J. Agric. Sci. Mansoura Univ., 30 (4): 1881 - 1888, 2005

EFFECT OF WATER STRESS AND PACLOBUTRAZOL APPLICATION ON GROWTH AND YIELD OF WHEAT PLANTS

Kassab, O.M. and H.A. El-Zeiny
Water Relations and Field Irrigation Department, National Research Centre, Dokki, Giza, Egypt

ABSTRACT

Two field experiments were carried out at the Agricultural Experimental Station of National Research Centre, at Shalakan, Kalubia Governorate during 2000/2001 and 2001/2002 seasons to study the effect of water stress (missing one irrigation at tillering, heading and milk-ripe stage) and paclobutrazol concentrations (0, 25, 50 and 100 ppm) on growth, yield and its attributes as well as grain total carbohydrates of wheat (Sakha 69 cv.). The results revealed that missing one irrigation at any of the three studied stages significantly reduced growth parameters and yield characters as well as the percentage of total carbohydrate and total carbohydrates yield as compared with the control plants (irrigation every 30 days).

The depressing effects of soil moisture stress were comparatively, high at tillering, intermediate at heading and low at milk-ripe stage. On the other hand, increasing the concentration of paclobutrazol up to 50 ppm significantly increased the aforementioned parameters as compared to the untreated plants. Increasing the concentrations of paclobutrazol up to 50 ppm increased weight of grain per plant, straw and biological yields per feddan and total carbohydrate percentage under the different irrigation treatments. The results suggested that irrigation every 30 days and application of paclobutrazol concentration at 50 ppm could be recommended for maximum yield of wheat plants under similar conditions.

Keywords: Water stress, Paclobutrazol, Wheat, Growth, Yield.

INTRODUCTION

Wheat (*Triticum aestivum vulgare* L.) is considered the main cereal grain crop in the world as well as in Egypt. Therefore, increasing grains production is considered one of the most important national aims in Egypt to face the great demand of the highly increasing population . Additional data (Mc Master *et al* 1994) demonstrated that water stress near jointing is a critical limitation to final yield production by reducing the number of secondary tiller spikes and later-appearing of primary tiller spikes. Further studies (Abo-Shetaia & Abd El-Gawad, 1995; Sawires, 2000; Kandil *et al* 2001 and Kassab *et al* 2004) revealed that skipping an irrigation either at tillering, heading, milk-ripe or dough-ripe stage depressed all growth characters studied, yield and yield attributes.

On the other hand, chemical plant growth regulators are increasingly being used to manipulate plant growth and yield. Paclobutrazol (PP_{333}) is a plant growth retardant and has been extensively used to reduce shoot vegetative growth, increase the yield of many different crops and to improve plant tolerance to water stress (Zhou & Xi, 1993; Wen xun *et al* 1995 and Abo El-Kheir *et al* 2000).

Therefore, the present study was undertaken to determine the efficiency of paclobutrazol to overcome the harmful effects of water stress on growth, yield and its attributes as well as grain total carbohydrate of wheat plants.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive seasons 2000/2001 and 2001/2002 at the Agricultural Experimental Station of the National Research Centre at Shalakan, Kalubia Governorate, Egypt in order to study the efficiency of paclobutrazol application on wheat plants grown under moisture stress imposed at three reproductive stages.

The investigation included 16 treatments which are the combination of four irrigation treatments and four paclobutrazol concentrations. A split-plot design with three replications was employed. The main plots were devoted to irrigation treatment and the sub plots were assigned for paclobutrazol concentrations.

Water stress treatments were imposed to the plants by missing one irrigation at tillering, heading and milk-ripe stages which were corresponding to 60, 90 and 120 days from sowing, respectively.

In both seasons, wheat plants of each water stress treatment were sprayed till drip, twice at 55 and 85 days after sowing, with either tap water (as control), or aqueous solution of paclobutrazol (25, 50 and 100 ppm). Paclobutrazol (PP_{333}) is a plant growth retardant and chemically known as (2RS, 3RS)-1- (4-Chlorophenyl)-4, 4-dimethyl 1-2 (1H-1, 2,4-triazol-1-y1) pentan-3-01.

