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PHYSIOLOGICAL EFFECT OF SOME GROWTH RETARDANTS ON PERFORMANCE OF GROWTH, LODGING DEGREE AND YIELD OF RICE

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ABSTRACT

Two field experiments were conducted at Research Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt during 2010 and 2011 seasons. The study aimed to evaluate the effect of Cycocel (CCC), a mixture of Cycocel and Dicloro Iso Butyric acid (DCIB) (MLU 208), Triapenthanol (RSW041I) and Uniconazole on physiological and growth behavior of rice plants, as well as lodging degree of Sakha 104 rice cultivar(long stem cultivar that is characterized by high rate of lodging).The most important results showed that CCC did not exhibit any significant retarding effect on rice plants .All levels of MLU 208, RSW04ll and Uniconazole markedly decreased the height 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 under all growth retardants except CCC. Degree of lodging was decreased by the application of proper levels of MLU 208, RSW04ll and Uniconazole. RSW performed better regarding lodging and reduced it to 75% of the control. All growth retardants increased the concentration of Chlorophyll A and Chlorophyll B in rice leaves but caratenoids were decreased. Nitrogen concentration in shoots and grains was increased while K was decreased. GA_3 concentration in shoots was decreased but ABA was increased by the application of MLU 208, RSW0411 and Uniconazole. The high levels of growth retardants increased the weight of l000-grain, starch and protein yields. Grain yield was the highest when Uniconazole, MLU 208and RSW041Iwere applied, respectively.

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

INTRODUCTION

Rice is one of the main cereal crops in Egypt. It covers about 17% of the cultivated area in the northern part of the Nile Delta. The policy of Egypt 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 increased cause and a decrease in the yield and productivity of rice; lodging is one of the main problems in intensive rice cropping under high nitrogen application rates, particularly when it occure in the early reproductive phase of development. The reduction in 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 of considerable importance in agriculture production. Plant growth retardants are synthetic compounds, which were used to reduce the shoot length of plants in a desired way without changing developmental patterns or being phytotoxic.

This is achieved primarily by reducing cell elongation, but also by lowering the rate of cell division. In their effect on the morphological structure of plants, growth retardants are antagonistic to gibberellins (GA_3) and auxines, the plant hormones that are primarily responsible for shoot elongation Rademacher, W (2000).Triapentbenol (RSW04l1) was found to be of 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 the first time by Otto and Schilling (1984) and Schilling and Echert (1985). Uniconazole is a plant growth retardant manufactured by Sumito Chemical Company Ltd in 1985 and now has a wide spread as a new growth regulator which was found to modify the biosynthesis of GA_3 in several crops Rademacher,W and Juny(1986), Rademacher,W(2000) and Sun *et al.*(2012). The present study was mainly aimed to investigate the effect of the new growth retardants MLU 208, RSW0411 (Triapenthenol) and Uniconazole in addition to CCC, as foliar application on the growth, chemical compositions and yield of rice plants (Sakha 104 cultivar).

MATERIALS AND METHODS

Two field experiments were conducted at the Rice Research and Training Center Farm, Sakha, Kafr El-Sheikh, Egypt during 2010 and 2011 summer seasons in loamy clay texture soil. The physical and chemical properties of soil for the two experiments were determined according to FAO (1976) and Black (1965) and presented in Table (A). Rice seeds of Sakha 104 slightly tall cultivar which characterized by high rate of lodging were sown on May *25th.*After thirty days, seedlings were transplanted at 20 x 20 cm spacing between rows and hills within rows in a complete randomized block design with three replicates. Mineral Fertilizers; N, P and K and all agricultural practices were done as recommended.

The treatments used as follow:

Nine treatments were studied using Cycocyl (CCC) at levels of 2 and 4liter/feddan a mixture of 29 % CCC and 36% DCIB wt/wt (MLU208) at rates of 2 and 4liter/feddan Triapenthenol(RSW0411) at levels of 100 and 200 gram/ feddan and Uniconazole at rates of 20 and 40gram/ feddan; besides the distilled water as control.

