RESULTS AND DISCUSSION

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4.1. First Experiment:

Effect of potassium Fertilization rate and application method on growth, yield components and storageability of potatoes.

4.1.1. Vegetative growth characteristics:

Data of the studied vegetative growth characteristics as affected by potassium fertilization rate and application method are presented in Table (3). It is evident from such data that increasing K-fertilizers rate up to 96 kg K_2O/fad. as soil application or application of 48 kg K_2O/fad. as soil addition plus one foliar application with potassium solution 36% K_2O (one liter/fad.) generally, showed the highest values of plant height. However, such increment were significant in the second season only.

Concerning number of stems per plant as affected by K-fertilizers rate and application method, using 72 kg K_2O/fad. as soil addition resulted in the highest value of number of stems per plant at both season of this work but without significant variations. Moreover, it is abvious from the same data in Table (3), that leaves dry weight was significantly afected in both seasons reaching its maximum values by using either 48kg K_2O plus three times foliar spray with potassium solution 36% K_2O or

Table (3): Plant vegetative growth as affected by potassium fertilization rate and application method.

Seasons	1996			1997		
Characters / Treatments	plant height (cm.)	No.of stems /plant	Dry weight of leaves (g/100g.)	Plant height (cm.)	No.of stems / plant	Dry weight of leaves (g/100g.)
O kg. K_2O/ fed.	45.7	2.9	14.6	49.0	2.0	16.1
48kg. K_2O/fed.	46.6	3.1	15.7	51.8	2.4	17.2
72 kg. K_2O/ fed.	47.4	3.3	16.7	57.6	2.6	18.2
96 kg. K_2O/ fed.	50.7	2.7	18.3	57.8	2.5	19.8
120kg. K_2O/ fed.	49.1	2.7	15.9	50.3	2.1	17.4
48kg.K_2O+spr.once	54.1	2.5	16.3	63.6	2.6	17.8
48kg.K_2O+spr. twice	50.7	2.8	17.5	57.5	2.2	19.0
48kg.K_2O+spr. 3 times	48.7	2.6	18.5	56.1	2.1	20.0
48kg.K_2O+spr. 4 times	48.5	2.6	15.8	25.4	2.3	17.3
L. S. D 5%	n. s	n. s	1.01	5.7	n. s	1.02

96 kg K_2O/fad. alone. These results held true during both growing seasons of this work. Obtained results may be due to the role of potassium in increasing meristematic activities and consequently the vegetative growth of plants. The obtained results coincide with those of Hassan et al (1985), who found that application of K- had no- significant effect on number of main stems/ plant using 0, 24, 48, 72 and 96 kg K_2O/ fad. Moreover, the results of EL-Gamal (1985); Arafa (1994) and Rabie (1996) indicated similar results where increasing potassium fertilization rate or NPK levels increased plant height, number of stems and dry weight of hulum. Such results were only parallel with leaves dry weight and plant height.

4.1.2. N, P and K leaves content:

Data showing the effect of potassium feritilization rate and application method on the mineral contents of potato leaves are presented in Table (4). It is obvious from such data that increasing K- fertilizer rate from 0 up to 120 kg K_2O/fad. significantly and gradually increased N, Pand K percentages of potato leaves. Such trend held true during both seasons of the experiment. Moreover, it is also evident that repeated sprays up till 4 times with K_2O slution accompanied with 48 kg K_2O/fad. as soil application or soil addition of 120 kg K_2O/fad. alone. showed the maximum values in N, P and K content as compared with either control or other used treatments during both seasons. Obtained results are in agreement with those of Jackson et al

Table (4): N, P and K contents of potato leaves (% of dry weight) as affected by potassium Fertilization rate and application method.

