9 *Egypt. J. Agron.* **Vol. 27**, No. 2, pp. 95 - 112 (2005)

Effects of Some Growth Retardants on Growth, Physiological Behavior, Lodging Degree and Yield of Rice Plants

B.A. Zayed*, A.G. Metwally*, A.K.M. Salem and R.N. Gorgy***

** Rice Research & Training Center, Sakha, Agriculture Research Center, and ** Field Crops Research Department, Agricultural Research Division, National Research Center, Dokki, Egypt.*

TWO FIELD experiments were conducted at Research Farm of the Rice Research and Training Center, Sakha, Kafr El-Sheikh during 2003 and 2004 seasons. The study aimed to evaluate the effect of CCC, MLU 208 (a mixture of CCC and DciB), RSWo411 (Triapenthanol) and Uniconazole on physiological and growth behavior of rice plants, as well as lodging degree of Sakha 104 rice cultivar . Results showed that CCC did not exhibit any significant retarding effect on rice plants

All levels of MLU 208, RSWo411 and Uniconazole markedly decreased the heights of plants in the terms of decreasing its lodging degree . Number of tillers/m^2, flag leaf area and dry weight of rice plants were increased by all growth retardants except CCC. Degree of lodging was decreased by the application of proper levels of MLU 208, RSWo411 and Uniconazole RSW performed better regarding lodging and reduced it to 75% of the control . All growth retardants increased the concentration of chl.a and chl.b in rice leaves but carotenoids were decreased. Nitrogen concentration in shoots and grains was increased while K was decreased. GA concentration in shoots was decreased but ABA was increased by the application of MLU 208, RSWo411 and Uniconazole. The high levels of growth substances stimulated the weight of 1000-grain, starch and protein yields. Grain yield was highest with UNIC (2),MLU(2) and RSW(2),respectively .

Keywords: Rice growth retardants, Lodging, Physiology, Phytohormones, Yield and yield components.

Rice is one of the main cereal crops in Egypt. It covers about 17% of the cultivated area in Nile Delta. The policy of the country aims to improve the production and quality of rice to meet the local consumption as well as the export demand. On the other side, several problems after cause a drop in the yield and productivity of rice; lodging is one of the principal problems in intensive rice cropping with high nitrogen application rates, particularly when it occure in the early reproductive stage of development. The reduction of rice yield caused by lodging may reach to about 30-40% of the total yield (Gendy 1985), within the last decade, a number of naturally occurring and synthetic growth regulators have been discovered and proved to be considerable importance in agriculture production. Triapenthenol (RSWo411) was found to be a growth retardant that controls the gibberellins biosynthesis and decrease the ratio of shoot vertical growth without affecting number of leaves or growth of root (Gendy 1985). MLU208 (a mixture of 29 % CCC and 36% DciB /wt) was described and tested for first time by Otto and Schilling (1984) and Schilling and Echert (1985).

Uniconazole (5330-7D) is a plant growth retardant manufactured by Sumito Chemical Company Ltd in 1985 and is now a wide spread as a new growth regulator which was found to modify the biosynthesis of GA in several crops (Rademarcher and Juny 1986). The present study was mainly aimed to investigate the effect of the new growth retardants MLU 208, RSWo411 (Triapenthenol) and Uniconazole in addition to CCC, as foliar application on the growth, chemical compositions and yield of rice plants.

Materials and Methods

Two field experiments were conducted in loamy clay texture soil of pH 7.4 at the Rice Research and Training Center, Sakha, Kafr El-Sheikh during 2003 and 2004 seasons. Rice seeds (Sakha 104 long stem cultivar that is characterized by high rate of lodging) were sown in May 25th. Thirty five days later seedling were transplanted at 20 x 20 cm spacing in a complete randomized block design. Fertilization (N, P and K) and agricultural practices were done as recommended by the following:

Nine treatments were studied using CCC in levels of 2 and 4L/fed MLU208 (a mixture of 29 % CCC and 36% DciB wt/wt) in rates of 2 and 4L/fed RSWo411 (Triapenthenol) in levels of 100 and 200 gm/fed and Uniconazole at rates of 20 and 40gm/fed; besides the distilled water as control.

All treatments were used as foliar spray at heading stage as recommended by Klomp (1977). Twine 20 was used at a concentration of 0.5 % as wetting agent. The volume of water used in all growth regulator treatments was 200L/fed. These compounds were kindly obtained from Prof. Dr. K. Lurssen, at Bayer AG, plant production D. 5090 lever Kusen Germany. Three samples were taken randomly from each treatment 15 days after the application of growth retardant. As soon as plants were picked up, they were carried immediately to the laboratory where the following data were recorded.

Growth analysis

Flag leaf area (m^2/m^2 land) was estimated 15 days after treatments (maximum length x maximum width x 0.75).

At harvest time the following characters were measured: culm length (cm), number of tillers / m^2 and dry matter of shoots (kg/ m^2 land) after drying at 70^0 C to constant weight.

Degree of lodging using the following scale: [1= no lodging and 9= total lodging (flat), culm diameter the main internode from the bottom.