All treatments were used in soak seeds for twenty-four hours have been sprayed as foliar on the plants at heading stage as recommended by Klomp (1977). Tween 20 was used at a concentration of 0.5 % as wetting agent. The volume of water used in all growth retardants treatments was 200 liter/feddan. 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 pulled out, and were transferred immediately to the laboratory where the following data were recorded.

A-Vegetative growth analysis:

1-Culm length (cm):

Culm length (cm) was measured from the soil surface to the top of the panicle.

2- Number of effective tillers/ m^2:

Number of tillers/m^2 was measured at harvest time.

3-Flag leaf area (m^2/ m^2) which estimated 15 days after treatments (maximum length x maximum width x 0.75). Yoshida *et al.* (1976).

4- Dry matter content (kg/ m^2):

Dry matter of shoots and roots *(kgl* m^2) after drying at 70°e to constant weight.

5- Culm diameter:

Culm diameter was measured for the third internode from upward.

6-Degree of lodging:

Using the following scale: [1= no lodging and 9= total lodging (flat)], Culm diameter the main internode from the bottom. Otto and Schilling (1984).

B-Chemical analysis:

1- Chlorophyll a & b and caratenoids: For the fresh leaves were determined spectrophotometrically 15 days after treatments as described by Wettestein (1967).

2-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).

3-Soluble sugars were extracted in 80 % ethanol in soxhn apparatus and were then determined colormetricaly according to Thomas and Dutcher (1924). Standard curve for carbohydrate was prepared with glucose and measured in an identical way.

4-Nitrogen% was determined using micro-kjeldahl method as described in A.O.A.C. (1970).

5-Phosphorus% was estimated colorimetrically using stannous chloride method as described by Troug and Mayer (1939).

6-potassium% was determined by the flame photometer According to Brown and Lilliand (1946).

7- Nitrate concentration in grains was extracted in micro- kjeldahl apparatus and was determined using dimethyl phenol (Xylenol) method according to Barls and Reekors (1960).

8-**Phytohormones in shoots** were extracted from the fresh materials with 80 %cold methanol according to Shindy and Smith (1975). The acidic ethylacetate fraction was used to determine IAA by the wheat coleoptiles straight bioassay (described by Bently and Rously, 1954), GA by lettuce hypocotyls assay (Frankland and Wareing, 1960) and ABA by wheat transpiration assay (Rademacher, 1978) whereas alkaline fraction was used to determine cytokinins by radish cotyledons assay (Letham, 1967).

C-Yield and its components:

At harvest time, number of panicles and tillers/m^2 were calculated. Grain and straw yields /fed were determined. Thousand grain weight (seed index) was weighted.

Starch % in grains:

Starch in dry grains was determined according to Yoshida *et al.* (1972).

Protein % in grains:

Total protein in dry grains were determined on bases of nitrogen determination using micro kjeldahl method (A.O.A.C.,1970) and protein was calculated by multiplying N values by the conversion factor 6.25 (ling,1963).

The collected data for each character in both seasons were subjected to the stander analysis of variance, according to the procedure outline by Gomez and Gomez (1986), using IRRISTAT Computer program. Differences among treatment means were compared using the Revised L.S.D. at 5%.

Table A: Mechanical and chemical analysis of the experiments soil.

Soil analysis	2010	2011
Mechanical analysis:		
Clay %	44.06	55.80
Silt %	28.64	32.00
Sand %	27.30	13.2
Texture class	Clay	Clay
Chemical analysis:		
Organic matter %	1.65	1.60
E.C. Ds/m	3.00	3.10
pH	8.10	8.19

RESULTS AND DISCUSSION

A-Vegetative growth analysis:

1-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 mode of action of these chemicals on the growth and development of plant tissues, or to their effects on a specific cells and /or plant organs.

In this concern, several studies (Schilling and Eckert, 1980, on MLU; Gendy and Marquard, 1989, on RSW; Sub *et al.*, 1992. on Uniconazole), 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.