Season	1996			1997		
Characters / Treatments	N%	P%	K%	N%	P%	K%
0 kg. K_2O / fad.	2.78	0.375	1.19	2.81	0.271	1.23
48kg. K_2O / fad.	2.87	0.395	1.31	2.95	0.295	1.31
72kg. K_2O / fad.	2.94	0.452	1.48	3.28	0.345	1.61
96kg. K_2O / fad.	2.96	0.451	1.61	3.31	0.368	1.68
120 kg. K_2O/fad.	3.21	0.460	1.73	3.47	0.374	1.79
48kg.K_2O+spr.once	2.95	0.391	1.45	2.97	0.297	1.36
48kg.K_2O+spr. twice	3.06	0.431	1.61	3.11	0.315	1.39
48kg.K_2O+spr. 3 times	3.17	0.474	1.69	3.12	0.338	1.47
48kg.K_2O+spr. 4 times	3.39	0.466	1.79	3.19	0.354	1.54
L. S. D 5%	0.30	0.029	0.11	0.08	0.032	0.13

(1981); Maier (1986); Trehn and Grewal (1991); Locascio et al (1992); Maier et al (1994) and Westermann et al (1994)[a] all working on potato indicating that increasing K - fertlization rates increased K content at the petioles of potato leaves. Moreover, obtained results are going in line with those of Teixeira et al (1991) and Sujatha and Krishnappa (1995); who reported that fertilization with K increased N, P and K content of potato leaves.

4.1.3. ***Yield and its components:***

Data dealing with the effect of potassium fertilization rate and method of application on potato yield and its components during 1996 and 1997 summer seasons are presented in Table (5). such data show that no-significant effects on tubers number / plant were detected. Eventhough, tubers/top ratio, tuber weight per plant, and tuber yield either by plot or faddan were signifcantly affected in this respect. The significant effects were not quit similar in both seasons, but it seems that the most promising treatments were those of 96kg K_2O/fad alone or 48 kg K_2O/fad. plus three sprays with K_2O solution compared to the control as well as other tested treatments. Such two treatments produced 31.0% and 36.2% as average increases in total yield of both seasons over the control.

It is worthy to mention herein that positive effects on the tuber yield and its components may be due to the favourable effect of the same treatments on leaves dry matter (Table, 3) and its N, P and K content (Table,4). The obtained results are supported in such a way by those of Simpson et al (1973); White

Table (5) : Potato tuber yield and its components as affected by potassium fertilization rate and application method.

Season	1996					1997				
Characters / Treatments	No. Of tubers / plant	tubers/ top ratio	yield/ plant (gm)	yield/plot (kg)	total yield/fad (ton)	No. Of tubers /plant	tubers/top ratio	yield/ plant (gm)	yield/plot (kg)	total yield/fad (ton)
0 kg/ K_2O / fad.	4.2	1.76	426.7	14.080	8.039	4.8	1.52	477.8	15.750	8.993
48 kg/ K_2O / fad.	4.4	1.82	469.0	15.805	9.025	5.8	1.83	579.6	19.123	10.919
72 kg/ K_2O / fad.	4.6	2.43	516.3	17.034	9.729	6.1	2.44	630.0	20.786	11.868
96 kg/ K_2O / fad.	4.9	2.54	538.0	17.754	10.137	6.7	2.56	648.4	21.393	12.215
120 kg/K_2O/fad.	4.3	1.62	451.0	15.216	8.688	5.6	1.64	621.2	20.496	11.703
48 kg.K_2O+spr.once	4.6	1.62	552.3	17.138	9.785	5.6	1.63	580.9	19.530	11.151
48 kg.K_2O+spr.twice	4.7	2.05	568.7	18.766	10.715	6.4	2.10	591.8	16.456	9.396
48 kg.K_2O+spr. 3 times	4.9	2.38	583.3	20.516	11.714	6.5	2.38	600.9	19.830	11.322
48 kg.K_2O+spr. 4 times	4.5	1.97	530.0	17.490	9.986	5.5	2.00	497.8	19.176	10.944
L.S.D. 5%	N.s	0.33	53.4	2.854	1.629	N.s	0.23	18.2	0.445	0.254