Chemical analysis

Chlorophyll a & b and carotenoids from the middle fresh leaves were determined spectrophotometrically 15 days after treatments as described by Wettestein (1967). Total carbohydrates (mg/g d.w.t.) were determined colorimetrically in the HCl hydrolysis using the phenol sulfuric acid method as described by Dubis *et al.* (1956). Soluble sugars were extracted in 80 % ethanol in soxhn apparatus and were then determined colorimetrically according to Thomes and Dutcher (1924). Standard curve for carbohydrate was prepared with glucose and measured in an identical way. Nitrogen was determined using micro-kjeldahl method as described in A.O.A.C. (1970). Phosphorus was estimated colorimetrically using stannous chloride and potassium was determined by the flame photometer (A.O.A.C. 1970). Nitrate concentration in grains was extracted in micro- kjeldahl apparatus and was determined using dimethyl phenol (Xylenol) method according to Barls and Reekors (1960). Phytohormones in shoots were extracted from the fresh materials with 80 %cold ethanol according to Shindy and Smith (1975). The acidic ethylacetate fraction ...d to determine IAA by the wheat coleoptiles straight bioassay (described ...y and Hously, 1954), GA by lettuce hypocotyls assay (Frankland and ...g, 1960) and ABA by wheat transpiration assay (Rademacher, 1978) ...eas alkaline fraction was used to determine cytokinins by radish cotyledons ...y (Letham, 1967).

ield and its components

At harvest time, number of panicles and tillers/m^2 were calculated. Grain and straw yields /fed were determined. Thousand rice grain weight (seed index) was weighted. Total protein and starch in dry grains were determined according to Yosihida *et al.* (1972).

...ll collected data were statistically analyzed according to Snedecor and Coch...n (1973) with the help of SYSTAT computer program for statistics. The differences among treatment means were tested by using least significant differences as reported by Waller and Duncan (1969).

Results and Discussion

1)Growth analysis

a- Culm length

Data in Table 1 indicated that CCC did not affect significantly the culm length in both seasons with regards to control plants. All levels of MLU, RSW and Uniconazole significantly decreased the culm length as compared with untreated plants. In this regard, the most negative effect on culms length was obtained under RSW treatment, particularly 200 g /fed which reduced the culm length by about 24 % and 33 % of control in the first and second seasons, respectively. The insignificantly effect of CCC on culms length may be attributed to its low absorption rate by plant tissues and leaves as was reported by Gendy (1985) who found that the absorption of CCC at the rate of 4 l/ha by rice leaves was about 2.5 %.

The unfavorable effects of MLU, RSW and Uniconazole on the culm length show in this may be attributed to the natural mechanism and made of action of these chemicals on the growth and development of plant tissues, or to their effects on a special cells and /or plant organs.

In this concern, several studies (Schilling and Eckert, 1980, on MLU; Gendy and Marquard, 1989, on RSW; Suh *et al.*, 1992. on Uniconazale), in addition to the present study showed that MLU, RSW and Uniconazole inhibited or, at least partially, reduced the cell division and cell elongation through their negative effects on the biosynthesis and translocation of endogenous phytohormones, particularly growth promoters gibberellin and auxin. Moreover, some endogenous inhibitors such as ABA (Table 5) were increased under such treatments leading to reducing the rate of longitudinal culm growth causing a decrease in its length. The above findings and conclusion are in harmony with those reported by Gendy (1990) on CCC, Otto and Schilling (1984) on MLU, Gendy and Marquard (1989) on RSW; and Sumito (1985) on Uniconazole.

b-Number of tillers

According to Table 1 CCC at rates of 2 and 4 L/fed. did not increase the number of tillers/m^2 while all other treatments caused a significant increase in the number of tillers/ m^{2} .The percent increase in number of tillers in the first seasons recorded 9 % and 21 % for MLU, 12 % and 22 % RSW and 9 % and 14 % for Uniconazole. Data in the second season followed almost the same trend. The greatest number of tillers associated with MLU, RSW and Uniconazole might be attributed to the inhibiting effects of these chemicals on the apical dominance as a results of reducing auxin transport to apical meristems thus stimulating the growth of basal buds leading to a subsequent release of more tillers/plant and consequently, increasing their number/m^2.

In this concern, Ibrahim and Gendy (1996) found that growth retardants given at tillering stage retarded the apical development of the main stem, which led to alternation in source-sink relationship, and thus increased the number of tillers/plant through enhancing tillering processes rather than tiller survival. This conclusion was also confirmed by Maria (1992).

TABLE 1. Effects of different growth retardants on vegetative growth parameters of rice plants at heading and harvest time during 2003 and 2004 seasons.

Treat.	Culm length (cm)	No. of tillers/m^2	Flag leaf area(m^2)/ m^2/land	Shoot D.W (kg/ m^2	Culm diam. (mm)	Degree of lodging
2003 season						
Control	122.64	450.6	1.333	1.32	4.1	8
CCC (2 L/fed)	123.98	451.3	1.322	1.32	4.1	8
CCC (4 L/fed)	122.39	449.5	1.316	1.36	4.2	8
MLU (2 L/fed)	112.56	491.1	1.389	1.42	4.7	6
MLU (4 L/fed)	109.70	545.0	1.429	1.53	5.3	4
RSW (100gm/fed)	94.33	505.6	1.403	1.43	4.8	3
RSW (200gm/fed)	92.90	551.0	1.465	1.57	5.4	2
UNIC (20gm/fed)	109.45	489.8	1.500	1.44	4.9	4
UNIC (40gm/fed)	105.25	513.6	1.510	1.60	5.5	3
LSD(5%)	13.36	36.2	0.035	0.07	0.4	
2004 season						
Control	120.96	427.92	1.130	1.313	4.0	8
CCC (2 L/fed)	120.62	425.52	1.120	1.300	4.0	8
CCC (4 L/fed)	120.12	420.48	1.114	1.34	4.1	7
MLU (2 L/fed)	104.41	471.6	1.186	1.39	4.5	5
MLU (4 L/fed)	97.69	474.0	1.243	1.42	5.0	4
RSW (100 gm/fed)	96.01	465.96	1.197	1.42	4.6	3
RSW (200gm/fed)	80.64	479.16	1.220	1.46	5.2	2
UNIC (20gm/fed)	109.45	466.56	1.276	1.44	4.7	5
UNIC (40gm/fed)	104.64	499.92	1.300	1.46	5.4	3
LSD(5%)	14.12	30.84	0.022	0.03	0.3	