Table1.Effect of different growth retardants on vegetative growth parameters of rice plants at heading and harvest time during 2010and 2011 seasons

Treatments	Culm length (cm)	+ of control	No. of tillers (per/ m^2/)	+of control	Flag leaf area (m^2/ m^2/)	+of control
2010 season						
Control	122.64	(100)	450.6	(100)	1.33	(100)
CCC(2L/fed)	123.98	(101)	451.3	(100.2)	1.32	(99.25)
CCC (4L/fed)	122.39	(99.80)	449.5	(99.60)	1.32	(99.25)
MLU(2L/fed)	112.56	(91.78)	491.1	(109.0)	1.39	(105.0)
MLU(4L/fed)	109.70	(89.44)	545.0	(121.0)	1.43	(107.0)
RSW(100g/fed)	94.33	(76.92)	505.6	(112.0)	1.41	(106.0)
RSW(200g/fed)	92.90	(75.75)	551.0	(122.0)	1.47	(111.0)
UNIC(20g/fed)	109.45	(89.24)	489.8	(109.0)	1.50	(113.0)
UNIC(40g/fed)	105.25	(85.82)	513.6	(114.0)	1.51	(114.0)
LSD at 5%	13.36	-	36.2		0.035	-
2011 season						
Control	120.96	(100)	427.92	(100)	1.13	(100)
CCC(2L/fed)	120.62	(99.71)	425.52	(99.44)	1.12	(99.12)
CCC (4L/fed)	120.12	(99.31)	420.48	(98.26)	1.11	(98.23)
MLU(2L/fed)	104.41	(86.32)	471.6	(110.0)	1.19	(105.0)
MLU(4L/fed)	97.69	(80.76)	474.0	(111.0)	1.24	(110.0)
RSW(100g/fed)	96.01	(79.37)	465.96	(109.0)	1.20	(106.0)
RSW(200g/fed)	80.64	(65.58)	479.16	(112.0)	1.22	(108.0)
UNIC(20g/fed)	109.45	(89.01)	466.56	(109.0)	1.28	(113.0)
UNIC(40g/fed)	104.64	(85.10)	499.92	(117.0)	1.30	(115.0)
LSD at 5%	14.12	-	30.84	-	0.022	-

CCC (Cycocel), MLU 208{Cycocel and Dicloro Iso Butyric acid DCIB}
RSW (Triapenthanol) and Unic. (Uniconazole).

2- Number of effective tillers/ m^2:

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% for RSW and 9 % and 14 % for Uniconazole. Data in the second season followed almost the same trend MLU10%and11%, RSW9%and 12% and Uniconazole 9% and 17%. The greatest number of tillers associated with MLU, 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 of tillers/ 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).

3- Flag leaf area

Statistical analysis showed that flag leaf area was significantly increased with all growth retardants (Table I). The first season was recorded Under Uniconazole treatments (13-14 %) followed by RSW (6-11 %) and MLU (5-7 %). The second season showed almost the same trend Uniconazole treatments (13-15 %) followed by MLU (5-10 %) and RSW (6-8 %). 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. hl 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 application of the growth retardants used in this study is an important issue 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).

4-Dry matter content

Data recorded in Table2 revealed that CCC showed neutral effect on dry matter of shoot, 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 contra] plants. Data recorded in the second season followed the same trend as those collected in the first season Uniconazole (18%), RSW (15 %) and 4l/fed MLU (10 %). 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).

5-Culm diameter

All growth retardants used in the present study except CCC caused a significant increase in culm diameter of rice plants during the two experimental seasons. As compared with control plants (Table 2), 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 composition as well as enhancing the stem diameter as a consequence.