The experimental plot area was 10.5 m^2 (3.5 x 3.0 m). Plots were isolated by borders of 1.5 m in width from all sides to avoid the effect of lateral movement of irrigation water. The soil texture was clay loam in both seasons. Wheat grains (*Triticum aestivum vulgare* L.) cv. Sakha 69 were sown on November 19 and November 17 in the first and second season, respectively. Phosphorus and potassium fertilizers were added to the soil before sowing at the rate of 30 kg P_2O_5/fed. in the form of calcium superphosphate (15.5% P_2O_5) and 24 kg K_2O/ fed. in the form of potassium sulphate (48% K_2O). Ammonium nitrate (33.5% N) was applied at the rate of 60 kg N/fed. in two equal portions before the first and second irrigation. Harvest date was 14th and 16th of May in the first and second season, respectively. Representative plant sample was collected from three replicates of each treatment after 137 days from planting and the following growth characters were measured: Plant height, number of both tillers, leaves and spikes per plant as well as root, stem, leaves, spikes and total dry matter per plant. At harvesting the middle one meter square was harvested from three replicates for each treatment for calculating grain weight per plant, 1000-grain weight, grain, straw and biological yields per feddan. Moreover, a representative samples were taken from three replicates to estimate grain yield/plant. Total carbohydrate content in the harvested grains was determined using the method adopted by Dubois *et al* (1956). The carbohydrate yield/fed. was calculated by multiplying the percentage of each constituent by grain yield / fed. The obtained data were subjected to the

statistical analysis of variance described by Snedecor and Cochran (1980) and the combined analysis of results of the two seasons were applied according to the method adopted by Steel and Torrie (1960).

RESULTS AND DISCUSSION

1. Vegetative growth

Data presented in Table (1) show that exposing wheat plants to water stress at each tillering, heading or milk ripe stages resulted in significant reduction in plant height, number of tillers, leaves and spikes per plant as well as the dry matter of root, stem, leaves, spikes and total per plant as compared with control treatment (irrigation every 30 days). This was true when one irrigation was skipped at each tillering, heading or milk-ripe stage. However, the response of wheat plants to water stress was more pronounced at tillering stage than the other two stages. The effect of water stress on cell division and enlargement has been carefully discussed by Kramer and Boyer (1995). These results are in agreement with those obtained by Abd El-Gawad *et al* (1993a); Abo Shetaia & ABd El-Gawad (1995) and Kandil *et al* (2001).

Such depression may be attributed to the general retardation of the enzymatic processes particularly those concerning with the reduction in photosynthetic rates (Abd El-Gawad *et al* 1993a).

The obtained results reveal further that foliar application of paclobutrazol significantly affected the vegetative growth i.e. Plant height, number of tillers, leaves and spikes per plant as well as the dry matter of root, stem, leaves, spikes and total per plant. Increasing the concentration of paclobutrazol up to 50 ppm caused a significant increase in the aforementioned parameters. Similar results were obtained by Zhou and Xi (1993) on rape, Wen Xun *et al* (1995) on rice and Abo El-Kheir *et al* (2000) on sunflower.

The interaction effect between water stress and paclobutrazol concentrations was significant for plant height, number of tillers, leaves and spikes per plant as well as the dry matter of root, stem, leaves, spikes and total per plant, it can be clearly noticed that increasing the concentration of paclobutrazol up to 50 ppm(control treatment), increased the aforementioned parameters as compared with the other treatments (Table, 1).

2- Yield, its attributes and grain total carbohydrate

Data shown in Table (2) elucidate that shortage of water at either tillering, heading or milk ripe stage caused a significant reduction in the weight of grain per plant 1000-grain weight, grain, straw and biological yields per feddan as well as total carbohydrate percentage and carbohydrate yield per feddan as compared with well irrigated plants. This was true if one irrigation was missed at each tillering, heading or milk-ripe stage. However, the response of wheat plants to water stress was more pronounced at tillering stage than the other two stages.

These results are in agreement with those obtained by Abd El-Gawad *et al* (1993b); Abo-Shetaia & Abd El-Gawad (1995); Sawires (2000); Kandil *et al* (2001) and Kassab *et al* (2004).

Table (1): Effect of water stress, paclobutrazol and their interaction on growth characters of wheat plants at 137 days from sowing (combined analysis of 2000/2001 and 2001/2002 seasons).