et al (1974); Grewal and Sharma (1980); Jackson et al (1981); Hassan et al (1985); Shaheen et al (1989); Al' Shevskü (1990); Mazur and Krefft (1991); Sud and Grewal (1991); Trehan and Grewal (1991); Gupta (1992); Randüawa and Düatt (1994); Westermann (1994)[a]; as they reported that the highest total tubers yield was given when K - fertilzation level ranged from 46 to 900 kg K/ha. Meanwhile, obtained results coincide nearly with those of El-Gamal (1985), who postulated that tubers yield of potato plants showed the highest values with the application of 104 kg K_2O/ fad. On the other hand, obtained results are not in agreement with those of Gregory et al (1972); Dubetz and Bole (1975); Mc-Dole (1978); Locascio et al. (1992) and Nakashgir et al (1994), who found that K - application had no effect on potato tubers yield. Moreover, similar results were reported by Sinha and Rai (1991) who concluded that increasing K fertilizer up to 180 kg K_2O/ ha. decreased the total potato tuber yield.

4.1.4 . Physical characteristics of potato tubers:

a. Tuber size:

Data presented in Table (6) show the effect of potassium fertilization rate and application method on the size of produced potato tubers . It is clear from such data that there were significant differences among used treatments during both growing seasons. Data indicate that, increasing K - fertilization rate up to 96 kg K_2O / fad. led to gradual and constant increase of total number of tubers obtained by plot. Further increase up to 120 kg K_2O/fad. showed deleterious effects in this respect, Table (6): Grading of potato tubers as affected by potassium fertilization rate and application method.

Seasons	1996							1997						
Characters / Treatments	Grade Size as No./ plot			Grade percentage No. %			Total tubers	Grade size as No./ plot			Grade percentage No. %			Total tubers
	*S	M**	L***	S	M	L	No./plot	S	M	L	S	M	L	No./plot
0kgK_2O/ fad	26.0	57.0	55.6	18.8	41.1	40.1	138.6	32.2	63.9	63.2	20.2	40.1	39.7	159.3
48kgK_2O/ fad	25.0	58.0	62.3	17.2	39.9	42.9	145.3	35.5	74.4	81.3	18.7	38.9	42.4	191.2
72kgK_2O/ fad	17.8	63.7	70.5	11.7	42.0	46.3	152.0	26.7	82.9	92.5	13.2	41.0	45.8	202.1
96kgK_2O/ fad	10.1	73.7	79.3	6.2	45.2	48.6	163.1	17.0	98.3	107.0	7.7	44.2	48.1	222.3
120kgK_2O/ fad	6.2	65.5	70.1	4.4	46.2	49.4	141.8	10.8	82.7	90.0	5.9	45.0	49.0	183.5
48 kg.K_2O+spr.once	21.4	65.3	65.0	14.1	43.0	42.8	151.7	28.8	77.1	77.8	15.7	42.0	42.4	183.7
48 kg.K_2O+spr.twice	18.0	67.2	70.1	11.6	43.3	45.1	155.3	27.6	88.7	93.6	13.1	42.3	44.6	209.9
48 kg.K_2O+spr. 3 times	13.2	73.8	75.0	8.1	45.5	46.3	162.0	20.7	95.6	98.4	9.6	44.5	45.8	214.7
48 kg.K_2O+spr. 4 times	11.1	67.2	70.1	7.5	45.3	47.2	148.4	16.3	80.2	85.2	9.0	44.2	46.9	181.7
L. S. D. 5%	3.4	11.1	10.8	1.2	0.5	1.2	n.s	3.9	11.4	14.3	1.2	0.4	1.3	28.9

* S = Small size (28- 35mm) ** M = Medium size (36-45 mm) *** L= Large size (over 46mm).