Table2.Effect of different growth retardants on vegetative growth parameters of rice plants at heading and harvest time during 2010and 2011 seasons

Treatments	Dry matter of shoot kg/m^2	+ of control	Culm diameter (mm)	+ of control	Degree of loading	+ of control
2010 season						
Control	1.32	(100)	4.1	(100)	7	(100)
CCC(2L/fed)	1.32	(100)	4.1	(100)	7	(100)
CCC (4L/fed)	1.36	(103)	4.2	(102)	7	(100)
MLU(2L/fed)	1.42	(108)	4.7	(115)	5	(71)
MLU(4L/fed)	1.53	(116)	5.3	(129)	3	(42)
RSW(100g/fed)	1.43	(108)	4.8	(117)	3	(42)
RSW(200g/fed)	1.57	(119)	5.4	(132)	2	(29)
UNIC(20g/fed)	1.44	(109)	4.9	(119)	4	(57)
UNIC(40g/fed)	1.60	(121)	5.5	(134)	3	(42)
LSD at 5%	0.07	-	0.4	-	-	
2011 season						
Control	1.31	(100)	4.0	(100)	7	(100)
CCC(2L/fed)	1.31	(100)	4.0	(100)	7	(100)
CCC (4L/fed)	1.34	(102)	4.1	(103)	7	(100)
MLU(2L/fed)	1.39	(106)	4.5	(113)	5	(71)
MLU(4L/fed)	1.44	(110)	5.0	(125)	3	(42)
RSW(100g/fed)	1.42	(108)	4.6	(115)	3	(42)
RSW(200g/fed)	1.50	(115)	5.2	(130)	2	(29)
UNIC(20g/fed)	1.44	(110)	4.7	(118	4	(57)
UNIC(40g/fed)	1.54	(118)	5.4	(135)	3	(42)
LSD at 5%	0.03	-	0.3	-	-	-

CCC (Cycocel), MLU 208{Cycocel and Dicloro Iso Butyric acid DCIB}, RSW (Triapenthanol) and Unic. (Uniconazole).

6-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(Otto and Schilling1984). Data collected for this purpose indicated that all treatments except CCC, which had no effect, caused a substantial decrease in the degree of lodging (Table2).

Data recorded in this table showed that the highest level of MLU results in 3 degrees of lodging thus it was decreased by about 58 % during the first and second seasons 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 71 % during the first and second seasons Moreover, lodging was decreased by about reduction 57% at the high level of Uniconazole and 42% at the low level as compared to control plants during the first and second seasons.

In a conclusion, 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 Schilling 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 times thus CCC, MLU, F..5W 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 Culm diameter and strengthen its wall (Hofner, 1981)).

B-Chemical analysis:

1. Photosynthetic pigments

1-In normal leaves:

Data in Table 3 indicated that Chlorophyll a and Chlorophyll a concentrations were significantly increased and caratenoids were decreased by all treatments as compared with control pants. In this regard 4 I/fed of CCC caused an increase of about 9% and 4% in Chlorophyll a and Chlorophyll b, respectively.

Table3.Effect of different growth retardants on chlorophyll concentration (mg/g.dwt^{-1}) in normal and flag leaves of rice plans at heading stage during 2010and 2011 seasons.