Treatments			Plant height (cm)	No. of Tillers/ plant	No. of Leaves/ plant	No. of spikes/ plant	Dry matter / plant				
							Root	Stem	Leaves	Spikes	Total
							(g)				
Water Stress (WS)	Unstressed (control)		120.39	5.30	15.39	5.50	3.33	10.61	4.47	7.25	25.66
	Missing one irrigation at tillering stage		104.25	3.42	12.08	3.47	2.11	7.36	2.22	3.50	15.19
	Missing one irrigation at heading stage		110.25	4.00	13.16	4.08	2.31	8.08	2.94	4.39	17.72
	Missing one irrigation at milk-ripe stage		114.47	4.19	14.05	4.50	2.75	9.39	3.42	5.47	21.02
L.S.D at 5% level for: WS			1.05	0.16	0.17	0.42	0.24	0.31	0.11	0.24	0.37
Paclobutrazol concentrations (PP)	0		106.19	3.36	12.66	3.56	2.28	7.47	2.05	3.83	15.63
	25		111.25	3.97	13.55	4.17	2.53	8.53	3.11	4.86	19.02
	50		118.89	5.39	15.00	5.58	3.16	10.89	4.61	6.80	25.47
	100		113.03	4.19	13.47	4.25	2.53	8.55	3.28	5.11	19.47
L.S.D at 5% level for: PP			0.89	0.16	0.22	0.36	0.12	0.17	0.15	0.22	0.36
Interaction (WS x PP)	Unstressed (control)	0	114.33	4.22	14.11	4.33	3.00	9.11	3.11	5.55	20.77
		25	118.33	4.78	14.78	4.89	3.22	10.11	4.11	7.11	24.55
		50	128.78	7.11	17.66	7.33	4.00	13.00	6.33	9.11	32.44
		100	120.11	5.11	15.00	5.44	3.11	10.22	4.33	7.22	24.88
	Missing one irrigation at tillering stage	0	97.11	3.00	11.00	3.00	2.00	6.111	1.33	2.55	11.99
		25	103.00	3.00	12.11	3.44	2.00	7.00	2.22	3.22	14.44
		50	111.22	4.11	13.11	4.00	2.33	9.22	3.11	5.00	19.66
		100	105.67	3.55	12.11	3.44	2.11	7.11	2.22	3.22	14.66
	Missing one irrigation at heading stage	0	104.11	3.00	12.33	3.11	2.00	6.55	1.78	3.11	13.44
		25	110.55	4.00	13.22	4.00	2.11	7.78	3.00	4.11	16.89
		50	115.11	5.00	14.11	5.22	3.00	10.22	4.00	6.22	23.44
		100	111.22	4.00	13.00	4.00	2.11	7.78	3.00	4.22	17.11
	Missing one irrigation at milk-ripe stage	0	109.22	3.22	13.22	3.78	2.11	8.11	2.00	4.11	16.33
		25	113.11	4.11	14.11	4.33	2.78	9.22	3.11	5.11	20.22
		50	120.44	5.33	15.11	5.78	3.33	11.11	5.00	6.89	26.33
		100	115.11	4.11	13.78	4.11	2.78	9.11	3.55	5.78	21.22
L.S.D at 5% level for: WS x PP			1.78	0.32	0.44	0.73	0.24	0.35	0.31	0.45	0.72

Table (2): Effect of water stress, paclobutrazol and their interaction on yield, its attributes and grain total carbohydrates (%) of wheat (combined analysis of 2000/2001 and 2001/2002 seasons).

Treatments			Wt. of grains /plant (g)	1000-grain wt.	Grain yield/ fed. (kg)	Straw yield/fed.	Biological yield /fed.	Carbohydrate yield /fed.	Total carbohydrate (%)
Water	Unstressed (control)		17.90	41.48	2383.08	3276.75	5659.83	1561.33	65.41
Stress	Missing one irrigation at tillering stage		11.05	37.55	1718.17	2723.83	4442.00	1088.97	63.25
(WS)	Missing one irrigation at heading stage		12.68	35.33	1945.83	2940.75	4886.58	1196.55	61.35
	Missing one irrigation at milk-ripe stage		14.59	33.37	2211.25	3043.17	5254.42	1338.24	60.44
L.S.D at 5% level for: WS			0.15	1.32	32.09	45.09	20.71	19.46	0.17
Paclobutrazol concentrations (PP)	0		12.33	35.33	1852.92	2795.25	4648.17	1128.48	60.78
	25		13.96	36.63	2037.42	2965.92	5003.33	1270.99	62.34
	50		16.50	38.78	2283.83	3236.08	5519.92	1476.58	64.59
	100		13.42	37.00	2084.17	2987.25	5071.42	1309.04	62.76
L.S.D at 5% level for: PP			0.17	0.76	29.85	44.00	35.73	18.69	0.14
Interaction (WS x PP)	Unstressed (control)	0	16.12	40.16	2160.00	3062.00	5222.00	1369.83	63.42
		25	17.87	41.19	2343.00	3214.67	5557.67	1526.13	65.14
		50	20.33	43.26	2619.67	3606.33	6226.00	1773.06	67.68
		100	17.28	41.32	2409.67	3224.00	5633.67	1576.29	65.42
	Missing one irrigation at tillering stage	0	9.18	35.50	1512.33	2541.00	4053.33	923.47	61.06
		25	11.35	37.96	1685.33	2742.67	4428.00	1064.52	63.16
		50	13.14	39.58	1932.33	2901.33	4833.67	1259.58	65.19
		100	10.52	37.19	1742.67	2710.33	4453.00	1108.32	63.60
	Missing one irrigation at heading stage	0	11.10	33.30	1735.67	2734.33	4470.00	1036.81	59.55
		25	12.30	35.15	1925.33	2950.33	4875.67	1174.04	60.98
		50	15.07	37.65	2141.67	3115.00	5256.67	1357.90	63.40
		100	12.24	35.22	1980.67	2963.33	4944.00	1217.46	61.47
	Missing one irrigation at milk-ripe stage	0	12.93	32.35	2003.67	2843.67	4847.33	1183.81	59.08
		25	14.32	32.23	2196.00	2956.00	5152.00	1319.29	60.08
		50	17.45	34.63	2441.67	3321.67	5763.33	1515.77	62.08
		100	13.64	34.28	2203.67	3051.33	5255.00	1334.09	60.54
L.S.D at 5% level for: WS x PP			0.35	N.S	N.S	87.99	71.46	N.S	0.29

