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Lydia Aviti

RESPONSE OF WHEAT, BARLEY AND OAT TO SEED DRESSING AND FOLIAR APPLICATIONS OF THREE GROWTH REGULATORS

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Scientific Annals
of the School
of Agriculture and Forestry
Aristotelian University
Volume: ΙΗ΄. Roussopoulos

THESSALONIKI, GREECE
1976

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INTRODUCTION

Yield increases of cereals in recent times has come mainly from higher yielding varieties, increased fertilizer use, advanced methods for controlling weeds, pests and diseases and better adaptation to the environment. Adaptation is partly due to the indeterminate pattern of growth by continued activity of the growing points of the shoots and roots of cereal plants.

The introduction of chemical plant growth regulators adds a new dimension to the possibilities for modifying plant growth so as to increase the economic yield and enable plant to adapt to adverse conditions as water stress or abundance of it in combination with high fertility levels, which cause lodging, both being the restrictive factors for making maximum grain yields of small grains achievable. Reduction of lodging through the use of growth regulators have been beneficial because of higher yields. Reduced plant height, lodging and increased grain yields of wheat, barley and oats varieties in Greece have been reported from application of CCC (Skorda, 1970).

The resistance of plants to the effects of water stress has frequently been shown to be increased by a previous history of exposure to stress (Levitt, 1956). Russian studies, reviewed by May, et al. (1962), on presowing drought hardening of plant by soaking seed in water and subsequently airdrying showed that plants from these treated seeds had an increased drought tolerence, which could lead to higher yields under conditions of water stress. However, similar studies by other workers have been extremely variable and inconclusive (Husain et al., 1968 and Woodruff, 1969). In the mean time the chemical Resistine was discovered, which renders to plants resistance to the effects of water stress.

The effect of three chemical compounds (RH - 531, Resistine and perfluidon) applied at various rates and stages of development on the agronomic characteristics, grain yield and quality of wheat, barley and oat varieties as compared, in some experiments, to CCC or presowing hardening is reported in this paper.

MATERIALS AND METHODS

The chemicals used and their formulations were as follows:

1. RH-531, 93.5% w.p. sodium 1 - (p - chlorophenyl) - 1,2 - dihydro - 4,6 - dimethyl-2-oxonicotinate.

2. Perfluidon, 50% w.p. 1,1,1 - trifluoro - 4 - (phenylsulfonyl) methanesulfono - o - toluidine.

3. CCC, (2 - chloroethyl) trimethylammonium choride.

4. Resistine (e.c.) an active substance extracted from Israeli herbs (Plantex Ltd. Chemical and Pharmaceutical Works).

The two first reduce plant height and increase resistance to lodging, while Resistine, according to Plantex Ltd. «transmits to treated plants a large capacity of resistance to drought and salinity».

Seven separate trials were conducted referred to thereby as experiments I through VII.

Experiment I was conducted to determine the optimum rate and stage of growth at which to apply RH-531 in comparison to the optimum rate and stage of CCC application, which has been determined in earlier studies (Skorda, 1970). Responses of wheat variety Niki to single foliar applications at 5th and 6th stages of growth (Large, 1954) in three rates (1.35, 2.7 and 5.4 kg/ha a.i.) of RH-531 were compared using a two-way split plot design (stage, rates). Experimental plots were located on Plant Breeding Institute recent alluvial semi-fertile soil. Wheat was planted in November in 5X2 m plot size spaced 27 cm apart using a seeding rate of 150 kg/ha. Prior to planting, plots received a broadcast application of 50 and 40 kg/ha of N and P_2O_5, respectively, in the form of ammonium phosphate sulfate and additional broadcast application of 50 kg/ha of N from calcium ammonium nitrate, when the wheat was at the fifth leaf stage. CCC and RH-531 were applied (water 600 liters/ha) with a wetting agent to give good coverage of foliage. All applications were made using a hand operated, compressed air sprayer.

Height measurements were taken several times during the season, while internodes lenght and lodging scoring (as percent of the plot area) at harvest. Grain was harvested from a central strip 1.25 m down each plot using a Hege mini plot harvester and yield recorded in kg/ha. A sample of grains from each treatment was saved and used for planting during the next season to determine any residual effects of CCC and RH-531.

Experiment II was carried out using two varieties of bread wheat (G-38290 and Niki), one durum (Limnos) and one barley (Zephyr). For each variety a separate trial with randomized complete block desing was established. The treatments consisted of 2 to 5 rates of RH-531 as seed dressing (0.25, 0.5, 1.0, 1.5 and 2.0), 2 to 7 rates as foliar spray at 3rd to 5th stages of growth and one rate of CCC seed dressing (1%) and one as foliar spray (3.2 kg a.i./ha). In the growth stages 3rd and 4th the rates were almost the same (0.3, 0.6, 0.9, 1.2, 1.7, 2.28 and 2.85 kg/ha), while in the 5th one lower and one between (0.15, 0.30, 0.60, 0.90, 1.2 and 1.5 kg/ha) because the results of the previous experiment showed that at 5th stage lower rates would be more beneficial. On the three wheat varieties almost the same rates were used, while on the barley only two rates as seed dressing and two as foliar spray at 3rd and 4th stages and one at 5th stage.

Planting date, plot size, soil type, cultural practices and fertilization program were similar to those in Experiment I and data were collected in a similar manner.

Experiment III was conducted to determine the responses of 10 bread, five durum wheat and five barley varieties to single foliar application of RH-531 at the fifth growth stage. Three rates 0.30, 0.60 and 0.90 kg/ha for wheat and one for barley were evaluated using a two-way split plot design (cultivar, chemical). Cultural practices and fertilization program were similar to those in experiment I and data were collected in a similar manner.

Experiment IV was carried out on wheat (cv Niki). The treatments consisted of untreated seed, seed which had been presowing drought hardening, seed soaked in four concentrations of Resistine (0.5, 1.0, 1.5, 2.0%), a treatment of single foliar application of RH-531(0,6 kg/ha) and CCC (3.2 kg a.i./ha) and one as seed dressing (1% a.i.). Treatments were arranged in a randomized complete block design with six replications as in experiment II. Seed were soaked in Resistine solution for 6 or 24 hours and dried in the shade until they were aquired their initial weight, about after 60 hours. Presowing drought hardening consisted of immersing grains in distilled water for 6 or 24 hrs at 20°C. The moist grains were then spread in thin layer and allowed to dry until they had reached their initial weight. This took approximately 60 hrs.

In experiment V were tested nine bread and three durum wheat varieties, as well as five barley varieties and one oat to determine their reaction to two Resistine rates (I and 2%) in comparison to presowing drought hardening. Plot size was such as to provide for a final harvesting area of 5.5 m² (after removing borders) in a two-way split plot design.

In experiment VI a soft red winter wheat (cv G-85458) was fall seeded at PBI recent alluvial semi-fertile soil in seven-row plots, with 26 cm between rows that were 10 m long. Seeding rate was 150 kg/ha. Treatments were arranged in randomized complete block design with six replications. Treatments consisted of single foliar spray with the rates of: a) 2, 3 and 4 a.i./ha of perfluidon, when plants were at early and late tiller stages, b) 10 and 15 kg/ha Siapton (contains 93-94% proteid and trace elements) at 5th growth stage and c) 3.2 a.i. kg/ha of CCC at 7th stage.

Perfluidon was included, because besides beign an effective herbicide against wild oat and other grass and broadleaf weeds (Skorda, 1974), also resulted in high yield increases, although wild oat population was small or weed control was not as good as with other chemicals. Also perfluidon caused dark green color of plants as CCC.

During the season trial received the usual cultural practices including the application of herbicide for controlling weeds on plots treated with CCC, Siapton and the check plot.

Experiment VII was conducted to determine the responses of seven wheat (six bread and one durum), two barley and one oat varieties, to perfluidon, Siapton and CCC, in one dose each. Experimental design, soil type, fertilization program and other cultural practices were similar to those in Experiment III.