* 1= No lodging & 9= complete lodging.

c- Flag leaf area

Statistical analysis showed that flag leaf area was significantly increased with all growth regulators (Table 1). The first season was recorded under Uniconazole treatments (13 %) followed by RSW (5-10 %) and MLU (47 %). The second season showed almost the same trend. It is significant to mention that flag leaves are very important to proved grain with photosynthetic assimilates, particularly at later stage of growth causing high grain filling rate. In this concern, flag leaf area represents around 70-80 % of the leaf area of rice plant (Mengel and Kirkby, 1987). In this matter, the present study showed that there was a positive correlation between the flag leaf area and the grain yield (r = + 0.61 and 0.71) which were recorded in the first and second seasons, respectively. Thus increasing flag leaf area in rice plants by the application of the growth retardants used in this study is an important matter for increasing the grain filling and consequently increasing the yield. In this concern, several studies showed that the growth retardants increased the flag leaf area (Mishra and Gaur, 1985).

d-Dry matter content

Data recorded in Table 1 revealed that CCC showed neutral effect on dry matter of shoots, while MLU, RSW and Uniconazole significantly stimulated the deposition of the dry matter in shoot tissues. The most increase in shoot dry weight was obtained under 40 gm/fed of Uniconazole (about 21 % increase in first season) followed by 200 gm/ fed of RSW (19 %) and 4L/fed MLU (16 %) with respect to control plants. Data recorded in the second season followed the same trend as those collected in the first season. It is obvious that simulative effect of the growth retardants used in this study on the number of tillers and leaf area/plant (as discussed above) as well as the increase in assimilates such as sugar (see Table 3) in plant tissues could contribute to the increase in dry matter content in treated, compared to untreated, plants.

It has been suggested that larger amounts of dry mass were accumulated in the temporarily sinks (culm and other non-grain tissues), the re-translocation of photo-assimilates to the major sink (grains) was probably enhanced by growth retarding substances. These results were in accordance with those obtained by Ibrahim and Gendy (1996).

e-*Culm diameter*

All growth retardants used in the present study except CCC, cuased a significant increase in culm diameter of rice plants during the two experimental seasons. As compared with control plants (Table 1) , the increase in culms diameter during the first seasons reached about 29 % , 32 % and 34 % for high level of MLU, RSW and Uniconazole, respectively; while the comparable increase in the second season were 25 %, 30 % and 35 %, respectively. The increased culm diameter respectively in this investigation may be attributed to positive effect of the growth retardants on stimulating the production and area of the conductive elements such as xylem and phloem as will be discussed later. In addition, it has been found in earlier studies by Hofner (1988) that growth retardant treatments increased the culms diameter via their stimulating effects on lignin production and cell wall materials as well as enhancing the stem diameter as a consequence.

f-Degree of lodging

As indicated in the Materials and Methods section, the degree of lodging was internationally ranked from 1 for non- lodging in rice plants to 9 flat plants. Data collected for this purpose indicated that all treatments except CCC, which had no effect, caused a substantial decrease in the degree of lodging (Table 1). Data recorded in this table showed that the highest level of MLU results in 4 degrees of lodging thus it was decreased by about 50 % below the untreated plants in which low level of RSW showed 3 degrees of lodging ; while the high level of RSW recorded 2 degree of lodging with reduction of 75 % during the first and second seasons. Moreover, lodging was decreased by about 60 % at the high level of Uniconazole as compared to control plants.

In Judgment, RSW was the best to reduce the lodging of rice plants followed by Uniconazole then MLU, while CCC had insignificant effect. These findings are in full agreement with those reported by Schiling and Eckert (1985) who showed that MLU gave a good resistance to lodging in wheat and barley plants, Gendy and Marquared (1989) who found that RSW prevented the lodging of rape plants completely. These early studies showed that lodging occurs after heading because of increasing the endogenous gibberellins at that time; thus CCC, MLU, RSW and Uniconazole acted as gibberellins antagonists and increased the standing ability of plants, on one hand by reducing the culms length and, on the other hand by increasing the culms diameter and strengthen its wall (Hofner, 1988).

2) Chemical analysis

a-Photosynthetic pigments

I-In normal leaves: Data in Table 2 indicated that (Chl.a) and (Chl.b) concentrations were significantly increased and carotenoids were decreased by all treatments as compared with control plants. In this regard 4 l/fed of CCC caused an increase of about 9% and 4% in Chl. a and Chl. b, respectively. Similarly, MLU, RSW and Uniconazole were nearly comparable in increasing, Chl.a and Chl. b by about 2-3 % as compared to control plants. Total chlorophyll increased by all treatments with special regard to CCC (about 5 % increases as compared with control plants). Other treatments caused between 3-4 % increases in total chlorophyll. Several evidence including previous reports showed the increase in chlorophylls and the decrease in carotenoids with the application of growth retardants to safflowers plants (Maria *et al.*, 1993). The increase in chlorophyll concentrations due to the effect of some growth retarding substance was attributed to the inhibitory effect of these chemicals on the synthesis of the enzymes catalyzing the degradation of chlorophyll (Zaky, 1985). Moreover, the accumulation of nitrogen resulted from MLU, RSW and Uniconazole treatments (as will be discussed) might also play an important role in increasing chlorophyll content of treated leaves (Gendy, 1990). In addition, Hofner (1988) showed that the decrease of carotenoids under the growth retardant treatments were connected with a decrease in the growth promoters particularly gibberellins. The present study showed that endogenous GA concentrations in rice tissues were decreased by the growth retardants and thus carotenoids were reduced in treated, compared to untreated, plants.

