grain yield. However, CCC treatment increased only the grain yield in Yecora rojo, and did not change the other measured traits.

Introduction

Lodging can be considered a major constraint in wheat production system [1-3]. The effect of lodging on grain yield and quality depends on its severity and time of occurence, with lodging at anthesis being the most deterimental [4, 5]. Lodging leads to reduction in quantity and quality of grain and straw due to decreased photosynthesis, increased disease severity, detrimental effects of moisture on a lodged crop canopy, and reduced harvest efficiency.

Although plant breeding programs have successfully developed lodging-resistant cultivars by selection for short stiff-straw and high harvest indices, short stiff-strawed cultivars have not eliminated the problem of lodging [4]. In addition, the trend towards shorter cultivars may eventually be reversed because of the strong association between potential grain yield, plant height, and total biomass [6]. Consequently, interest exists for the use of plant growth regulators that control lodging.

In recent years growth regulators have been used in agriculture in increasing amounts to aid in lodging control and yield enhancement. The most widely applied growth regulator is a choline derivative, chlorcholine chloride (CCC) known com-

mercially as "Cycocel" [7, 8]. Under field conditions, applications of CCC had consistently no effect on total dry matter accumulation of wheat [8, 9]. In contrast, grain yield response to CCC application has been very inconsistent. In some field studies, CCC increased grain yield only if lodging occurred [10]. Bragg *et al.* [9] reported no yield response to CCC in their studies in which no lodging occurred. Other researchers, however, have reported an increase in wheat yields with CCC in the absence of lodging [3, 11].

A field study was carried out to examine the vegetative and reproductive growth of two wheat cultivars in response to CCC application. The objective was to determine the effectiveness of CCC in altering the growth pattern of wheat, thereby increasing or decreasing the yield in the presence or absence of lodging.

Materials and Methods

The present research work was conducted during the winter seasons of 1985-1986 and 1986-1987 on a loamy sand soil at the Agricultural Experiment Station of King Saud University at Deirab, near Riyadh (24 N, 46 E). The soil test values indicated a pH of 7.6 and low levels of N and P. Two wheat cultivars were selected for the study. The local cultivar, Sama, was chosen as an old cultivar with known lodging problems, while Yecora rojo was chosen as a recently introduced cultivar that was recommended for production in Saudi Arabia. Both cultivars were seeded in the two seasons on 20 November at the rate of 150 kg/ha. Starter fertilizer was applied at the rate of 67, 119, and 30 kg/ha of N, P, and K, respectively. All plots (2 × 2.5 m) received a split N application of NH_4NO_3 at 40 kg N/ha during tillering and 40 kg/ha three weeks after. Flood irrigation was applied once a week up to anthesis and every 3-5 days thereafter. Growth regulator (GR) treatments consisted of a check plot, and a foliar spray treatment of CCC at 500 ppm at the fifth leaf stage. The experimental design was a split-plot with four replications. Cultivars represented the main plots and CCC treatments were assigned to the subplots. A border strip of wheat was maintained between subplots to minimize interplot interference.

Data were recorded for days to heading (DH) and maturity (DM), plant height (PH), spike number/m^2 (SN), kernel number/spike (KN), 1000 kernel weight (KW), grain yield (GY), and lodging (LOD). Days to heading was defined as the number of days when 50% of the spikes reached flowering, and days to maturity as the number of days when 75% of the spikes turned yellow. Plant height was measured at maturity as the distance from the soil surface to the tip of the main tiller's spike. Grain yield was estimated as the weight of clean grain from 1 m^2 taken at random from the central rows of each plot. Kernel weight was determined from 1000 kernels

of the clean grain. Lodging scores were based on the scale of 0.0 to 4.0 (0.0 = no lodging and 4.0 = 100% lodging). Data were statistically analyzed according to Steel and Torrie [12].