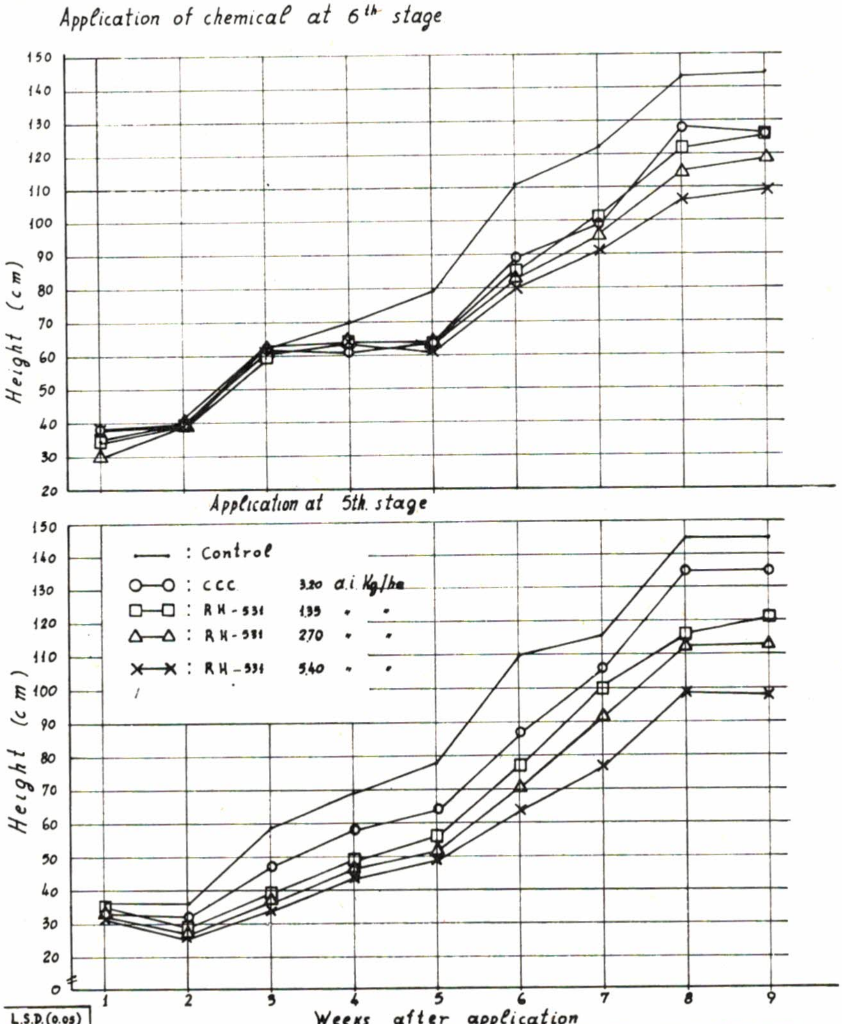
For all experiments prior to harvest a few plants were pulled from several places in the inside border row of each plot and composited for component analysis. Ten culms with spikes intact were then randomly selected from each composite and measurements were recorded for length of each internode, number of spikelets, seeds per spike and seed weight. Test weight, and percent N in both years were recorded for the combine-harvested grain. Plant height and lodging were recorded prior to harvest.

RESULTS

Experiment I. The application of RH-531 at 5th and 6th stages with all rates of RH-531 and CCC resulted in dark color of wheat plants. The height of plants was reduced with CCC and RH-531, relative to rate, for the two stages of application (Fig. 1). Lodging was reduced only by RH-531 application relative to rate and the reduction was higher when it was applied at 6th stage. Grain yield was not affected by CCC and RH-531 when it was applied at the 5th stage with all rates and at 6th with the two lower doses. On the contrary it was decreased significantly by the highest rate at 6th stage and increased by CCC (Fig. 2).

The seed weight increased slightly by the application of CCC at the two stages, while it decreased slingtly at the 5th stage and increased significantly at the 6th stage by RH-531 application, which was proportional to the decrease of the grain per spike (Fig. 3).

The number of grains per spike, while was increased or decreased slightly by the lower rates of RH-531, it was decreased almost up to 60% by the highest



L.S.D. (0.05)	1	2	3	4	5	6	7	8	9
Stages	–	2.36	3.09	2.97	4.43	–	–	–	–
Treatments	–	1.72	2.71	2.34	2.26	17.49	6.66	4.74	4.38
Interaction		2.43	3.84	3.90	3.19	–	–	6.59	6.18

Fig. 1. Average weekly height of Niki wheat following application of RH-531 and CCC.

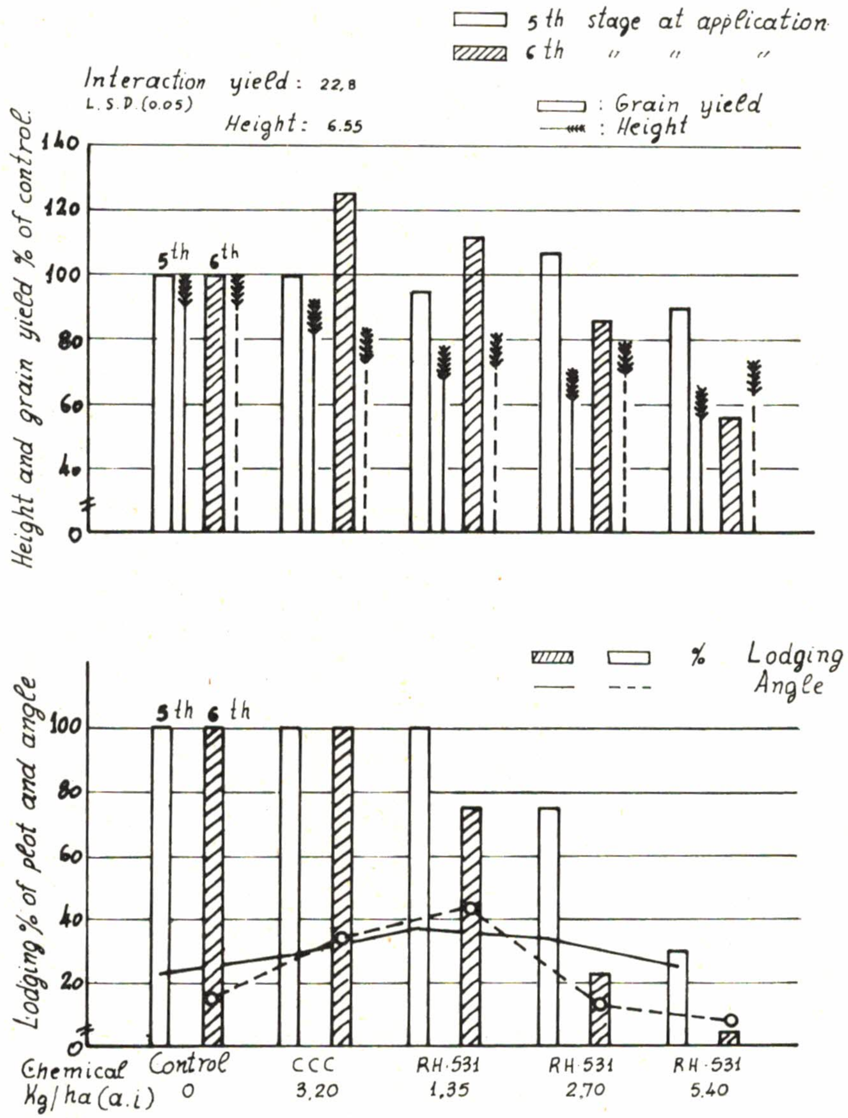
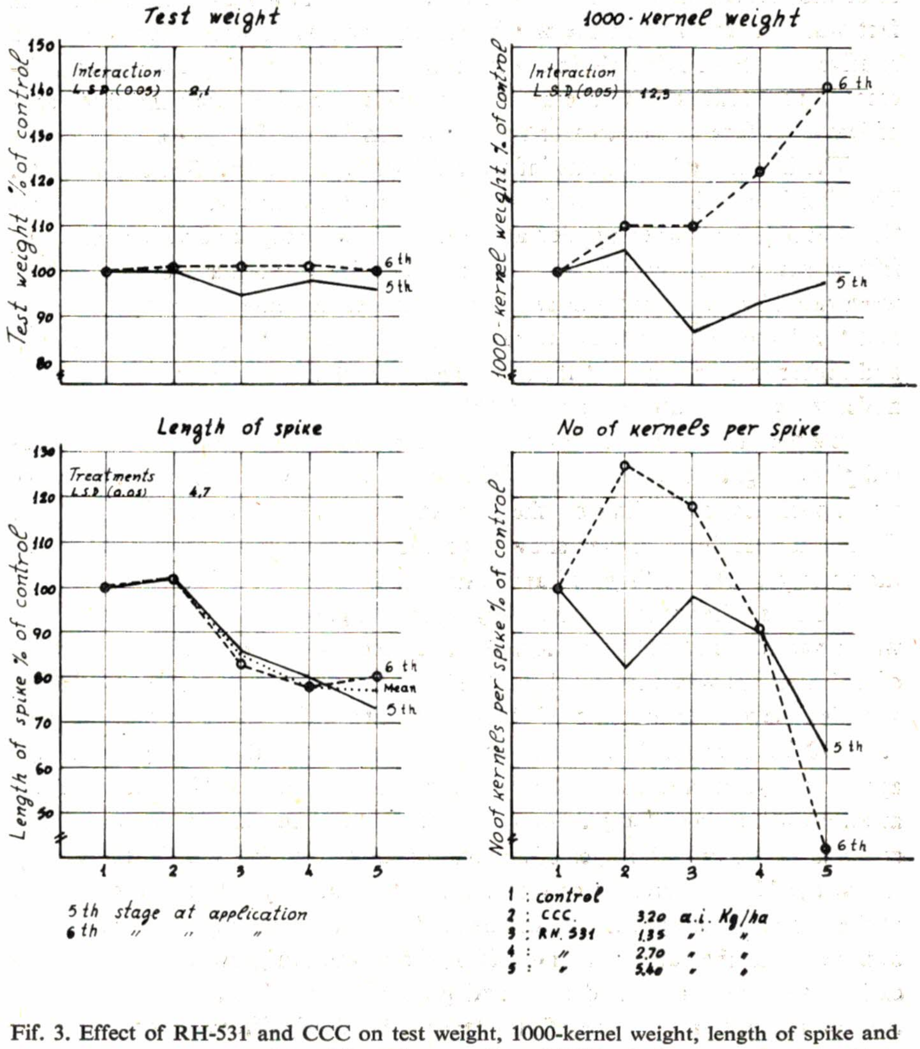


Fig. 2. Effect of RH-531 and CCC on height, grain yield and lodging of wheat variety Niki.