2-In flag leaves: The important role of flag leaves in grain filling made it consequential to determine the photosynthetic pigments in these leaves (Table 2). Data recorded in the table indicated that Chl.a and Chl.b concentration were significantly increased by all growth regulators used, except CCC. As was discussed above in this study and also in other early studies by Hofner (1988), the negative effects of the growth retardants on the concentrations of the carotenoids were associated with similar negative reduction in the concentration of gibberellins in plant tissues.

b-Carbohydrate concentration

1-In shoots: Data recorded in Table 3 showed clearly that soluble and total sugars in shoots were increased significantly under the application of all growth retardants (particularly at high levels) except CCC which did not cause any significant change. In this regard, soluble sugars were increased by 84%, 96 % and 94% under the higher levels of MLU, RSW and Uniconazole, respectively. The corresponding increases in total sugars were about 10-16 % of control in the first seasons. Data in the second seasons were nearly similar to those collected in the first one. The stimulative effects of growth regulators on soluble sugars of rice plants were reported by Younis *et al.* (1974) who found that relatively high concentration of growth retardant "Alar" caused an increase in concentration of sucrose and other soluble sugars as well as polysaccharides in treated leaves of broad bean plants. The enhancing effects of these growth chemicals on chlorophyll pigments within plant leaves, sequentially stimulating the photosynthetic activity, might attribute to increasing the sugar formation in the leaves. Thus activate the translocation of these sugars to other plant organs (Iliev *et al.*, 1985)

TABLE 2. Effects of different growth retardants on chlorophyll concentration (mg/g.dwt^{-1}) in normal and flag leaves of rice plants at heading stage during 2003 and 2004 seasons.

Treat.	Normal leaves				Flag leaves			
	Chl-a	Chl-b	Carot.	(a+b)/Carot.	Chl-a	Chl-b	Carot.	(a+b)/Carot.
				2003 season				
Control	20.29	7.61	1.84	15.16	20.67	7.26	1.79	15.60
CCC (1)	22.06	7.81	0.60	49.78	21.05	7.41	1.80	15.81
CCC (2)	22.17	7.92	0.56	53.73	22.11	8.53	1.77	17.31
MLU (1)	22.73	7.89	0.80	38.28	21.37	7.94	1.71	17.14
MLU (2)	23.87	7.87	1.12	38.34	22.38	8.97	1.28	24.49
RSW (1)	22.79	7.63	1.20	25.35	21.40	7.48	1.08	26.74
RSW (2)	23.83	7.85	1.08	29.33	22.49	8.06	1.23	24.01
UNIC (1)	22.37	7.89	0.80	37.83	21.22	7.81	1.41	20.60
UNIC (2)	23.73	7.94	0.68	46.57	22.73	8.89	1.10	26.90
LSD(5%)	1.91	0.29	0.60		0.49	0.16	0.18	
				2004 season				
Control	20.05	7.51	1.60	17.23	21.07	7.49	2.18	13.10
CCC (1)	21.08	7.82	1.00	28.90	21.22	7.72	2.19	13.21
CCC (2)	21.23	8.90	0.92	32.75	22.31	8.80	2.11	14.74
MLU (1)	22.22	7.81	0.82	36.62	22.60	8.04	1.08	28.37
MLU (2)	23.79	8.76	0.60	54.25	22.63	8.84	1.23	19.39
RSW (1)	22.32	7.73	0.40	75.13	21.83	7.78	1.11	26.68
RSW (2)	22.73	8.89	0.40	79.05	22.95	8.80	1.24	25.60
UNIC (1)	22.63	7.84	0.46	66.24	21.73	7.89	1.10	26.93
UNIC (2)	23.89	8.57	0.34	95.47	21.90	8.01	1.17	25.56
LSD(5%)	1.80	1.16	0.44		0.47	0.22	0.26	

2. *In grains:* Data in Table 3 revealed that soluble and total sugars of rice grains were increased significantly under the treatments of MLU, RSW and Uniconazole. Meanwhile, CCC did not affect the grain soluble sugars significantly. It is obvious that soluble sugars increased by increasing the concentration of growth retardants. In this concern, the high rates of MLU, RSW and Uniconazole increased the soluble sugars by about 65 % and 66 % and sequentially increased the percentage of spikelets fertility, Hofner *et al.* (1988) showed that application of growth retarding substances reduced the development of main culm apices of wheat. Such inhibition could reduce apical dominance of the dominant sinks. Therefore, it could make assimilates available for the secondary sinks which decreased the competitiveness of different sinks. This might lead to more synchronized individual spikelet development within a spike panicle.

TABLE 3. Effects of different growth retardants on soluble and total sugars (mg/g dwt^{-1}) in shoots and grains of rice plants during 2003 and 2004 seasons.

Treat.	Shoots		Grains	
	Soluble sugars	Total sugars	Soluble sugars	Total sugars
2003 season				
Control	3.00	41.12	3.58	28.78
CCC (1)	3.10	41.78	3.70	29.94
CCC (2)	3.12	41.64	3.77	30.11
MLU (1)	3.26	42.33	5.52	38.46
MLU (2)	5.52	45.70	5.92	35.49
RSW (1)	4.90	44.82	5.60	39.68
RSW (2)	5.87	47.79	5.94	37.97
UNIC (1)	4.90	45.00	5.13	38.85
UNIC (2)	5.82	45.27	5.68	33.00
LSD(5%)	0.27	3.46	0.26	3.63
2004 season				
Control	5.90	51.53	3.77	31.55
CCC (1)	6.00	51.93	3.75	31.48
CCC (2)	6.21	51.68	3.80	31.09
MLU (1)	6.77	54.66	3.96	34.19
MLU (2)	9.77	56.84	4.08	43.01
RSW (1)	10.35	54.88	4.02	34.39
RSW (2)	11.00	57.65	4.52	32.16
UNIC (1)	9.10	59.67	4.44	34.65
UNIC (2)	9.19	56.20	4.75	32.38
LSD (5%)	0.17	2.30	0.28	4.60