Treatments	Third leaves				Flag leaves			
	Ch1orophyll a	Ch1orophyll b	Carotenoids	(a+b)/ caratenoids	Ch1orophyll a	Ch1orophyll b	Carotenoids	(a+b)/ carotenoid
2010 season								
Control	20.29	7.61	1.84	15.16	20.67	7.26	1.79	15.60
CCC(2L/fed)	22.06	7.81	0.60	49.78	21.05	7.41	1.80	15.81
CCC(4L/fed)	22.17	7.92	0.56	53.73	22.11	8.53	1.77	17.31
MLU(2L/fed)	22.73	7.89	0.80	38.28	21.37	7.94	1.71	17.31
MLU(4L/fed)	23.87	7.87	1.12	38.34	22.38	8.97	1.28	17.14
RSW(100g/fe	22.79	7.63	1.20	25.35	21.40	7.48	1.08	24.49
RSW(200g/fe	23.83	7.85	1.08	29.33	22.49	8.06	1.23	26.74
UNIC(20g/fed	22.37	7.89	0.80	37.83	21.22	7.81	1.41	24.01
UNIC(40g/fed	23.73	7.94	0.68	46.57	22.73	8.89	1.10	20.60
LSD at 5%	1.91	0.29	0.60		0.49	0.16	0.18	26.90
2011 season								
Control	20.05	7.51	1.60	17.23	21.07	7.49	2.18	13.10
CCC(2L/fed)	21.08	7.82	1.00	28.90	21.22	7.72	2.19	13.21
CCC(4L/fed)	21.23	8.90	0.92	32.75	22.31	8.80	2.11	14.74
MLU(2L/fed)	22.22	7.81	0.82	36.62	22.60	8.04	1.08	28.37
MLU(4L/fed)	23.79	8.76	0.60	54.25	22.63	8.84	1.23	19.39
RSW(100g/fed	22.32	7.73	0.40	75.13	21.83	7.78	1.11	26.68
RSW(200g/fed	22.73	8.89	0.40	79.05	22.95	8.80	1.24	25.60
UNIC(20g/fed	22.63	7.84	0.46	66.24	21.73	7.89	1.10	26.93
UNIC(40g/fed	23.89	8.57	0.34	95.47	21.90	8.01	1.17	25.56
LSD at 5%	1.80	1.16	0.44		0.47	0.22	0.26	

CCC (Cycocel), MLU 208{Cycocel and Dicloro Iso Butyric acid DCIB},
RSW (Triapenthanol) and Unic. (Uniconazole).

Similarly, MLU, RSW and Uniconazole were nearly comparable in increasing, Chlorophyll a and Chlorophyll b by about 2-3 % as compared to control plants. Total chlorophyl1 increased by all treatments with special regard to CCC (about 5 % increases as compared with control plants). Other treatments caused arrange 3-4 % increases in total chlorophyll. Several evidence including previous reports showed the increase in chlorophylls and the decrease in caratenoids 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 might also play an important role in increasing chlorophyll content of treated leaves (Gendy, 1990). In addition, Hofner (1988) showed that the decrease of caratenoids under the growth retardant treatments were connected with a decrease in the growth promoters particularly gibberellins. The present study showed that endogenous GA_3 concentrations in rice tissues were decreased by the growth retardants and thus caratenoids were reduced in treated, compared to untreated, plants.

2 -Carbohydrate concentration for rice shoats:

Data recorded in Table 4 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 season. 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 m 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)

Table4. Effect of different growth on soluble and total sugars (mg / g) dwt^{-1}) in shoots and grains of rice plants during 2010 and 2011 seasons.

Treat.	Shoots		Grains	
	Soluble sugars	Total sugars	Soluble sugars	Total sugars
2010 season				
Control	3.00	41.12	3.58	28.78
CCC(2L/fed)	3.10	41.78	3.70	29.94
CCC (4L/fed)	3.12	41.64	3.77	30.11
MLU(2L/fed)	3.26	42.33	5.52	38.46
MLU(4L/fed)	5.52	45.70	5.92	35.49
RSW(100g /fed)	4.90	44.82	5.60	39.68
RSW(200g /fed)	5.87	47.79	5.94	37.97
UNIC(20g /fed)	4.90	45.00	5.13	38.85
UNIC(40g /fed)	5.82	45.27	5.68	33.00
LSD at 5%	0.27	3.46	0.26	3.63
2011season				
Control	5.90	51.53	3.77	31.55
CCC(2L/fed)	6.00	51.93	3.75	31.48
CCC (4L/fed)	6.21	51.68	3.80	31.09
MLU(2L/fed)	6.77	54.66	3.96	34.19
MLU(4L/fed)	9.77	56.84	4.08	43.01
RSW(100g /fed)	10.35	54.88	4.02	34.39
RSW(200g /fed)	11.00	57.65	4.52	32.16
UNIC(20g /fed)	9.10	59.67	4.44	34.65
UNIC(40g /fed)	9.19	56.20	4.75	32.38
LSD at 5%	0.17	2.30	0.28	4.60

CCC (Cycocel), MLU 208{Cycocel and Dicloro Iso Butyric acid DCIB}, RSW (Triapenthanol) and Unic. (Uniconazole).