Fif. 3. Effect of RH-531 and CCC on test weight, 1000-kernel weight, length of spike and number of kernels per spike of Niki wheat.

rate applied at the two stages, since RH-531 causes male sterility, especially after later applications. At the high rates used, particularly during the stage of first stem elongation, severe blasting of florets occured, which resulted in reduced number of seeds per spike and higher 1000-kernel weight. RH-531 decreased significantly the lenght of spikes (Fig. 3) and leaves, relative to rate, while increased or did not affect the leaf width, but not proportionally to decrease of the leaf length so as the assimilative surface of the leaves decreased. This fact was confirmed from the weight of ten dry leaves, which decreased also relative to rate of RH-531. In contrast, by CCC, increased the width and decreased proportionally to the decrease of leaves length so that the same area of leaves surface as the area of control was maintained (Fig. 4).

The internode length was influenced by both CCC and RH-531 (Fig. 5). The first internode was affected very slight by CCC and RH-531 (not significant at 5% level) when applied at the sixth growth stage and very high at the fifth growth stage higher by RH-531 than by CCC without any difference between rates. The 2nd, 3rd, 4th and 5th internodes decreased by both chemicals and the decrease was relative to rate of RH-531 at both stages of application and higher in some cases at the 5th stage. CCC did not affect the 5th internode, which was affected by RH-531.

Experiment II. Several treatments of RH-531 significantly reduced plant height and lodging. The reduction of height was different in the three tested varieties, depending on the rate and growth stage of application (Fig. 6). The lowest decrease was showed on the durum wheat and the highest in the variety G-38290. Stage of application and rate were critical.

CCC as foliar spray significantly increased grain yield of the three tested wheat varieties but not of barley, while, as seed dressing, increased the yield of G-38290 but was unaffected for Niki and Limnos wheat and Zephyr barley varieties. Several treatments of RH-531 significantly reduced grain yield of G-38290, but some of the lower doses. At the two lower rates at 5th growth stage application yield of G-38290 was not reduced. The yield of Niki at low rates at all growth stages of application was not affected and was reduced with higher doses at two growth stages of application and seed dressing. In the variety Limnos yield was increased or was not affected but only with two higher rates at the 3rd stage of application and as seed dressing. The highest increase was obtained with the rates 0.60 and 1.20 kg/ha at the 5th growth stage of application. At almost all tested rates and growth stages of application, but with the lower at 3rd and the one of 5th stages, RH-531 significantly reduced grain yield of barley, but the lowest decrease of yields was obtained after RH-531 application at the 3rd and 5th stages.

RH-531 tended to increase the number of spikes per m^2 of wheat varieties.

Both CCC and RH-531 did not affect test weight, while 1000-kernel weight was slightly increased by RH-531, when the number of seeds per spike was reduced. The number of spikelets per spike was not affected, while the length of spike and the number of seeds per spike were decreased.

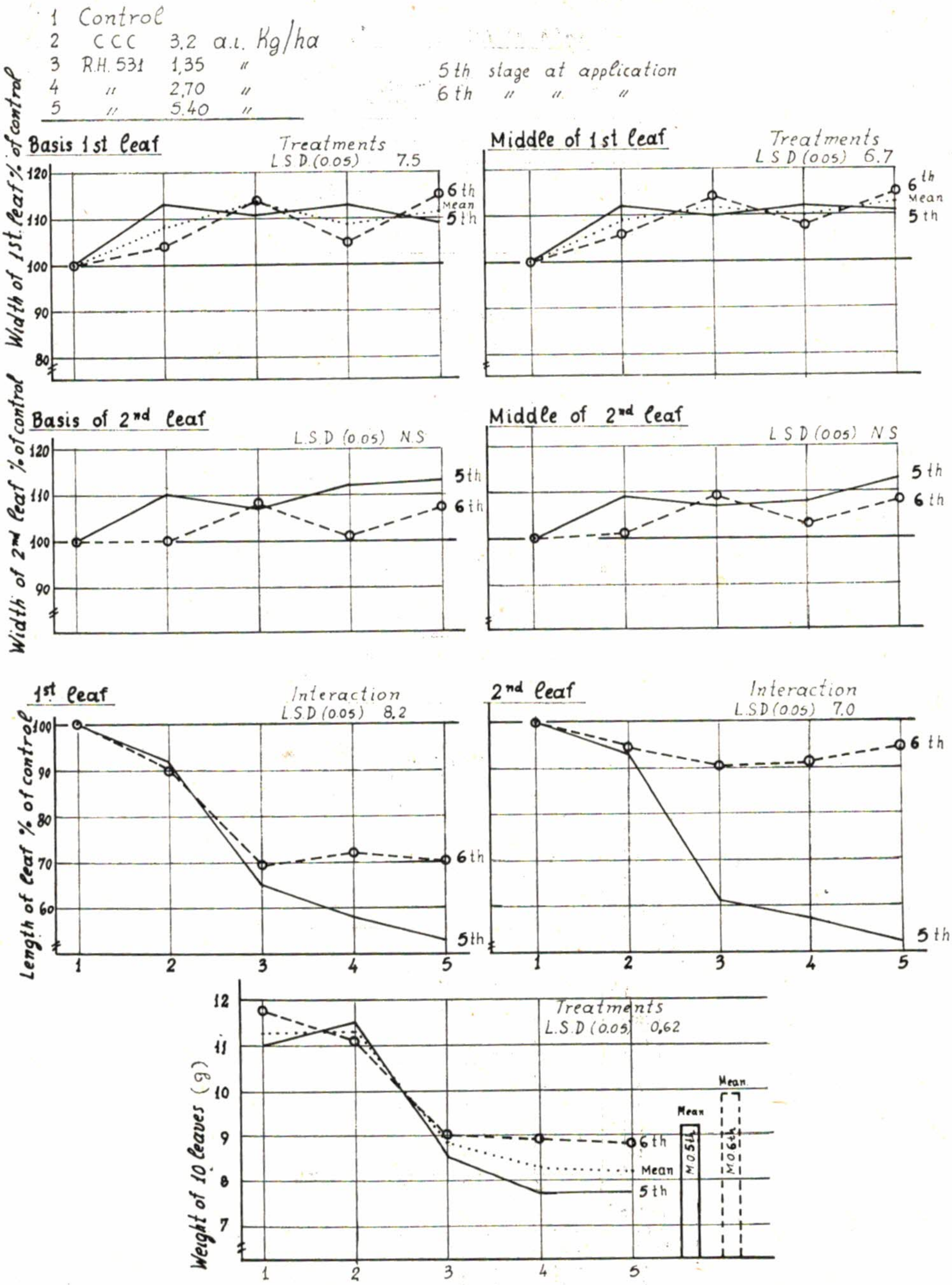


Fig. 4. Effect of RH-531 and CCC on width, length and weight of leaves of Niki wheat variety.

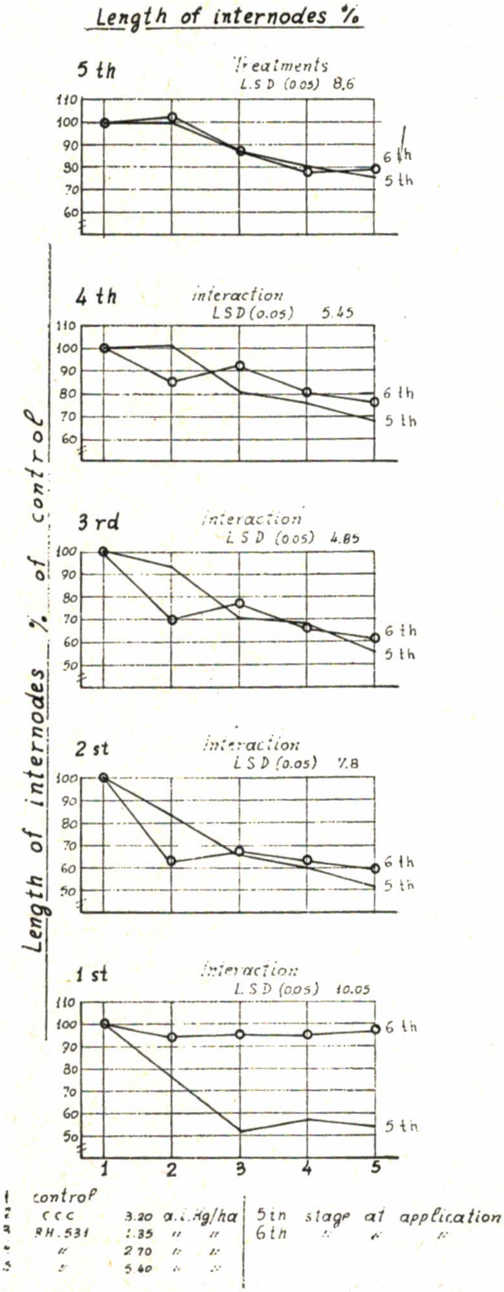


Fig. 5. Internode lengths of wheat Niki variety following application of RH-531 and CCC.