c- N, P and K^+ concentrations

1-In shoots: Nitrogen percentage was not changed significantly by CCC, but increased significantly by high levels of MLU (27% increase). RSW (31 %) and Uniconazole (20 %) treatments. While phosphorus percentage was not affected significantly by growth retardants. In contrary, Potassium percentage was decreased by all treatments particularly at the high levels of CCC (8 % decrease), MLU (15%), RSW (25 %) and Uniconazole (5 %) (Table 4). In this concern, Mengel and Kirkby (1987) demonstrated that root morphology; such as root length, number of root hairs, and probably the individual K^+ uptake potential (K absorbing power) of crop species appear to be important factors influencing competition between plant species for K. The reduction of growth retardant substances was a consequence of the decrease in root fresh weight. His competition for the nutrients was observed between N and K in this investigation. In this concern, Gendy (1990) found similar results for P on rice shoots.

2 -In grains: Data recorded in Table 4 showed clearly that N% in grains was increased significantly by high doses of MLU (3% increase), RSW (4 %) and Uniconazole (3 %) during the first season. The grain P% was not changed significantly by any of the treatments. In that respect, Gendy (1990) found similar results. Data in the same table indicated that the highest levels of MLU, RSW and Uniconazole decreased the percentage of K in rice grains by about 6 %, 9 %

and 2 % of control, respectively, at the first season and by about 19 %, 8 % and 11% of control, respectively, at the second season. The decrease in K concentration in grains might be attributed to the consequence decrease in the same element in shoots as a results of increasing the N concentration (antagonistic effect) by the growth retardants. This conclusion is confirmed by that of Mengel and Kirkby (1987). Data obtained in Table 4 declared that nitrate concentration was significantly increased by high concentration of CCC (about 25 % increase), MLU (37%) and RSW (33 %); while Uniconazole either decreased (low concentration) it. The increase in nitrate concentration under these growth retardants might be attributed to the increase in N absorption and concentration within plant tissues under same treatments as discussed above .

TABLE 4. Effects of different growth retardants on N,P and K(%) in shoots and grains and NO_3 (ppm) in grains of rice plants during 2003 and 2004 seasons.

Treat.	Shoots			Grains			
	N%	P%	K%	N%	P%	K%	NO_3 (ppm)
2003 season							
Control	3.25	1.05	3.74	2.22	1.60	3.63	156
CCC (1)	3.27	1.04	3.43	2.23	1.35	3.64	196
CCC (2)	3.26	1.05	3.44	2.20	1.33	3.70	188
MLU (1)	4.06	1.06	3.40	2.26	1.75	3.48	181
MLU (2)	4.13	1.08	3.19	2.29	1.85	3.41	213
RSW (1)	3.64	1.03	2.89	2.27	1.63	3.51	206
RSW (2)	4.26	1.04	2.80	2.30	1.65	3.31	208
UNIC (1)	3.83	1.00	3.64	2.23	1.65	3.52	130
UNIC (2)	3.90	1.07	3.57	2.28	1.75	3.42	156
LSD(5%)	0.043	NS	0.086	0.043	NS	0.049	4.40
2004 season							
Control	4.20	1.04	3.83	2.14	1.65	3.73	156
CCC (1)	4.23	1.03	3.63	2.18	1.45	3.71	195
CCC (2)	4.20	1.03	3.72	2.15	1.55	3.72	190
MLU (1)	4.42	1.05	3.73	2.31	1.75	3.61	176
MLU (2)	4.53	1.09	3.01	2.50	1.80	3.01	207
RSW (1)	4.39	1.00	2.11	2.39	1.65	3.52	198
RSW (2)	4.62	1.04	2.09	2.53	1.70	3.44	202
UNIC (1)	4.69	1.00	3.57	2.24	1.60	3.62	127
UNIC (2)	4.90	1.00	3.51	2.35	1.70	3.32	158
LSD(5%)	0.062	NS	0.098	.062	NS	0.044	9.19

D-Phytohormone concentration

Data presented in Table 5 showed that IAA concentration was not changed significantly, while endogenous GA significantly decreased by growth retardants at the two seasons. In this regard, the most decrease of the GA during the first season was obtained at the highest level of RSW (-49 %) and Uniconazole (-53%). Same trend was observed at the second season. The decrease in GA concentration was discussed by Rademecher and Juny (1986) and was attributed to the blocking effect of growth retardants on mono-oxygenase enzymes which oxidize the ent-kauren via ent-kaurenol and ent-kaurenal, in the pathway of GA3 biosynthesis, to ent-kaurenoic acid. Growth retardants may also interfere with other metabolic reactions involving cytochrome systems (Mengel and Kirkby, 1987)

Conversely, endogenous ABA concentration was significantly increased by any treatments, either in the first or in the second season. In that concern, at the first season, the most increase in ABA was obtained under the highest rate of MLU (+15%) and RSW (+16 %) and Uniconazole (+17%) as compared with control. It appears also that there is a positive correlation between the rate of applied growth retardant and the endogenous ABA level in plant tissues. Increasing endogenous ABA concentration in treated plants might be ascribed to the inhibition of GA3 biosynthesis at late stage of growth (Gendy, 1990). Data recorded in the same table illustrated that the growth retarding substances MLU, RSW and Uniconazole, particularly at high levels, caused a conspicuously decrease in the ratios of promoters to inhibitors i.e. (IAA+GA + cytokinin) / (ABA) as compared with untreated plants during both seasons.