Results and Discussion

Examination of the effect of the growing seasons, cultivars, and CCC treatments on some agronomic characteristics of wheat plants (Table 1) indicated that the response to CCC treatment varies significantly among seasons and cultivars. The average effect of CCC over the growing seasons and cultivars indicated that CCC application had a significant effect on plant lodging and grain yield. Grain yield was increased by about 15% and lodging was reduced by about 24% in comparison to the control. On the other hand, the number of days to heading and maturity, plant height, spike number, and kernel number and weight were not significantly affected by the CCC application, with the concentration used in this experiment (500 ppm), (Table 1).

Moreover, there were significant differences between the two growing seasons and between the two cultivars used, almost for all traits. These differences were expected as a result of the direct effect of the environmental conditions on plant response. For example, Sama cultivar surpassed Yecora rojo for all characters except for spike number, kernel weight, and grain yield. In addition, the mean values of all traits were significantly higher in 1986-1987 than in 1985-1986 season, except for the number of days to heading (Table 1).

These results were in agreement with those obtained by Demidenko [13] who suggested that the effectiveness of CCC treatment depended on environmental effects, tillage practices, and genotype.

The average grain yield, yield components, and lodging of the two wheat cultivars are given in Table 2. Cycocel application tended to increase significantly the grain yield production of both cultivars. The average increase was 12% and 19% above that of the control for Yecora and Sama wheat cultivars, respectively. Also, the data presented in Table 3 showed a positive correlation between CCC and grain yield ($r=0.379$) but a negative correlation between cultivars and grain yield ($r=-0.499$) which may explain the differential response of cultivars to CCC appliation. These results are in accordance with those obtained by Primost [14], and Ibrahim *et al.* [15]. On the other hand, Asseed *et al.* [16] reported that there were no effects of CCC on grain yield, final biomass, or yield components. Bastiman [10] stated that CCC increased wheat yield only in the presence of lodging. This may be

Table 1. Effect of cycocel application, cultivars, and growing season on some agronomic characteristics *

Source	DH	DM	PH	SN	KN	KW	LOD	GY
	Days	Days	Cm	No./m^2	NO./spike	1000 grains/g	0.0–100%	g/m^2
Treatment:								
Control	85.07	127.00	101.64	606.57	37.22	39.82	0.34 a	325.10b
CCC	64.64	127.07	101.57	649.93	36.19	38.57	0.26 b	373.76a
LSD (0.05)	NS	NS	NS	NS	NS	NS	0.033	30.99
Cultivar:								
Yecorad	80.71b	121.43b	83.21b	651.64a	32.46b	40.96a	0.000b	381.48a
Sama	89.00a	132.64a	120.00a	604.86b	40.94a	37.43b	0.600a	317.38b
LSD (0.05)	1.04	1.17	1.58	44.05	2.45	3.02	0.033	30.99
Season:								
1985-1986	85.08	119.25b	96.67b	467.00b	33.30b	35.50b	0.267b	322.28b
1986-1987	84.69	132.88a	105.31a	749.19a	39.25a	41.97a	0.325a	369.79a
LSD (0.05)	NS	1.18	1.60	44.51	2.48	3.05	0.033	31.31

* = Means followed by the same letter are not significantly different at P=0.05.

NS = not significant; DH = days to 50% heading; DM = days to 75% maturity; PH = plant height (cm); SN = spike number/m^2; KN = kernel number/spike; KW = 1000 kernel weight (g); LOD = lodging; GY = grain yield (g/m^2).

Table 2. Grain yield, yield components, and lodging of the two wheat cultivars treated with cycocel.*

Cultivar	treatment	GY	SN	KN	KW	LOD
		g/m^2	$No./m^2$	No./spike	1000 grains/g	0.0-100%
Yecora	Control	360.67b	645.14a	30.27d	41.36a	0.00c
	CCC	402.29a	658.14a	34.66c	40.57a	0.00c
Sama	Control	289.52c	568.00b	39.79b	38.29b	0.69a
	CCC	345.24b	641.71a	42.10a	36.57b	0.51b

* = Data are means of two growing seasons and four replications.
Means followed by the same letter are not significantly different at P=0.05.