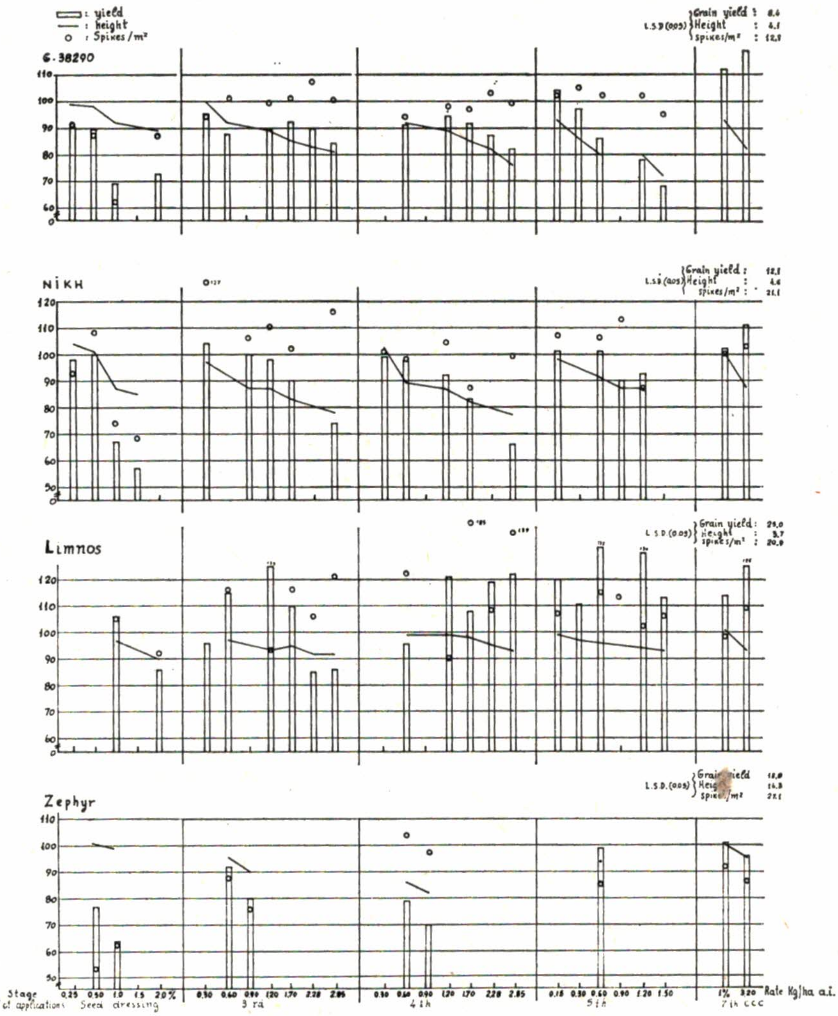


Fig. 6. Effect of different rates and growth stages at application of RH-531 on height, spikes/m² and grain yield of wheat and barley varieties.

E x p e r i m e n t III

Wheat varieties. Almost all treatments of RH-531 as well as CCC significantly reduced the height of plants of all tested wheat varieties relative to rate, but not in the same degree (Fig. 7-8). Some rates increased the number of spikes/m^2 in some varieties and in others they were decreased. Heading date, 1000-kernel weight, test weight and protein content of some varieties were slightly affected by the two growth regulators.

CCC and lower rates of RH-531 treatments significantly increased or did not affect grain yield, while higher rates of RH-531 decreased grain yield of some varieties or did not affect yield of the others. Lower rates of RH-531 increased the yield of durum wheat varieties, except Capeiti, while the other rates increased or did not affect yield. Highest dose decreased more the yield of Capeiti.

Barley varieties. CCC treatment did not affect plant height of all tested varieties and increased yield of two varieties and did not affect yield of the rest. RH-531 significantly decreased plant height and grain yield of all tested varieties (Fig. 9).

E x p e r i m e n t IV.

The application of Resistine in different rates as well as the presowing hardening in two procedures of grain wetting speeded the emergence of the seedlings and established a vigorous crop stand without affected any other of the studied agronomic characteristics. In some cases grain yield was increased slightly but this increase was not significant in the 5% level (Fig. 10). In both experiments only CCC increased significantly grain yield, decreased plant height and lodging and affected some other traits of wheat, as usually, by foliar spray, while RH-531 decreased the height and grain yield.

E x p e r i m e n t V

Wheat. Both Resistine application and presowing hardening did not affect standing, lodging, heading or maturity date, plant height and protein content of all wheat tested varieties. On the contrary, Resistine application resulted in an increase of the number of spikes/m^2 and grain yield of some varieties, but the increase was not significant at the 5% level, probably because of small plot size (Fig. 11). Presowing hardening increased the number of spikes/m^2 and grain yield of six varieties and did not affect or increased the grain yield of the rest but the increase was not significant at the 5% level.

Barley and oat. Presowing hardening did not affect any characteristics of barley varieties tested but G-80552-12-1, whose an increased number of spikes/m^2 and grain yield was observed. Resistine application did not affect height of plants of barley varieties tested but decrease the yield of Beka and Zephyr varieties by the higher rate and increased the yield of Elassona with the lower rate and G-80552-12-1 with the two doses (Fig. 12).

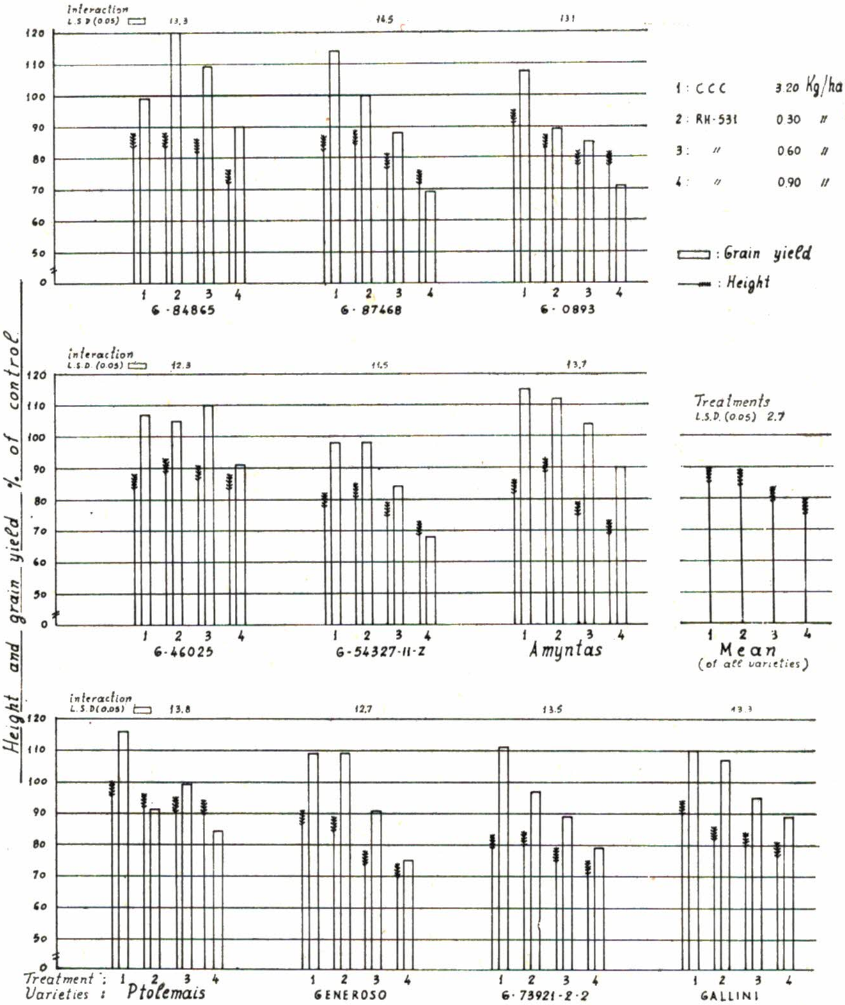


Fig. 7. Effect of RH-531 on height and grain yield of ten wheat varieties.