The obtained results reveal also that foliar application of paclobutrazol significantly affected the yield and its attributes i.e. grain, straw, biological yields per feddan, weight of grain per plant, 1000 grain weight as well as total carbohydrates percentage and carbohydrates yield per feddan. Increasing the concentration of paclobutrazol up to 50 ppm caused a significant increase in the aforementioned parameters. Similar results were obtained by Zhou and Xi (1993) on rape, Abo El-Kheir *et al* (2000) on sunflower and Kandil *et al* (2000) on maize.Moreover Zhou and Xi (1993) indicated that paclobutrazol increased chlorophyll content and photosynthetic rates, prolonged leaf longevity and significantly increased total rape oil production by 13.4% over the control.

The interaction effect between water stress and paclobutrazol concentrations was significant on all studied yield characters except for 1000-grain weight, grain and carbohydrate yields per feddan. It could be noticed that increasing the concentration of paclobutrazol up t o 50 ppm increased weight of grain per plant, straw and biological yields per feddan and total carbohydrates percentage under the different irrigation treatments. The highest biological yield per feddan and total carbohydrates were obtained when plants were irrigated normally and sprayed with 50 ppm of paclobutrazol.It is worthy to mention that under stress treatments spraying wheat plants with 50ppm paclobutrazol improved biological yield.

The results suggested that irrigation every 30 days and application of paclobutrazol concentration with 50 ppm could be recommended for maximum yield of wheat plants under similar conditions.

REFERENCES

Abd El-Gawad, A.A.; Nemat A. Noureldin; M.A. Ashoub and M.A. Kashabah (1993a). Studies on consumptive use and irrigation scheduling in relation to nitrogen fertilization on wheat. I. Growth and stomata behaviour of wheat plants. Annals Agric. Sci., Ain Shams Univ., Cairo, 38(1): 161-172.

Abd El-Gawad, A.A.; Nemat A. Noureldin; M.A. Ashoub and M.A. Kashabh (1993b).Studies on consumptive use and irrigation scheduling in relation to nitrogen fertilization on wheat.II. Response of wheat yield and its attributes.Annals Agric.Sci.,Ain Shams Univ.,Cairo,38(1):173-181.

Abo El-Kheir, M.S.A.; S.A. Kandil and H.A. El-Zeiny (2000). Growth, yield and some physiological processes of sunflower plants as affected by paclobutrazol treatments under salt stress conditions Egypt. J. Agron. Vol. 22: 107-124.

Abo-Shetaia, A.M. and A.A. Abd El-Gawad (1995). Growth, yield and yield attributes of wheat in relation to N-fertilization and withholding an irrigation at different stages of growth. Annals Agric. Sci., Ain Shams Univ., Cairo, 40(1): 195-211.

Dubois, M.; K.A. Gilles; J. Hamilton; R. Rebers and F. Smith (1956). Colorimetric method for determination of sugar and related substances. Anal. Chem., 28: 350-356.

Kandil, S.A.; A.A. Abo-Ellil and H.A. El-Zeiny (2000). Effect of water stress and paclobutrazol application on growth, yield and grain chemical composition of maize. Egypt. J. Appl. Sci., 15(7): 71-86.

Kandil, S.A.; M.S.A. Abo-El Kheir and H.A. El-Zeiny (2001). Response of some wheat cultivars to water stress imposed at certain growth stages. Egypt. J. Appl. Sci., 16(1): 82-98.