Table 3. Correlation coefficients among CCC and related traits

Traits	Cultivar	PH	LOD	SN	KN	KW	GY
CCC	0.000	–0.002	–0.136	0.135	–0.074	–0.121	0.379
Cultivar		0.958	0.949	–0.145	0.603	–0.342	–0.499
PH			0.923	–0.001	0.706	–0.213	–0.447
LOD				–0.055	0.514	–0.217	–0.457
SN					0.195	0.676	0.635
KN						–0.071	–0.241
KW							0.578

a result of compensating adjustments between final biomass and harvest index. Sorour and El-Sharkawy [17] showed that CCC consistently increased harvest index but not grain yield, which suggested compensatory reductions in final biomass through decreasing straw yield.

Regarding the spikes number (SN), it is obvious from Table 1 that the two wheat cultivars responded differently. Cycocel treatment had no significant effect on the spike number of the recommended cultivar Yecora, while the local cultivar, Sama, showed a significant increase with CCC application. These results are in agreement with the finding of Wunsche [18] who reported that CCC may, in some cases, increase the production of barley tillers. Moreover, the degree that tiller production in wheat is increased by CCC depends on genotype [8, 19].

Application of CCC significantly increased the kernel number per spike (KN) of the local cultivar, Sama, while Yecora showed no response. On the other hand, kernel weight (KW) was not affected by CCC (Table 2). Accordingly, the increase in grain yield might be attributed to the increase in spike number and/or number of grains per spike especially for Sama cultivar. This may be true as the correlation coefficient between spikes number and grain yield was highly significant ($r=0.635$), (Table 3). Roebuck [20] stated that increases in number of grains per spike had "occasionally been demonstrated" after CCC application. Gale [21] found that the number of grains per spike was also related to the action of gibberellins. Semi-dwarf mutants of cereals were characterized by a blocking of gibberellin function, which was associated with a reduction in culm length and a higher number of grains per spike.

The effect of CCC application on plant lodging was also quite different in the two growing seasons (Table 1). The overall mean of lodging across the two growing seasons and the cultivars was significantly decreased only in Sama cultivar by the

CCC treatment (Table 2). The reduction was about 26% in this case. In fact, the CCC treatment had no effect on the dwarf cultivar, Yecora. Furthermore, data presented in Table 3 showed a negative correlation between CCC and lodging ($r=-0.136$), with the increase in grain yield in both cultivars. It seems that CCC suppresses internodal growth of the tall cultivar. The effect of CCC on the dwarf cultivar was not apparently due to its effect on shortening the internodes since the mean plant height remained unaffected. These results are in agreement with those obtained by Wiersma *et al.* [2].

In conclusion, it is suggested that cycocel application may increase grain yield in the absence of lodging for the tall cultivar (Sama) by increasing spikelet production and kernels per spike. The differential responses for the two growing seasons could be due to the environmental variables or to the genotype effect.

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استجابة صنفين من القمح للمعاملة بواسطة الكلورمكوات (السيكوسيل)

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ملخص البحث. أجريت تجربتان في محطة الأبحاث والتجارب الزراعية بديراب في موسمي ١٩٨٥-١٩٨٦م، ١٩٨٦-١٩٨٧م لدراسة تأثير الرش بالسيكوسيل بتركيز ٥٠٠ جزء في المليون على المحصول ومكوناته وكذا الرقاد لصنفين من القمح: الصامة وهو من الأصناف المحلية الطويلة والتي تميل للرقاد، ويوكورا روجو وهو من الأصناف القصيرة التي تزرع في المملكة. وقد أوضحت النتائج المتحصل عليها أن الرش بالسيكوسيل أدى إلى تقليل نسبة الرقاد، زيادة عدد السنابل في المتر المربع، زيادة عدد الحبوب بالسنبلة، زيادة وزن الألف حبة وبالتالي زيادة محصول الحبوب وذلك في الصنف المحلي الصامة، بينما أدت المعاملة بالسيكوسيل إلى زيادة محصول الحبوب فقط في الصنف يوكورا روجو.