however, it was still superior compared with the control treatment. Similar trend was also detected by comparing all K_2O foliar sprays treatments as combined with 48kg K_2O/fad. as basal soil addition, where repeating sprays up to 3 times (one liter solution 36% K_2O /fad. each time) showed superiority in this respect. As for tuber size by absolute number/plot, potato plants supplemented with 96 kg K_2O /fad. alone or 48 kg K_2O / fad. plus spraying three times with K_2O solution produced the highest number of tubers of medium and large size during both seasons of this experiment . This trend held true to some extent regarding grade size percentages of potato tuber. Data in Table (6) indicate also that increasing K - fertilization rate either through soil basal application or foliar sprays decreased the small tuber size in both seasons as compared with the untreated control treatment . In this connection, the highest used rate of K - fertilizer i.e. 120 kg K_2O /fad. or that of 48 kg/K_2O /fad plus four times foliar sprays by potassium solution after 60, 70, 80 and 90 days from planting using one liter / fad. 36% K_2O per each time gave the lowest values of small tubers (28 _ 35 mm).

The general trend in both seasons pointed out that using 96 kg K_2O /fad. alone or 48 kg K_2O /fad. plus 3. sprays with K_2O solution proved to be the best treatment that increased medium (36/ 45 mm) and large size (over 46 mm) tubers. This might be due to the favourable effects of potassium fertilizer on the efficiency of photosynthesis capacity and inturn more accumulation of stored food in potato tubers.

The obtained results in this respect are in agreement with those reported by White et al (1974); El-Gamal (1985); Hassan et al (1985) and Al'Shevskü (1990), who concluded that with high proportion of potassium (from 99 to 150 kg K/ha), the percentages of medium and large sized tubers increased. The results mentioned by Trehan and Grewal (1991) and also those of Randüawa and Düatt (1994), who reported that K - application ranged from 99 to 150 kg K/ha. increased the rate of grade A: total yield are in conformity with the results of this work. On the other hand, Rykbost et al. (1993) working on potato reported that tubers yield grade did n't respond to K rate.

b. **Dry weight, specific gravity and feathering of tubers:**

Data showing the effect of K - fertilization rate and application method on dry weight; specific gravity and feathering of tubers are presented in Table (7). It is evident from such data that increasing applied K - fertilizer rate up to 96 kg K_2O / fad. led to a significant and gradual increase in dry weight and specific gravity of potato tubers . However, further increase up to 120 kg K_2O / fad. showed deleterious effects in this respect, although, it was still superior compared with the control treatment. Similar results were also observed by using K_2O solution as foliar spray plus 48 kg K_2O / fad. as basal soil addition, whereby repeated sprays up to two times proved to induce the most favorable effect on dry weight and specific gravity of potato tubers as compared with all tested K - fertilizer treatments. This trend held true

Table (7): Dry weight, specific gravity and feathering of potato tubers as affected by potassium fertilization rate and application method.

Seasons	1996			1997		
Charactars / Treatments	Dry weight %	specific gravity	Feathering	Dry weight %	specific gravity	Feathering
0kg.K_2O/fad	20.6	1.064	2.3	16.5	1.042	2.3
48kg.K_2O/fad	21.2	1.072	1.6	17.6	1.050	1.6
72kg.K_2O/fad	21.5	1.080	1.3	18.9	1.055	1.6
96kg.K_2O/fad	23.7	1.080	1.0	20.1	1.056	1.3
120kg.K_2O/fad	23.3	1.072	1.6	19.0	1.045	1.6
48 kg.K_2O+spr.once	22.7	1.081	2.0	17.9	1.053	2.0
48 kg.K_2O+spr.twice	24.3	1.084	1.6	19.8	1.077	1.6
48 kg.K_2O+spr. 3 times	21.6	1.078	1.3	18.9	1.072	1.3
48 kg.K_2O+spr. 4 times	21.1	1.074	2.0	18.2	1.058	2.0
L. S. D 5%	1.9	0.011	0.7	1.0	0.024	n. s

during both seasons in this experiment. Obtained results on dry weight are in agreement with those of El-Gamal (1985); Stanley and Jewell (1989), Sharma and Arodra (1992), and Sujatha and Krishnappa (1995), who reported that increasing K - fertilization from 60 to 900 kg K /ha. increased tuber dry matter. On the other hand, obtained results are not in agreement with those of Müller (1988), who reported that tuber dry matter decreased with increasing K up to 300 kg K/ha. and those of Guerra et al (1990), who indicated that tuber dry matter was unaffected by K-fertilizers rate from O to 150 kg. As for the specific gravity, obtained results are not in agreement with those of White (1974); Chapman et al (1992); Locascoi et al (1992) and Westermann et al (1994)[a], where they indicated that increasing K- fertilization decreased specific gravity of potato tubers.