Kassab, O.M.; H.A. El-Zeiny and M.M. Ibrahim (2004). Effect of water deficit and micronutrients foliar application on the productivity of wheat plants. Minufiya J. Agric. Res. Vol., 29: 4: 925-932.

Kramer, P.J. and J.S. Boyer (1995). Water relations of plants and soils. Academic Press, San Diego, New York, Boston, London, Sydney, Tokyo, Toronto, 360-380.

Mc Master, G.S.; W.W. Wilhelm and P.N.S. Bartling (1994). Irrigation and culm contribution to yield and yield components of winter wheat. Agron. J.; 86: 1123-1127.

Sawires, Eman, S. (2000). Yield and yield attributes of wheat in relation to N-fertilization and withholding an irrigation at different stages of growth. Annals Agric. Sci., Ain Shams Univ., Cairo, 45(2): 439-452.

Snedecor, G.W. and W.G. Cochran (1980). Statistical Methods, 7th ed., Iowa State Univ. Press, Iowa, USA.

Steel, R.G.D. and J.H. Torrie (1960). Principles and procedures of Statistics. McGraw Hill Book Co., Inc., New York, Toronto, London.

Wen Xun, T.; B. Baozhang; Z. Jing Yang and M. Jing Yong (1995). Physiological and biochemical changes in dry-raised rice seedlings after application of paclobutrazol. J. Jilin Agric. Univ. 17(1): 25-28.

Zhou, W. and H. Xi (1993). Effects of mixtalol and paclobutrazol on photosynthesis and yield of rape (*Brassica napus* L.). J. Plant Growth Rge., 12: 157-161.

تأثير الإجهاد المائى والمعاملة بالباكلوبترازول علي نمو ومحصول نباتات القمح

أسامة مصطفى إبراهيم كساب – حسنى عبدالغنى الزينى
قسم العلاقات المائية والرى الحقلى- المركز القومى للبحوث- الدقى- الجيزة- مصر

أقيمت تجربتان حقليتان بمزرعة المركز القومى للبحوث بشلقان (محافظة القليوبية) خلال موسمى ٢٠٠٠-٢٠٠١، ٢٠٠١-٢٠٠٢ بهدف دراسة تأثير معاملات الرى (الرى كل ٣٠ يوم، حرمان رية واحدة عند كل من مرحلة التفريع، وطرد السنابل، وطور النضج اللبنى) وتركيزات منظم النمو الباكلوبترازول (صفر، ٢٥، ٥٠، ١٠٠ جزء في المليون) علي النمو والمحصول وصفاته ومحتوى ومحصول الكربوهيدرات الكلية للقمح صنف سخا ٦٩.

ويمكن إيجاز أهم النتائج فيما يلى:

- أدى تعريض النباتات للإجهاد المائى نتيجة الحرمان من الرى في أى من المراحل الثلاث المشار إليها إلي نقص معنوى في صفات النمو (وهى ارتفاع النبات وعدد كل من الأشطاء والأوراق والسنابل للنبات وكذلك المادة الجافة لكل من الجذور والساق والأوراق والسنابل للنبات والمادة الجافة الكلية للنبات)، والمحصول وصفاته (وهو وزن الحبوب للنبات ووزن الـ ١٠٠٠ حبه ومحصول كل من الحبوب والقش والمحصول البيولوجى للفدان) ومحتوى ومحصول الكربوهيدرات الكلية مقارنة بنباتات الرى المنتظم (معاملة المقارنة)- وكان هذا التأثير السلبى مرتفعاً نسبياً عند مرحلة التفريع، ومتوسطاً عند مرحلة طرد السنابل وقليلا عند مرحلة النضج اللبنى.
- أدت معاملة نباتات القمح بمنظم النمو الباكلوبترازول بتركيز حتى ٥٠ جزء في المليون إلي زيادة معنوية في معظم الصفات المدروسة للنمو والمحصول وصفاته ومحتوى ومحصول الكربوهيدرات الكلية مقارنة بالنباتات غير المعاملة.
- بالنسبة للتفاعل بين الإجهاد المائي والمعاملة بالباكلوبترازول أدى زيادة تركيز الباكلوبترازول حتى ٥٠ جزء في المليون إلى زيادة صفة وزن حبوب النبات ، محصول القش، المحصول البيولوجي للفدان ومحتوى الكربوهيدرات تحت معاملات الري المختلفة.
- يمكن التوصية برش نباتات القمح بمنظم النمو الباكلوبترازول بتركيز ٥٠ جزء في المليون مع استمرار الرى كل ٣٠ يوما وذلك لتحقيق أعلى محصول من نباتات القمح.