3-Carbohydrate concentration for rice grains: Data in Table4 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 dominate 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.

4-N,P and K^+ concentrations:

N,P and K^+ concentrations In shoots:

Data in Table5 cleared that 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 under all treatments particularly at the high levels of CCC (8% decrease), MLU (15%), RSW (25%) and Uniconazole (5%) (Table4). 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 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 and effects for P on rice shoots.

Table 5: Effect of different growth retardants on N, P and K (%) contents in shoots and rains and NO_3 (ppm) in grains of rice plants during 2010 and 2011 seasons.

Treat.	Shoots			Grains			
	N%	P%	K%	N%	P%	K%	NO_3
2010 season							
Control	3.25	1.05	3.74	2.22	1.60	3.63	156
CCC(2L/fed)	3.27	1.04	3.43	2.23	1.35	3.64	196
CCC (4L/fed)	3.26	1.05	3.44	2.20	1.33	3.70	188
MLU(2L/fed)	4.06	1.06	3.40	2.26	1.75	3.48	181
MLU(4L/fed)	4.13	1.08	3.19	2.29	1.85	3.41	213
RSW(100g /fed)	3.64	1.03	2.89	2.27	1.63	3.51	206
RSW(200g /fed)	4.26	1.04	2.80	2.30	1.65	3.31	208
UNIC(20g /fed)	3.83	1.00	3.64	2.23	1.65	3.52	130
UNIC(40g /fed)	3.90	1.07	3.57	2.28	1.75	3.42	156
L.S.D (5%)	0.043	NS	0.086	0.043	NS	0.049	4.40
2011 season							
Control	4.20	1.04	3.83	2.14	1.65	3.73	156
CCC(2L/fed)	4.23	1.03	3.63	2.18	1.45	3.71	195
CCC (4L/fed)	4.20	1.03	3.72	2.15	1.55	3.72	190
MLU(2L/fed)	4.42	1.05	3.73	2.31	1.75	3.61	176
MLU(4L/fed)	4.53	1.09	3.01	2.50	1.80	3.01	207
RSW(100g /fed)	4.39	1.00	2.11	2.39	1.65	3.52	198
RSW(200g /fed)	4.62	1.04	2.09	2.53	1.70	3.44	202
UNIC(20g /fed)	4.69	1.00	3.57	2.24	1.60	3.62	127
UNIC(40g /fed)	4.90	1.00	3.51	2.35	1.70	3.32	158
L.S.D (5%)	0.062	NS	0.098	0.062	NS	0.044	9.19

CCC (Cycocel), MLU 208{Cycocel and Dicloro Iso Butyric acid DCIB}, RSW (Triapenthanol) and Unic. (Uniconazole).

N,P and K^+ concentrations In Grains:

Data recorded in table 5 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 P% content in the grain was not changed significantly by any of the treatments. In that respect, Gendy (1990) found similar results.

Data also indicated that the highest levels of MLU, RSW and Uniconazole increased the percentage of K in rice grains by about 6% , 9% and 2 % control, respectively, in the first season and by about 19 %, 8% and 11 % of control, respectively, in 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 result 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%). 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 befor.

5-Phytohormone concentration

Data presented in Table 6 showed that IAA concentration was not changed significantly, while endogenous GA_3 significantly decreased by growth retardants at the two seasons.

Table6.Effect of different growth retardants on pheromones concentration (ng g^{-1} fwt) in rice shoots at tillering stage during 2010 and 2011 seasons.