As for feathering studies, it is clear from data in Table (7) that increasing K- fertilization level up to 96 kg K_2O / fed or using 48 kg K_2O / fad. plus three times foiler sprays with K_2O solution improved the appearance of tubers through decreasing feathering values, whereby low values are associated with the best tubers without feathering.

4.1.5 Chemical composition of potato tubers:

Data showing the chemical composition of potato tubers at harvest time as affected by K fertilization rate and method of application are presented in Table (8). It is clear from such data that increasing K - fertilization rate significantly and consistently increased N, P, K , sugars fractions and protein content compared

Table (8): Chemical composition of potato tubers, as % of dry weight at harvest time, as affected by potassium fertilization rate and application method.

Seasons	1996								1997							
characters / Treatments	N	P	K	Sugars reducing	Sugars non-reducing	Sugars total	total protein	starch	N	P	K	Sugars reducing	Sugars non-reducing	Sugars total	total protein	starch
Control	1.20	0.135	1.99	0.140	0.566	0.706	7.49	21.1	1.32	0.127	1.97	0.133	0.526	0.659	8.27	18.5
48kg K_2O/fad	1.70	0.175	2.38	0.153	0.610	0.763	10.64	21.9	1.63	0.185	2.15	0.146	0.573	0.719	10.19	19.1
72kg K_2O/fad	2.05	0.189	2.57	0.180	0.740	0.920	12.79	22.7	2.22	0.234	2.64	0.190	0.754	0.943	13.85	20.3
96kg K_2O/fad	2.11	0.223	2.76	0.190	0.753	0.943	13.21	23.3	2.27	0.242	2.70	0.193	0.770	0.963	14.21	20.6
120kg K_2O/fad	2.18	0.245	2.88	0.196	0.776	0.972	13.64	24.7	2.34	0.252	2.79	0.196	0.773	0.969	14.60	21.3
48 kg.K_2O+spr.once	1.56	0.153	2.18	0.166	0.666	0.832	9.77	21.1	1.70	0.188	2.18	0.160	0.636	0.796	10.62	18.8
48 kg.K_2O+spr.twice	1.65	0.166	2.31	0.176	0.703	0.0.879	10.29	22.1	1.89	0.195	2.25	0.180	0.736	0.916	11.81	18.8
48 kg.K_2O+spr. 3 times	1.71	0.187	2.42	0.180	0.733	0.913	10.69	23.1	1.95	0.199	2.38	0.186	0.740	0.926	12.19	19.7
48 kg.K_2O+spr. 4 times	1.87	0.189	2.57	0.186	0.743	0.929	11.71	23.5	2.12	0.222	2.46	0.190	0.753	0.943	13.27	19.8
L. S. D. 5%	0.14	0.017	0.19	0.012	0.057	0.067	0.86	n. s	0.10	0.029	0.24	0.009	0.028	0.034	0.63	n.s

to control treatment during both seasons of this experiment. As for starch content, the same trend could be detected, although differences did not reach the 5% level of significance. During both seasons, it seems that addition of 96 or 120 kg K_2O /fad to the soil or 48 kg K_2O/fad. plus four foliar sprays by potassium solution 36% K_2O (one liter / fad per each spray) were the best among the tested treatments as they caused the highest contents of N, P, K, sugars , total protein and starch. Obtained results are in agreement with those reported by Maier (1986); Teixeira et al (1991); Locascio et al (1992) and Sujatha and Krishnappa (1995), who indicated that increasing K- fertilization increased K content in potato tubers. In addition, Almazov and Kholuyako (1994) reported that decreasing NPK fertilizers decreased tuber N, P and K contents. On the other hand, Guerra et al (1990) found that tuber N, P and K contents were unaffected due to K fertilization. Respecting the positive effect on starch and protein content, obtained results are in coincidence with those of Shukla and Singh (1976); Al'Shevskü (1990); Negrila et al (1994) and Sing and Sing (1996) , who stated that starch and protein content in potato tubers increased by increasing K- application. However, Anand and Krishanappa (1990) found that protein tubers content was not much affected by increasing K- rate . Furthermore, Cepl (1994) postulated that starch content tended to be the highest at 60 kg K/ha.