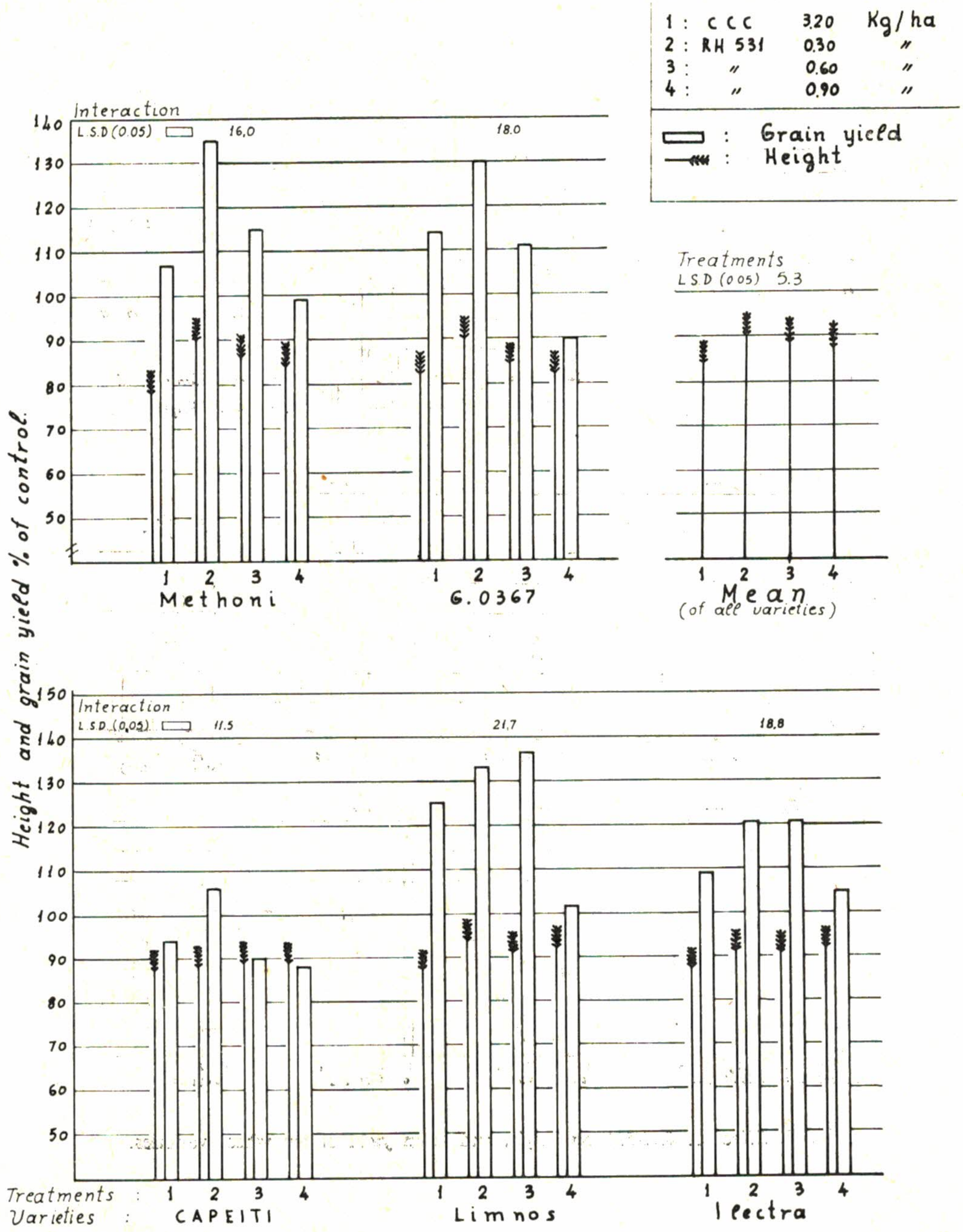


Fig. 8. Effect of RH-531 and CCC on height and yield of five durum wheat uarieties.

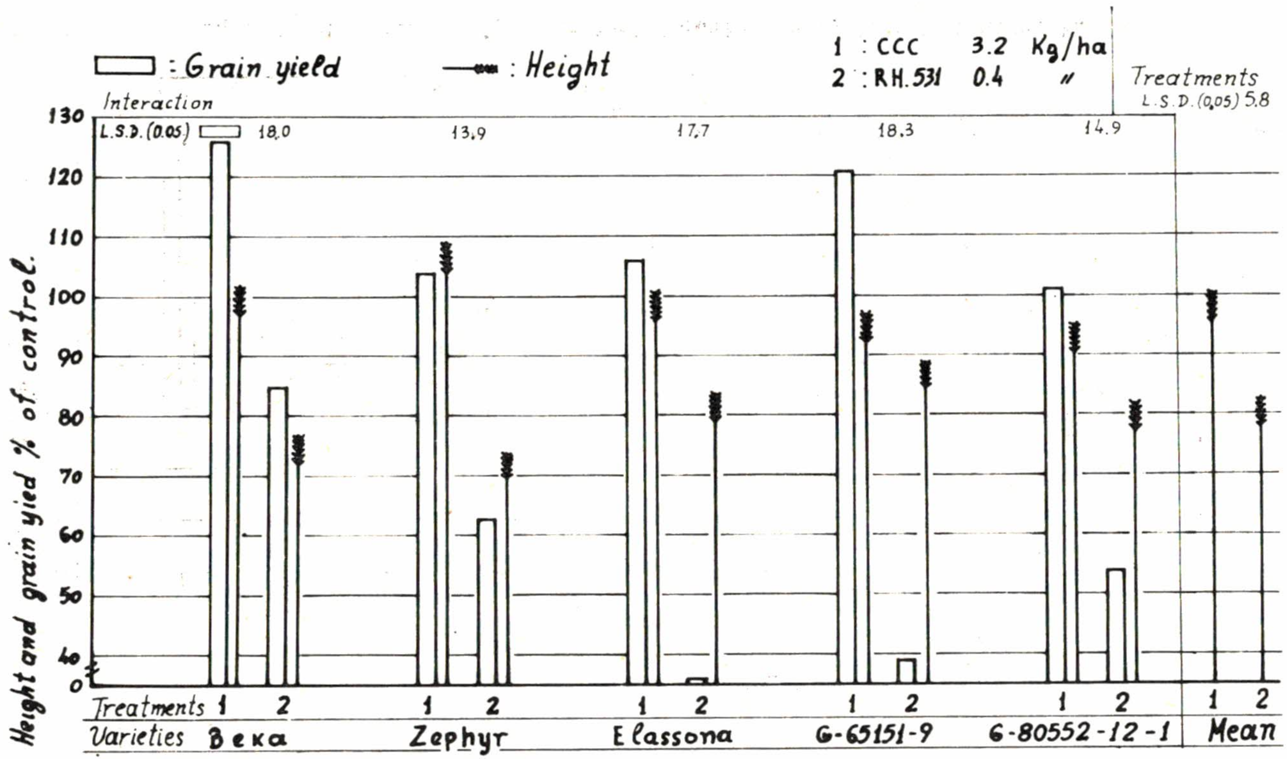


Fig. 9. Effect of RH-531 and CCC on height and grain yield of five barley varieties.

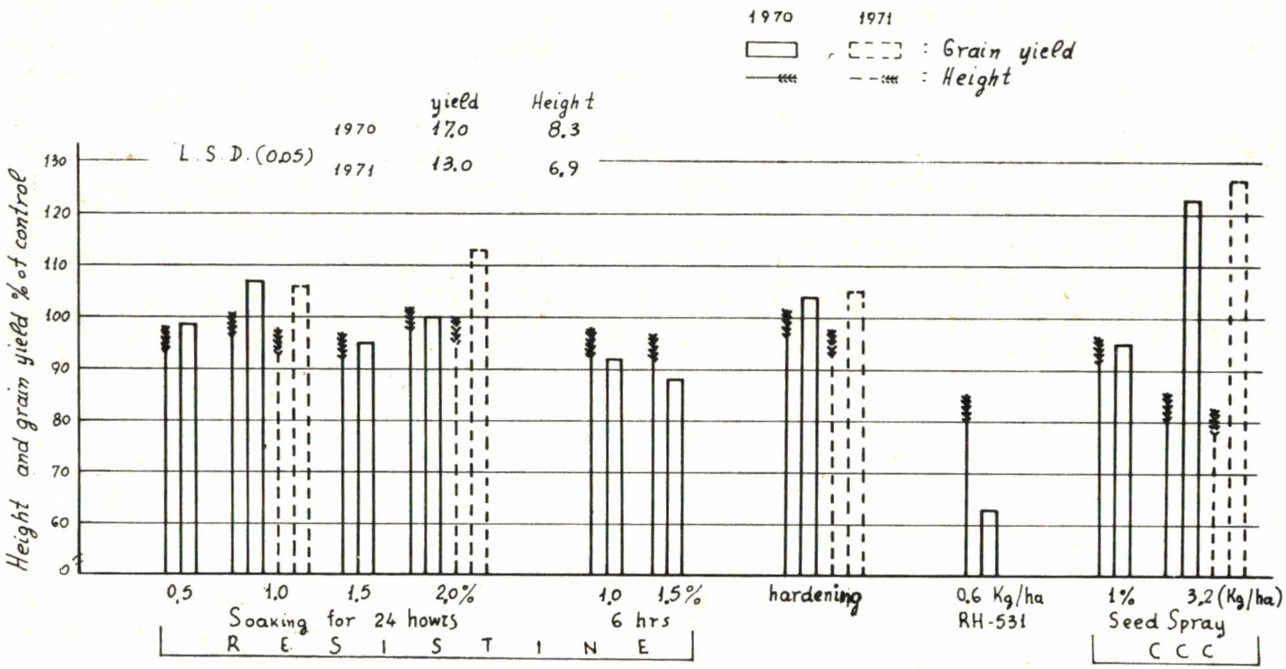


Fig. 10. Effect of Resistine and presowing hardening on height and yield of wheat variety Niki.