Treatments	IAA	GA	Cyt.	ABA	(IAA+GA_3+Cyt)/ABA
2010season					
Control	120	85	230	17.2	25.29
CCC(2L/fed)	120	83	229	17.6	24.55
CCC (4L/fed)	121	82	227	17.9	24.02
MLU(2L/fed)	121	66	225	19.0	21.68
MLU(4L/fed)	118	52	222	19.8	19.80
RSW(100g/fed)	119	57	225	19.2	20.90
RSW(200g/fed)	118	43	220	19.9	19.15
UNIC(20g /fed)	117	64	224	18.9	21.43
UNIC(40g /fed)	119	40	225	20.2	19.01
L.S.D (5%)	NS	7.81	NS	0.50	
2011 season					
Control	122	83	231	17.0	25.24
CCC(2L/fed)	123	82	230	17.4	25.00
CCC (4L/fed)	124	80	228	17.8	24.27
MLU(2L/fed)	123	59	226	18.4	22.17
MLU(4L/fed)	120	40	221	19.0	20.05
RSW(100g/fed)	122	63	224	18.6	21.93
RSW(200g fed)	124	50	219	19.2	20.47
UNIC(20g /fed)	119	61	222	18.7	21.50
UNIC(40g /fed)	121	43	224	19.9	19.50
LSD (5%)	NS	8.03	NS	0.011	

CCC (Cycocel), MLU 208{Cycocel and Dicloro Iso Butyric acid DCIB}, RSW (Triapenthanol) and Unic. (Uniconazole).

In this regard the most remarkable decrease of the GA_3 during the first season was obtained at the highest level of both RSW (-49 %) and Uniconazole (-53%). Same trend was observed at the second season. The decrease in GA_3 concentration was discussed by Rademacher 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 GA_3 biosynthesis, to ent-kaurenoic acid. Growth retardants may also interfere with other metabolic reactions involving cytochrome systems (Mengel and Kirkby, 1987), (Rademacher2000) and (Sun *et al.*2012). 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%), 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 GA_3 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_3 + cytokinin) /(ABA) as compared with untreated plants during both seasons.

3) Yield and its components

a- Number of panic1es/m^2

Data recorded in Table 7 showed that number of panicles/m2 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-One thousand grain weight (g)

Data presented in Table 7 showed that one thousand grain weight (g**)** (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.

c- Grain Yield (ton/fed**)**

Data in Table 7 showed that grain yield (t/fed) was increased by applying a 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 and reducing lodging. Previous studies showed the unbiased effect of CCC on rice yield (Hofner *et al.*, 1988) and the positive effect of MLU on cereal yield (Hofner *et al.*, 1988) and the positive effect of MLU on cereal yield (Ibrahim 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 cytokines content which led to promoting spikelets and floret development whereas, it was increased significantly by the application of the growth retardant CCC promoting spikelets and floret development whereas, it was increased significantly by the application of the growth retardant CCC .

Table 7: Effect of different growth retardants on yield and its components and grain quality of rice plants during 2010 and 2011 seasons.

Treatment	Number of panicles/ m^2	1000 grain (g)	Grain yield ton/fed	Starch		Protein		Straw yield ton/fed
				(%)	+control	(%)	+control	
2010 seasons								
Control	351	25.88	3.86	57.0	(100)	0.54	(100)	5.52
CCC2L/fed	340	26.45	4.29	57.0	(100)	0.60	(111)	5.64
CCC4L/fed	339	26.58	4.20	57.4	(101)	0.58	(107)	5.63
MLU(2L/fed	452	27.83	4.25	57.4	(101)	0.60	(111)	5.68
MLU4L/fed	425	26.57	4.41	58.6	(103)	0.63	(117)	5.17
RSW100g/fed	443	26.78	4.18	57.7	(101)	0.59	(109)	5.57
RSW200g fed	437	26.57	4.33	58.8	(103)	0.63	(117)	5.63
UNIC20g /fed	365	27.60	4.29	57.6	(101)	0.60	(111)	5.54
UNIC40g /fed	380	26.79	4.45	58.9	(103)	0.64	(119)	5.83
LSD at5%	6.55	0.17	0.46	1.30	-	0.09	-	0.23
Control	337	26.54	3.80	57.5	(100)	0.54	(100)	5.49
CCC2L/fed	334	26.79	4.18	57.5	(100)	0.59	(109)	5.48
CCC4L/fed	332	26.91	4.11	57.3	(100)	0.54	(100)	5.58
MLU(2L/fed	371	27.86	4.18	58.0	(101)	0.56	(104)	5.67
MLU4L/fed	361	29.06	4.37	59.1	(103)	0.59	(119)	5.65
RSW100g/fed	354	28.78	4.14	58.2	(101)	0.58	(107)	5.59
RSW200g fed	340	29.06	4.33	58.4	(102)	0.60	(111)	5.73
UNIC20g /fed	343	28.8	4.22	58.7	(102)	0.57	(106)	5.63
UNIC40g /fed	358	28.18	4.41	59.9	(104)	0.60	(111)	5.85
LSD at5%	6.15	0.16	0. 46	1.61	-	0.08	-	0.062