3) Yield and its components

a. Number of panicles/m^2

Data recorded in Table 6 showed that number of panicles/m^2 was significantly increased by all growth retardant treatments except CCC which was ineffective. The most increase in number of panicles was recorded at the high concentrations of MLU, RSW under which the increment reached about 25 % and 29 % respectively, as compared to control. The increase in number of panicles could be attributed to the increased number of tillers under such treatments.

b. 1000- grain weight(gm)

The 1000- grain weight (seed index) was significantly increased under the low levels of MLU (8 % increase), RSW (4% increase) and Uniconazole (7 % increase) with regard to control (Table 6). Similar results were reported by Ibrahim and Gendy (1996) on cereal grains.

TABLE 5. Effects of different growth retardants on phytohormones concentration (ng g^{-1} Fwt) in rice shoots at tillering stage during 2003 and 2004 seasons.

Treat.	IAA	GA	Cyt.	ABA	(IAA+GA+Gyt)/ABA
2003 season					
Control	120	85	230	17.2	25.29
CCC (1)	120	83	229	17.6	24.55
CCC (2)	121	82	227	17.9	24.02
MLU (1)	121	66	225	19.0	21.68
MLU (2)	118	52	222	19.8	19.80
RSW (1)	119	57	225	19.2	20.90
RSW (2)	118	43	220	19.9	19.15
UNIC (1)	117	64	224	18.9	21.43
UNIC (2)	119	40	225	20.2	19.01
LSD(5%)	NS	7.81	NS	0.50	
2004 season					
Control	122	83	231	17.0	25.24
CCC (1)	123	82	230	17.4	25.00
CCC (2)	124	80	228	17.8	24.27
MLU (1)	123	59	226	18.4	22.17
MLU (2)	120	40	221	19.0	20.05
RSW (1)	122	63	224	18.6	21.93
RSW (2)	124	50	219	19.2	20.47
UNIC (1)	119	61	222	18.7	21.50
UNIC (2)	121	43	224	19.9	19.50
LSD(5%)	NS	8.03	NS	0.11	

c. Grain yield

Data in Table 6 showed that grain yield (t/fed) was increased by MLU, RSW and Uniconazole treatments , maximum increment in grain yield (15 % and 16 % at first and second seasons, respectively) was obtained by the high dose of Uniconazole. On the other side, CCC treatments were ineffective on the yield of rice. The enhancing effect of growth retardants on grain yield may be ascribed to their stimulating effects on producing some valuable characters, such as increasing number of tillers, increasing starch content, increasing, weight of 1000 grains (as will be discussed) and reducing lodging (as discussed above). Previous studies showed the unbiased effect of CCC on rice yield (Hofner *et al.*, 1988) and the positive effect of MLU on cereal yield (Ibrahium and Gendy, 1996). Same trend was recorded in the second season.

Improving the yield of rice, as a result of growth retarding substances, may be due to the increased cytokinins content which led to promoting spikelets and floret development whereas, it was increased significantly by the application of the growth retardant CCC

TABLE 6. Effects of different growth retardants on yield and its components as well as grain quality of rice plants during 2003 and 2004 seasons.

Treat.	Number of panicles per m²	1000 grain (gm)	Grain yield (ton/fed)	Starch		Protein		Straw yield (ton/fed)
				(%)	(ton/fed)	(%)	(ton/fed)	
2003 season								
Control	351	25.88	3.86	57.00	2.20	13.90	0.54	5.52
CCC (1)	340	26.45	4.29	57.00	2.45	13.88	0.60	5.64
CCC (2)	339	26.58	4.20	57.44	2.41	13.80	0.58	5.63
MLU (1)	452	27.83	4.25	57.45	2.44	14.11	0.60	5.68
MLU (2)	425	26.57	4.41	58.60	2.58	14.32	0.63	5.17
RSW (1)	443	26.78	4.18	57.65	2.41	14.24	0.59	5.57
RSW (2)	437	26.57	4.33	58.80	2.55	14.44	0.63	6.23
UNIC(1)	365	27.60	4.29	57.55	2.47	14.90	0.60	5.54
UNIC(2)	380	26.79	4.45	58.85	2.62	14.31	0.64	6.03
LSD(5%)	6.55	0.17	0.46	1.30	0.19	0.28	0.086	0.23
2004 season								
Control	337	26.45	3.80	57.50	2.19	13.40	0.51	5.49
CCC (1)	334	26.79	4.18	57.50	2.20	13.28	0.59	5.48
CCC (2)	332	26.91	4.11	57.34	2.36	13.21	0.54	5.54
MLU (1)	371	27.86	4.18	57.99	2.42	13.51	0.56	5.67
MLU (2)	361	29.06	4.37	59.14	2.58	13.75	0.59	5.65
RSW (1)	354	28.78	4.14	58.20	2.41	13.70	0.58	5.59
RSW (2)	340	29.06	4.33	54.40	2.57	13.82	0.60	5.73
UNIC(1)	343	28.78	4.22	58.65	2.47	13.54	0.57	5.63
UNIC(2)	358	28.18	4.41	59.90	2.64	13.19	0.60	5.85
LSD(5%)	6.15	0.16	0.46	1.61	0.16	0.29	0.077	0.062

4) Starch and protein yields

Regarding to the yield of starch and protein, data recorded in Table 6 showed that starch (yield/fed) was increased by all treatments although starch percentage in grains was not significantly changed except at high treatments of MLU, RSW and Uniconazole which increased starch % by about 3 %. This increase in starch concentration of grains may be attributed to capacity of the plants for CO^2 assimilation and increasing biomass as a consequence. While the increase in starch (yield/fed) is obviously ascribed to increasing grain yield/fed at nearly all treatments. These results are in full agreement with those reported by Gendy (1990), who attributed the starch concentration increase in the endosperm cells in grains; consequentially the capacity of plants for starch building metabolites became greater.