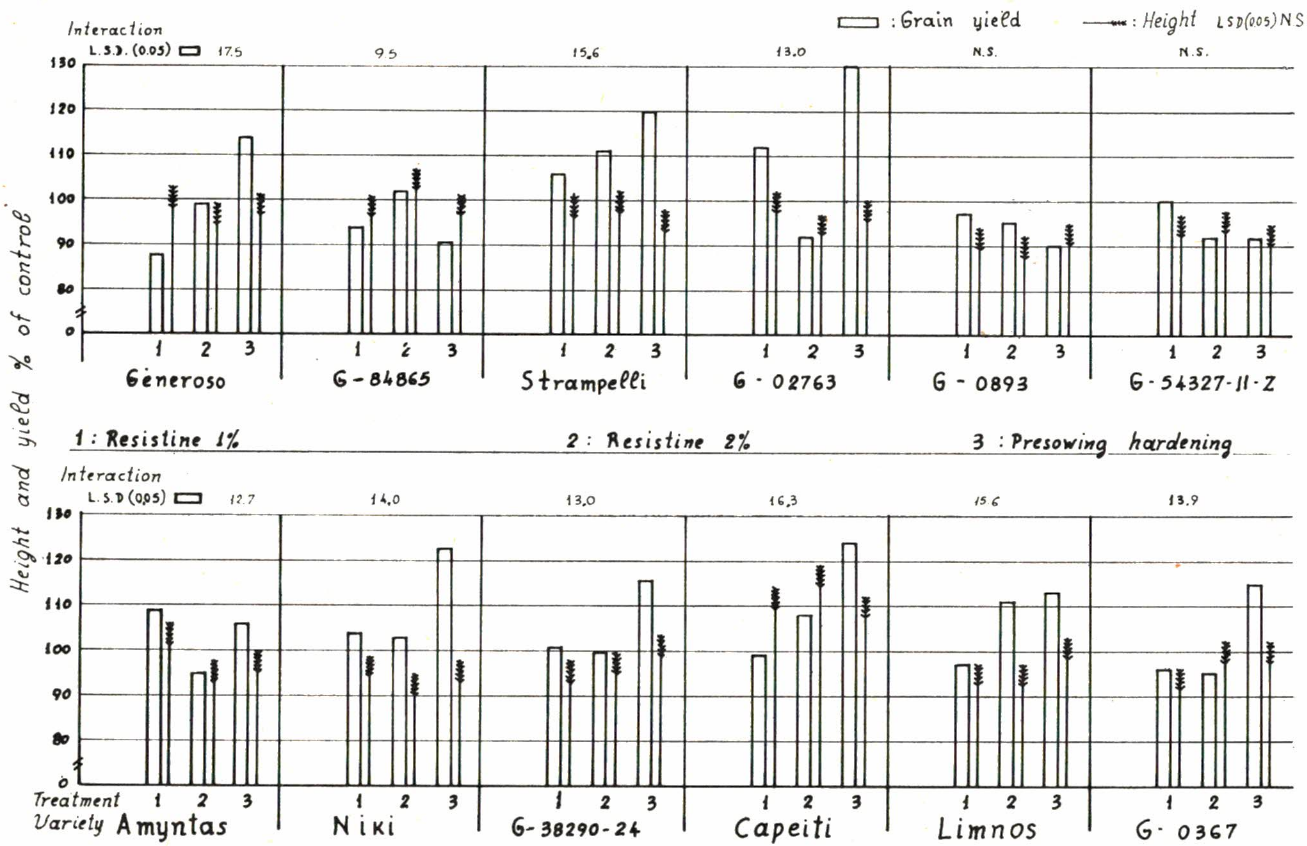


Fig. 11. Effect of Resistine and presowing hardening on height and yield of 12 wheat varieties.

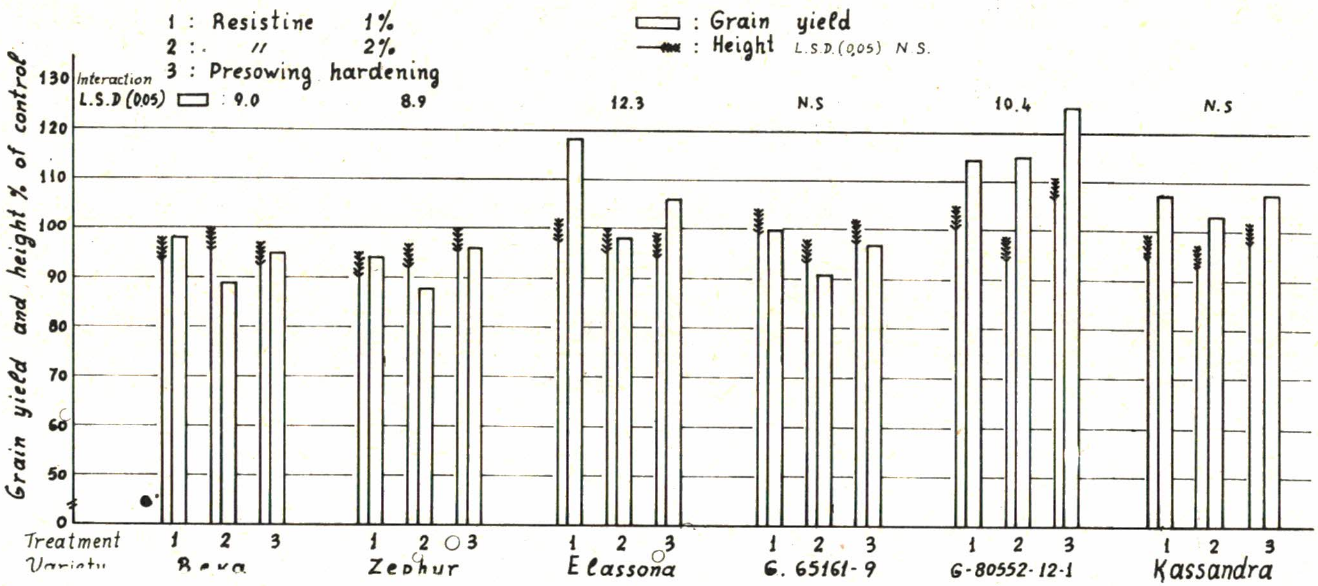


Fig. 12. Effect of Resistine and presowing hardening on height and grain yield of five barley varieties.

Experiment VI

The effect of perfluidon applied at various rates and at two stages of growth upon the wheat variety G-85458 is shown in Table I. Only plots treated with 4 kg a.i./ha perfluidon at early tillering stage yielded more that the control, while the other rates at the two growth stages gave the same yield as control. Treatment affected yield reduced also lodging and slightly the plant height.

The two treatments with Siapton and the one with CCC yielded also more than the control and almost the same as perfluidon at the rate of 4 kg a.i./ha. CCC decreased also height of plant and lodging. Siapton decreased only lodging and protein content and increased seed weight. Both chemicals did not affect other characteristics.

Experiment VII

Wheat. Perfluidon application decreased plant height of wheat at the first growth stages but the height at harvest time was the same as control. In barley the reduction of plant height remained until harvest time (Table II, III). The color of plants of almost all varieties tested was darker than the color of the control. Perfluidon did not affect heading time, but resulted in an increased protein content and sedimentation test values of some varieties, while did not affect the others. The same was true as far as yield concerned. In three varieties it was increased, while in others was not affected after the perfluidon application.

Siapton did not affect any of the characterics of the tested varieties but yield, which was increased in two varieties, and decreased in three, while it did not affect the others.

Barley and oat. Perfluidon application decreased plant height of barley and oat varieties and it did not affect grain yield of barley. Yield of oat decreased severely by perfluidon, as it was expected. Siapton decreased slightly plant height of barley and oat, did not affect grain yield of barley and decreased severely the yield of oat (Table III).