CCC (Cycocel), MLU 208{Cycocel and Dicloro Iso Butyric acid DCIB},
RSW (Triapenthanol) and Unic. (Uniconazole).

Starch and protein percentage in grains

Regarding to starch and protein percentage, data recorded in Table 7 showed that starch in grains were increased under all treatments. Starch percentage in grains at high treatments of MLU, RSW and Uniconazole which increased 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. These results are in full agreement with those reported by Gendy (1990), who attributed the starch concentration increase in the endosperm cells in grains; consequently the capacity of plants for starch building metabolites became greater.

Protein percentage in grains was influenced by all treatments. The protein percentages in grains were increased under all treatments. This elevation in protein in grains is attributed to the increase in grain yield/fed at all treatments. The highest protein % 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 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-Gharabawy (1979) on bean plants.

5) Straw Yield

Data recorded in Table 7 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, Culm diameters and the deposition of dry matter in shoots by treatments, as discussed before (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 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 height 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_3. 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.

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الأثر الفسيولوجي لبعض مؤخرات النمو على النمو والرقاد ومحصول نباتات الأرز

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أقيمت تجربتان حقليتان خلال موسمي صيف ٢٠١٠ و٢٠١١ فى مزرعة مركز البحوث والتدريب في الأرز بسخا كفر الشيخ مصر لدراسة تأثير مؤخرات النمو التالية :- MLU208, CCC , RSW0411 وUniconazole على النمو والسلوك الفسيولوجي ودرجة الرقاد والمحصول للصنف سخا ١٠٤(صنف مصري طويل الساق قابل للرقاد عند مستويات التسميد النيتروجينى العالية).

وقد أوضحت النتائج أن مادة السيكوسيل CCC لم تظهر أي تأثير مؤخر على نباتات الأرز وأن كل المستويات المستخدمة من مؤخرات النمو الثلاثة الأخرى (RSW0411وUniconazoleوMLU208) أدت إلى انخفاض معنوي فى طول النبات ودرجة الرقاد.

كما أدت إضافة مؤخرات النمو المذكورة إلى زيادة معنوية فى عدد الأشطاء فى المتر المربع ومساحة ورقة العلم والوزن الجاف للنباتات ما عدا عند إضافة مادة السيكوسيل CCC .

كما أدت إضافة كل مؤخرات النمو إلى زيادة تركيز كلوروفيل أ ، ب فى الأوراق وتركيز النيتروجين فى السيقان والحبوب ولكن انخفض البوتاسيوم . ووجد أيضا أن تركيز الجبريلينات فى السيقان انخفض بينما ارتفع تركيز ABA بإضافة RSW0411وUniconazoleوMLU208 .

كما أظهرت النتائج أن المستويات المرتفعة من مؤخرات النمو أدت إلى زيادة وزن الألف حبة ونسبة النشا والبروتين وعدد الداليات فى المتر المربع ومحصول الحبوب والقش .

كما أعطت المستويات المرتفعة من مادتي MLU208 وUniconazole أعلى محصول من الحبوب.

وعلية فانه يمكن التوصية بالمعاملة بمؤخرات النمو للأصناف الطويلة الساق ذات القابلية للرقاد وخاصة عند مستويات التسميد العالية أو عند الزراعة عقب محاصيل عالية التسميد مثل البصل والبنجر والبطاطس.

قام بتحكيم البحث

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