Protein (yield/fed) was influenced by all treatments although not all treatments stimulated the protein percentages in grains. This elevation in protein yield/fed is attributed to the increase in grain yield/fed at almost all treatments.

The highest protein yield/fed recorded an increase of about 17 % and 19 % at high levels of MLU, RSW and Uniconazole respectively, as compared with control grains protein . An early studies by El-Hattab *et al.* (1987) showed that protein (yield/ha) of faba beans was inhibited by the use of several growth substances, including growth retardants. The influence of nitrogen absorption under the growth retardants, used in the present work, might be one of the reasons that increased protein percentage and protein yield in rice grains. In this regard, Maria (1992) stated that the grain protein percentage had the same pattern of protein yield of wheat grains as well as total sugars . Data collected during the second season followed the same trend of the first one. The increase in total carbohydrates in grains might be attributed to simulated-synthesis and translocation of the soluble sugars within shoot tissues, as discussed above. These results and conclusions are in harmony with those reported by Mostafa and El-Gharbawy (1979) on bean plants.

5) Straw yield

Data recorded in Table 6 indicated that straw yield (t/fed) was increased by all treatments particularly at high concentrations. The increase in straw weight/fed is attributed to the increase in number of tillers/m^2, clum diameters and the deposition of dry matter in shoots by treatments, as discussed above (Table 1). Similar results were reported by Sen and Naik (1977).

From this study, it can be concluded that CCC did not exhibit any significant retarding effect on rice plants when used alone. This negligible effect was explained to be due to the low absorption rate of CCC by rice leaves and tissues. The lodging problem in rice plants can be solved through the application substances such as MLU,RSW and Uniconazole. These compounds shortened the plant high and decreased lodging rate. The decrease of culms length caused by the application of growth retardants may be due to the decrease in the concentrations of growth promoter such as GA. The increase in yield by MLU, RSW and Uniconazole applications is of primary importance since they increased the paddy yield significantly. The increased in grain yield may be due to at last three factors: 1) increased number of tillers/m^2, 2) increased contents of starch and protein yield, and 3) increased of 1000 grain weight.

References

A.O.A.C. (1970) *Official Methods of Analysis,* 10^{th} ed. Association of Official Agriculture Chemists. Washington, D.C.

Balrs, R. and Reekers, I. (1960) Nitrate bestimmung in plfanzensubtanz mit 1.2.4-xylenol. *Land .Forsch.* **13,** 134 .

Bently, I.A. and Hously, S. (1954) Bioassay of growth hormones. *Plant Physiol.* **7**,405.

Dubois, M, Gilles, K.A. Hamiltion, J.K. Rebers, P.A. and Smith, F. (1956) Colorimetric method for determination of sugar and related substances. *Anal. Chem.* **28**,350 .

El-Hattab, A.H., Hassan, E.A., Shaban, S.H. and Abo El-Suoud, M.R. (1987) Effect of some growth factors and Glyphosate Herbicide on pigments and protein in faba bean (*Vicai faba* L.). *J. Agronomy and Crop Science* **156**, 250 .

Frankland, B. and Wareing, P.F. (1960) Effect of gibberellic acid on hypocotyls growth of lettuce seedlings. *Nature* **185**, 255.

Gendy, A.A. (1985) Untersuehungen Zur Halmstabilisierung bei Rice (*Oryza sativa* l.) under besondered Beritcksichitgung des Wirkstoffes 2,3-ichlorisobuttersourr. Diss. A. Martin-Luther- Univ Halle, Germany.

Gendy, A. and Marquard, M. (1989) Studies of nitrogen fertilization and growth regulators on seed-yield and some quality criteria of oil seed. Rape (*Brassica napus* L.) *fat. Sci. tenchol.* **91**, 9 .

Gendy, A.A. (1990) Effect of growth retardants on the growth, N,P,K and gibberellin content of rice seedlings (*Oryza sativa* L.) in water culture experiments. *Beiter. Trop. Land. Vet. Med* **28**, 407 .

Hofner, W. (1988) Bioregulatoren, Werkzeuge mogern pflanzenproduktion (sammel-referat). *Die Bodenkultur*, **39**, 101.

Ibrahim, M.E. and Gendy, A.A. (1996) Effect of nitrogen application and growth retarding treatment on growth, phytohormone concentration and yield of wheat. *Zagazig J. Agric. Res.* **23**, 1 .

Ilive, L., Karanov, E. and Boshkova, R. (1985) Influence of some purine and phenylurea cytokinins and atrazin on the photochemical and photosynthetic activity in ageing radish leaves (*Raphanus sativus* L.). *Acta Agric.* **33**, 449 .

Klomp, A.D. (1977) Early Senescence of rice and *Drechslera oryzea* in the wageningen polder, saninom. *Agricultural Res. Reports*, **859** .

Letham, D.S. (1967) Chemistry and physiology of kinetin like compound. *Ann. Rev. Plant Physiol.* **18**, 249.

Maria, A.M. (1992) Effect of growth regulators on salt tolerance in wheat plants. *Menofiya J. Agric. Res* **17**, 1067.

Maria, A.M., Genedy, A.A. and Moftah, A.E. (1993) Safflower response to pix treatments. *Monfiya J. Agric. Res.*, **4**, 2177 .

Mengel, K. and Kirkby, E.A. (1987) *Principles of Plant Nutrition*. International Potash Institute, Switzerland, p. 443.