DISCUSSION

Plants are subject to various environmental stresses in which they have to become adapted to tolerate. The continued activity of the growing points of the shoots and roots as well as organs of determinate growth, such as leaves, which are capable of great modification by both «internal» and «external» factors offer an adaptive plasticity to the cereal plant, which enables it to tolerate environmental stresses. Thus the discovery of chemical growth regulators offered exceptional opportunities for modifying plants growth and development by man and increase their adaptability, which in turn means

TABLE I. Effect of CCC, perfluidon and Siapton on lodging, height, grain yield, test and 1000-kernel weight, protein content and sedimentation test value.

Chemical	Rate a.i kg/ha	Stage at application	Lodging		Height cm		Yield		Test Weight	1000 Kernel weight	Sed. value	Protein content %
			%	Angle	13/3	22/4	kg/ha	%				
Control			23	26	26	80	3147	100	76.9	32.1	36.3	14.66
CCC	3.2	7th	0	0	27	67	3993	127	76.2	30.5	34.0	14.29
Perfluidon	2.0	Early tillering	16	13	25	77	3052	97	77.5	32.1	33.7	14.54
»	3.0	» »	23	30	23	76	3167	101	76.9	30.8	35.2	14.62
»	4.0	» »	6	10	22	73	3712	118	77.9	31.7	35.0	13.97
»	2.0	End tillering	41	51	25	81	3150	100	76.9	32.9	32.7	14.64
»	3.0	» »	46	46	27	78	3163	101	76.7	32.1	34.3	14.64
»	4.0	» »	51	53	27	77	2825	90	76.7	33.3	35.2	14.91
Siapton	10.0	5th	11	25	27	77	3690	118	78.8	36.3	32.2	13.40
»	15.0	5th	15	11	27	79	3507	112	79.2	35.0	31.0	12.85
LSD (0.05)						4	382	12	N·S	2.8	N.S	1.21

TABLE II Effect of perfluidon, Siapton and CCC on height, yield, protein content and sedimantetion value on seven wheat varieties.

Variety	Chemical	Rate a.i. kg/ha	Height (cm) 22/4	31/5	Yield kg/ha	%	Protein content	Sed. value
Generoso	Control		73	113	1968	100	11.66	16
	CCC	3.2	68	95	1809	92	12.66	18
	Perfluidon	2.0	76	106	1955	99	15.32	25
	Siapton	15.0	80	113	2009	102	10.74	13
Niki	Control		95	133	2418	100	12.63	27
	CCC	3.2	71	123	2614	108	12.87	34
	Perfluidon	2.0	97	133	2618	108	14.05	39
	Siapton	15.0	93	139	2023	83	12.43	28
G-38290	Control		87	131	1664	100	13.70	30
	CCC	3.2	60	99	1786	108	13.46	24
	Perfluidon	2.0	83	131	2032	122	13.46	29
	Siapton	15.0	85	140	1973	119	10.87	14
Amyntas	Control		91	126	1359	100	14.90	31
	CCC	3.2	72	127	2055	151	14.38	30
	Perfluidon	2.0	90	132	2032	149	16.32	43
	Siapton	15.0	87	133	1632	120	12.42	22
G-84865	Control		64	108	2182	100	12.48	20
	CCC	3.2	56	94	2255	103	12.48	22
	Perfluidon	2.0	72	103	2305	106	11.85	23
	Siapton	15.0	72	103	1668	77	9.96	13
G-02763	Control		72	108	1923	100	12.60	32
	CCC	3.2	64	102	2200	115	11.33	24
	Perfluidon	2.0	72	110	2382	124	11.50	26
	Siapton	15.0	75	111	1868	97	9.62	17
Capeiti	Control		86	115	833	100	14.11	
	CCC	3.2	55	103	987	118	13.09	
	Perfluidon	2.0	57	110	778	93	14.30	
	Siapton	15.0	65	108	373	45	11.48	
	LSD (0.05)							
	Treatments		4.6	4.2	122			
	Interaction		N.S	11.2	299			

TABLE III. Effect of perfluidon, Siapton and CCC on height, yield, protein content and sedimantetion value on two barley and one oat varieties.

Variety	Chemical	Rate a.i. kg/ha	Height (cm) 22/4	Height (cm) 31/5	Yield kg/ha	%	Protein content
Beka	Control		89	115	2086	100	14.20
	CCC	3.2	87	109	1855	89	11.34
	Perfluidon	2.0	80	104	1727	83	14.79
	Siapton	15.0	88	110	2014	97	12.67
Elassona	Control		98	121	1686	100	15.79
	CCC	3.2	87	126	1805	107	13.32
	Perfluidon	2.0	80	106	1759	104	13.81
	Siapton	15.0	96	116	1800	107	13.62
Kassandra	Control		72	139	573	100	12.45
	CCC	3.2	67	140	623	109	14.50
	Perfluidon	2.0	41	105	114	19	14.43
	Siapton	15.0	50	121	236	42	13.75
	LSD (0.05)						
	Treatments		7.5	6.4	183		
	Interaction		—	11.0	—		

stable increased yield. The advantages for man being able to modify plant growth and development by chemical applications are increasingly apparent.

The objective of these experiments was to evaluate the effects of the growth inhibitors RH-531 and perfluidon in comparison to CCC on wheat and barley varieties as well as the response to wheat, barley and oat varieties to presowing drought hardening and to Resistine, which transmits to treated plants resistance to drought.

Application of RH-531 at four stages of growth induced a significant height decrease in both species relative to rate of application and this dwarfing was permanent extending also to the spike of both species, whereas CCC decreased height of both species in the early stages of growth, but this effect diminished during the period of stem elongation in barley. Skopik and Cervinka (1967) related differential response of wheat and barley to CCC applied to the rate at which the chemical was metabolized to a quarternary ammonium base and translocated to the root. The metabolism and transport of CCC take place much more slowly in wheat plants than in barley.

On the contrary, both species may display in RH-531 slow metabolism and translocation resulting in a persistent effect. Foliar spray were more effective in reducing the height of wheat plants than seed dressing eventhough it is an attractive method, since it obviates spraying the growing crop. Unfortunately seed dressing decreased germination ability in high rates and hence grain yield. RH-531 was more effective to durum than to bread wheat as far as increase of yield was concerned, but the height and lodging reduction were lower. These results showed that RH-531 affected other characteristics, which resulted in yield increase in durum wheat.

In terms of yield response it is of interest to note that only some varieties treated with low rates of RH-531 applied as foliar spray resulted in an increased grain yield. It is probable, moreover, that each of the varieties tested produced this yield increase as a result of different physiological prossesses. This increase was the result of increased number of fertile tillers or the number of seeds per spike or prevention of lodging. The decrease of grain yield was possibly due to the lower net assimilation rate of treated plants than normal. This result may be attributed to either the effect of the chemical on the photosynthetic process *per se,* or the below normal requirements of the shortened leaves and plant for photosynthesis. This may be expressed in decreased root growth and kernel or spike formation. Also the greater height depression obtained in this experiment resulted in the greatest yield decreased, while by CCC yield increases were unrelated to the degree of stem shortening (Pinthus and Rudich 1967). Large amounts of RH-531 affected yield adversely. Oplinger et al. (1975) found that RH-531 reduced significantly grain yield, test weight, plant height and lodging of oat. Only two treatments (0.45 and 0.56 kg/ha) applied to «Ajax» oat at the boot stage effectively reduced lodging without affected yield.

In an attempt to classify the varieties as groups of the same behaviour and to isolate some characteristics, which could be used to predict the reaction of any variety according to its resemblance to one or another group the results of this research was disappointing. The same was reported for CCC (Koller, 1968). Also some varieties which were involved in the experiments for more than one year showed in one year a behaviour different from that observed in the other. The problem of varietal reaction is difficult to solve. In wheat RH-531 affected stem as well as leaf growth relative to rate. Leaves were shorter and broader, but broadening of them were not proportional to shortening.

The ability of RH-531 treated wheat and barley to withstand lodging, depends partly to its reduced height, so that the weight of the ear exerts less force on the base of the straw and partly on the thicker stem. Although no actual measurements were made, the diameter of the main tiller of plants, which were reduced in height as a result of treatment, appeared greater than those of untreated plants.

Timing of application in both crops, particularly in wheat, is important to ensure that elongation of lower internodes is effectively controlled. RH-531 should be applied to wheat and barley at 3-5 stages. At later stages the reduction of number of seeds per spike is very high and at application of six-leaf stage or 20 days before heading RH-531 can be used to induce male-sterily (Wang and Lund, 1975). Besides, the later application after the 5th stage did not affect the first intermode, since the applied CCC and RH-531 exert a shortening effect on the actual or future growth of the still non-differentiated internodes and this effect diminishes gradually for the upper primordia, which at the time of treatment are still latent or semi-latent.

The effect of RH-531 in all traits was proportional to rate. The higher the rate the more pronounced the effect.