Meanwhile, converse results were stated by Müller (1988) and Westermann et al (1994)[b] on potato who found a reduction in starch content with increasing K - rate. Eventhough, the significant positive effect of K on starch and NPK. contents were not detected by Guerra et al (1990) and Divis and kuncl (1993) all working on potato using rates from O - 150 kg K /ha.

Concerning the effect of tested potassium fertilization treatments on percentages of reducing , non - reducing and total sugars, data in Table (8) show that an increasing tendency in all sugar fractions could be detected as K rates increased compared to the untreated control. Generally, using 96 or 120 kg K_2O / fad. as basal soil addition or 48kg K_2O/fad. plus four foliar sprays by potassium solution 36% K_2O (one liter / fad. per each spray) showed the highest significant values in this respect . Obtained results are in agreement with those of Stanley and Jewell (1989), who reported that reducing sugars content of tubers was increased after the addition of 300 kg K_2O / ha. However, contra results were obtained by Winkelmann (1992) on the content of tubers reducing sugars, who found that it was not affected by K - application. In addition, Westermann et al (1994)[b] reported that K application had negative effects on reducing sugars content of potato tubers.

*4.1.6 **Storageability studies:***

a. Weight loss :

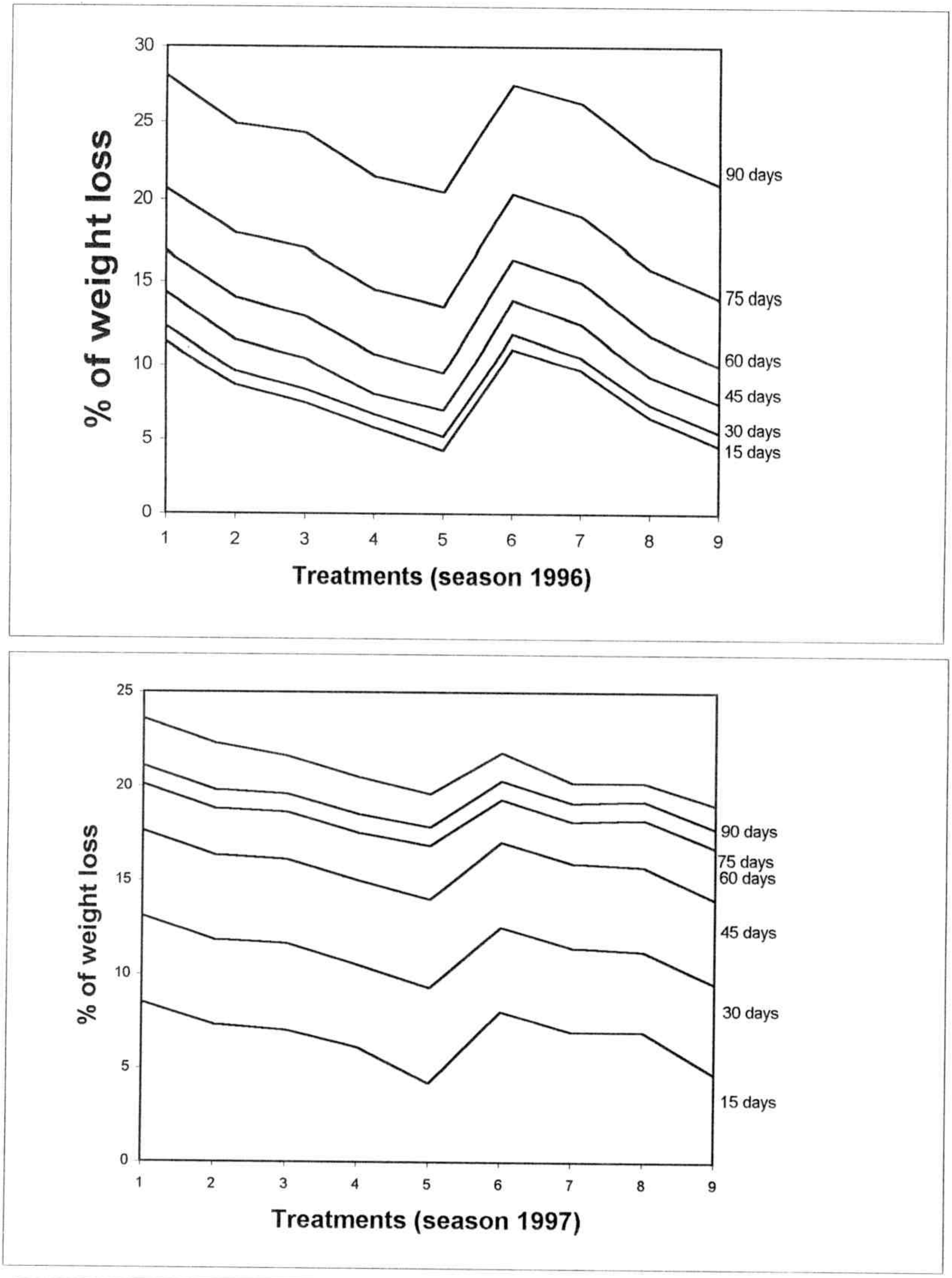
Data showing the effect of potassium fertilization rate and application method on weight loss of potato tubers during storage period are presented in Table (9) and Fig. (1). Generally, increasing storage period up to 90 days increased the percentages of weight loss for all K- treatments and untreated plants during