Mishra, S.D. and Gaur, K. (1985) Modification of flag leaf senescence and yield characters in Barley (*Hordeum vulgare* L.) by growth regulators. *J. Plant Growth Reg.* **4**, 63.

Mostafa, S.M. and El-Gharbawy, A.H.A. (1979) Differential effects of the retarding chemicals. CCC and B9 on growth and metabolism of sugar beet plants. *Proc. Biol. Soci.* **3**, 103 .

Otto, St. and Schilling, G. (1984) Einsatzmoglichkeiten im Getriedebau. *Akad. Land Wirtsch, Berlin* **224**, 307 .

Rademacher, W. (1978) *Gas-chromatographische Analyse der Verandrungen im Hormongehalt des Wachsenden Weizenkons*. Diss Gottingen, Germany.

Rademacher, W. and Juny, J. (1986) GA Biosynthesis inhibitors. *Proc: of the Thirteenth Annual Meeting of the Plant Growth Regulator*. Society of America, p. 102 .

Schilling, G. and Eckert, H. (1980) Moglickheiten zur Steuerung der Nahrstoffverwertung durch Einsataz von Wachstumsregultoren. *Arch. Acker-und pflanzenbau Bodenked,* **24**, 289 .

Schilling, G. and Eckert, H. (1985) Different efficiency of 2,3-Dichloroiso-butyric acid preparation (DCIB) on growth and gibberellin transport in *Triticum* and *Hordeum*. *11th Inter. Conf. on Plant Growth Substances*. Wales, p. 242 .

Sen, S.K. and Naik, J. (1977) Growth and flowering response of pinched and unpinched chrysanthemum to growth regulator treatments. *Ind. J. Pharm.* **24**, 95.

Shindy, W.W. and Smith, D.E. (1975) Identification of plant hormones from cotton ovules. *Plant Physiol.* **55**, 550 .

Snedecor, G.W. and Cochran, W.O. (1973) *Statistical Methods*. Ames, Iowa State Univ. Press., IOWA, U.S.A.

Suh, J.k., Park, N.P., Franssen, J.M. and Munkw, J.DE (1992) The use of anti-gibberellins in the production of tulip plants. *Hort. Abst.*1994 . **64**, 2.

Sumito Chemical Co., Ltd. (1985) Plant Protection Division-International, Osaka, Japan.

Thomas, W. and Dutcher, R.A. (1924) Methods for carbohydrate determination. *J. Amer. Chem. Soc.* **46**,1662 .

Waller, P.A. and Duncan, D.B. (1969) A rule for the symmetric multiple comparison problem. *Amer. Sta. Assoc.* J. 1503.

Wettestein, D. (1967) Chlorophyll-letal und der submikorskopiche form-wechsel der Plastiden. *Exptl. Cell Res.* **12**, 427 .

Yoshida, S., Forn, D.A. and Cock, J.H. (1972) *Laboratory Manual for Physiological Studies of Rice*. 2nd ed. The Inter. Rice Res. Institute.

Younis, M.E., Foda, H.A. and moustafa, S.M. (1974) Metabolic changes in broad bean plants treated with growth retardants. *Mansoura Sci. Bull.* **2**, 33.

Zaky, L.M. (1985) Effect of certain chemicals on the physiology of *Linum ustatissmum* L. plant. *Ph.D. Thesis*, Ain Shams Univ., Fac. Sci., Egypt.

(*Received* 15/6/2005;
accepted 19/2/2006)

تأثير بعض مؤخرات النمو علي النمو والسلوك الفسيولوجي والرقاد ومحصول نباتات الأرز

بسيوني عبد الرازق زايد* ،عبد الفتاح جابر متولي* عبد العظيم قطب سالم** ، رفعت نصيف جورجي*

* مركز البحوث والتدريب في الأرز - سخا - كفر الشيخ - مركز البحوث الزراعية و** قسم بحوث المحاصيل الحقلية - شعبة البحوث الزراعية - المركز القومي للبحوث- الدقي - مصر.

أقيمت تجربتان حقليتان بمزرعة مركز البحوث والتدريب في الأرز، سخا، كفر الشيخ خلال موسى٢٠٠٣ ، ٢٠٠٤ لدراسة تأثير مؤخرات النمو التالية MLU208, Uniconazole, RSW0411, CCC - علي النمو والسلوك الفسيولوجي ودرجة الرقاد والمحصول لصنف الأرز سخا ١٠٤ ،وقد أوضحت النتائج أن مادة CCC لم تظهر أي اثر مؤخر علي نباتات الأرز وان كل المستويات المستخدمة من مؤخرات النمو الثلاثة الاخري أدت إلي انخفاض معنوي في طول النبات ودرجة الرقاد. وقد أدت إضافة مؤخرات النمو المذكورة إلي زيادة معنوية في عدد الأفرع في المتر المربع ومساحة ورقة العلم والوزن الجاف للأرز ماعدا عند إضافة مادة CCC. كما أدت إضافة كل مؤخرات النمو المذكورة إلي زيادة تركيز كلوروفيل أ ، ب في أوراق الأرز وتركيز النيتروجين في السيقان والحبوب ولكن البوتاسيوم انخفض ، ووجد أيضا أن تركيز الجبرلينات في السيقان انخفض بينما ارتفع تركيز ABA بإضافة -MLU208 Uniconazole – RSW0411 ، كما أظهرت النتائج أن المستويات المرتفعة من مؤخرات النمو أدت إلي زيادة وزن الألف حبة ونسبة النشا والبروتين وعدد السنابل في المتر المربع ومحصول الحبوب والقش، وعموما أعطت المستويات المرتفعة من مادتي -MLU208 و Uniconazole أعلي محصول حبوب.