It would seem difficult to explain these manifold effects of RH-531 and CCC, but there is evidence that «retardants are potent inhibitors of gibberillin biosynthesis at several steps in pathway» (Dicks, 1976). CCC and RH-531 may act similarly but there have been reports that CCC actually causes increases in endogenous giberillins in some species. However, both substances cause a wide spectrum of response i.e. flower initiation, except stem growth inhibitors, probably because they affect endogenous hormone levels. Moreover, the reduction of shoot and leaf growth itself will have secondary effects, particularly on the distribution and partition of assimilates within the plant. It is also probable that some of the responses to growth retardants will be sideeffects, which are independent of their effect on endogenous hormones or the partition of assimilates. Hockett and Feltner (1975) question the use of RH-531 for production of hybrid barley since the side-effect are drastic, when a high degree of sterility is obtained. RH-531 may act as inhibitor of cell division in apical meristems and so suppresses shoot growth and internode elongation.

The effects of CCC and RH-531 on grain quality and baking characteristics are conflicting, but it seems rather that effects are slight.

The overall effect of RH-531 treatment on the growth habit of wheat and barley plant therefore, may be summed up as follows: a) reduced plant height, b) shortened internodes, c) darker green color or possibly increase of chlorophyll content, d) prossibly thickened culms, e) increased resistance to lodging and f) induced male sterility.

Perfluidon, although is an effective herbicide against wild oat and other grass and broadleaf weeds as well, in experiments tested as growth inhibitoror reduced height of wheat in the early stages of growth and increased satisfactorly grain yield. Treated wheat may grow faster after perfluidon disappears probably due to gibberillins increase, which might be the result of the root system being stimulated immediately after perfluidon is applied. Perfluidon on barley was phytotoxic. Rate and growth stage at application of this chemical were important as far as its effect was concerned. It seems that perfluidon is a very promising chemical for wheat.

Resistine was the less effective of the four chemical tested. It increased the grain yield of some wheat and barley varieties, probably because of drought resistance. However the results of three years trials were very conflicting.

The presowing drought hardening by speeding the emergence of the seedling resulted in establishing a vigorous crop stand. The same was found by Berrie and Drennan (1971) for oat grains. A seed planted in the cold soil during fall may take several days to achieve Phase I of germination before further growth can proceed, while presowing hardening hastened it or preferably achieved Phase I before the seed was sowing, at the time of imbibition of seeds for presowing hardening. In the Phase I the embryo takes up water and starts to synthesize protein (Osborne, 1972).

In the two succesive year trials wheat variety Niki did not respond to presowing treatment, although the responses to presowing treatment reported by Russian and other workers were very variable. This is probably due to plump seeds of this variety with normally high percentage of emergence, which were not improved by hardening and the subsequent resistance to drought. Woodruff (1969) has shown that plants from drought hardening seeds develop low relative water contents (RWR) at a lower rate than plants from untreated seed during drought periods. These differences could be the result of a large active root system in hardened plants. Variety Niki has a large active root system and is resistant to drought so that hardening did not affected it. Thomas et al. (1972) found for celery seeds that presowing treatment was partly an enhancement of germination and partly a protection against the stress of high temperature.

The variation of grain yield increases due to the hardening treatment in the different experiments and varieties is explained in terms of both the phenological stage at which RWC defferences occurred and the transient effect of the RWC differences.

The effect of presowing drought hardening on the yield was depended upon the variety used as found for drought resistance of cereal seedling by Salim and Todd (1968). A degree of natural drought hardening for each variety can occur during the maturation of seed or during the first drought stress occurring during vegetative growth (Osborne 1972). Presowing treatment did not affect grain size as was observed by Husain et al. (1968). The differential response of some varieties to seed hardening or Resistine treatment, which can considered as hardening, can be attributed to the lower capacity of these varieties to synthesize protein in the early hours of germination. According to Osborne (1972) the achievement of Phase I before planting is of greatest advantage for poor quality seed or for seed with poor performance under the conditions of test, because, not only the days to emergence are reduced but the time over which emergence is spread, is contracted.

The results of these experiments strongly indicate that a number of wheat and barley varieties are sensitive to growth regulators and showed a significant advantage in presowing herdening. Variety, rate and stage at application play important role to effectiveness of these chemicals. But in all the experiments CCC has been more effective than the other treatments and especially in increasing grain yield and this beneficial effect was consistent in all trials which were performed in different years. Also perfluidon was very promising. As far as other treatments were concerned more research is needed for elucidating their effects on cereals or tested other treatments.

ABSTRACT

The effects of the chemicals RH-531, perfluidon and Resistine applied at different stages of growth and rates, in comparison to CCC and presowing drought hardening on wheat, barley and oat varieties were studied.

The application of RH-531 at different rates as seed dressing and foliar spray at 3rd, 4th and 5th stage of application effectively decrease plant height,

lodging, length of spikes, number of seeds per spike (due to partial sterility) and leaf area of plants, by shortening than broadening proportionally the leaves. The magnitute of effects was closely related to rate and stage of application and in several cases accounted for decreases in yield. Lower rates although reduced height and lodging usually did not affect yield or increased it slightly, when applied before the 5th stage of growth. Some of the treatments accompanied by lower yields, some by higher and mosts by similar yields with untreated control. On durum wheat yield was not affected or increased by RH-531, but it was less effective in reducing plant height and lodging. On barley almost in all cases beneficial effects such as reduced height and lodging were accompanied always by reduced yield. With a few exceptions the treatments had little effect on grain quality. RH-531 as foliar spray was more effective than as seed dressing.

Perfluidon applied at early tillering stage reduced lodging and plant height, soon after application, but later the plants were grown faster and finally reached the same height as untreated plants. With some exceptions perfluidon increased grain yield of wheat varieties but not of barley.

Seed soaking in Resistine solution and presowing drought hardening of wheat and barley increased slightly yield of some varieties or did not affect others. There was evidence that this increase was the results of resistance to water stress. A varietal difference in the response to a given of the tested treatments was evident, some varieties being more sensitive than others.

LITERATURE

1. Berrie, A. M. M. and Drennan, D. S. H. 1971. The effect of hydration-dehydration on seed germination. *New Phytol. 70:* 135-142.
2. Dicks, J. W. 1976. Chemical restriction of stem growth in ornamentals, cereals and tobacco. *Outl. Agric. 9:* 69-75.
3. Hockett, E. A. and Feltner, K. C. 1975. Sterility induced in barley by a chemical gameticide. *Agron. Abstr.* p. 55.
4. Husain, I., May, L. H. and Aspinall, D. 1968. The effects of soil moisture stress on the growth of barley. IV. The response to presowing treatment. *Aust. J. Agric. Res. 19:* 213-220.
5. Koller, J. 1968. Variety and application date as factors influencing theresponse of wheat to CCC. *Euphytica (Suppl. I) 17:* 251-257.
6. Large, E. C. 1954. Growth stages in cereals. Illustration of the Feekes scale. *Plant Path. 3:* 128-129.
7. Levitt, J. 1956. «The hardiness of plants». *Academic Press:* New York.
8. May, L. H., Milthorpe, E. J., and Milthorpe, F. L. 1962. Pre-sowing hardening of plants

to drought. An appraisal of the contributions by P. A. Genkel. *Field Crop Abstr. 15:* 93-98.

9. Oplinger, E. S., Veith, W. A. and Youngs, V. L. 1975. Oat agronomic and grain quality responses to growth regulators. *Agron. J. 67:* 443-445.
10. Osborne, D. J. 1972. Can weed problems be reduced by impoving crop establishment. Some possibilities for enhancing seed germination. *Proc. 11th. Weed Control Conf. 3:* 1161-1172.
11. Pinthus, M. J. and Rudich, J. 1967. Increase in grain yield of CCC-treated wheat *(Triticum aestivum)* in the absence of lodging. *Agrochimica 11:* 565-570.
12. Salim, M. H. and Todd, G. W. 1968. Seed soaking as a pre-sowing, drought-hardening treatment in wheat and barley seedlings. *Agron. J. 60:* 179-182.
13. Skopik, P. and Cervinka, M. 1967. Study of the effect of CCC on cereals. I. Movement and changes of CCC after application to wheat and barley leaves. *Cesk. Akad. Zemed Ved. Shor. R. Rostl. Vyr. 13:* 547-558.
14. Skorda, E. A. 1970. The influence of growth regulator CCC on the yield and the physiology of cereals. *Scientif Bul. of P.B.I. Thessaloniki-Greece, 38: 1-95.*
15. Skorda, E. A. 1974. Control of wild oat with new chemicals in wheat and barley. *Proc. 12th Br. Weed Control Conf. 3: 901-912.*
16. Thomas, T. H. Palevitch, D. and Austin, R. B. 1972. Stimulation of celery seed germination with plant growth regulators. *Proc. 11th Br. Weed Control Conf. 2:* 760-765.
17. Wang, R. C. and Steve Lund. 1975. Studies on male sterility in barley induced by sodium 1 - (p - chlorophenyl) - 1,2 - dihydro - 4,6 - dimethyl - 2 - oxonicotinate. *Crop. Sci. 15:* 550-553.
18. Woodruff, D. R. 1969. Studies on presowing drought hardening of wheat. *Aust. J. Agric. Res. 20:* 13-24.