Table (9): Effect of potassium fertilization rate and application method on weight loss % during the storage period .

Seasons	1996						1997					
Characters / Treatments	% of weight loss after (days)											
	15	30	45	60	75	90	15	30	45	60	75	90
control	11.4	12.3	14.3	16.8	20.7	28.1	8.5	13.1	17.6	20.1	21.1	23.6
48 kg K_2O/fad	8.7	9.6	11.5	14.0	17.9	24.9	7.3	11.8	16.3	18.8	19.8	22.3
72 kg K_2O/fad	7.5	8.4	10.4	12.9	17.0	24.3	7.0	11.6	16.1	18.6	19.6	21.6
96 kg K_2O/fad	5.8	6.7	8.1	10.7	14.5	21.5	6.1	10.5	15.0	17.5	18.5	20.5
120kg K_2O/fad	4.3	5.2	7.0	9.5	13.5	20.5	4.2	9.3	14.0	16.8	17.8	19.6
48 kg.K_2O+spr.once	11.0	11.9	13.9	16.4	20.4	27.5	8.0	12.5	17.0	19.3	20.3	21.8
48 kg.K_2O+spr.twice	9.7	10.5	12.5	15.0	19.0	26.3	6.9	11.4	15.9	18.1	19.1	20.2
48 kg.K_2O+spr. 3 times	6.5	7.4	9.3	11.8	15.8	22.8	6.9	11.2	15.7	18.2	19.2	20.2
48 kg.K_2O+spr. 4 times	4.6	5.5	7.5	10.0	14.0	21.0	4.7	9.5	14.0	16.7	17.7	19.0
L. S. D 5%	2.5	1.6	1.5	1.3	1.3	2.1	1.1	0.8	1.1	1.4	1.0	0.8

Table (9): Effect of potassium fertilization rate and application method on weight loss % during the storage period .

Seasons	1996						1997					
Characters / Treatments	% of weight loss after (days)											
	15	30	45	60	75	90	15	30	45	60	75	90
control	11.4	12.3	14.3	16.8	20.7	28.1	8.5	13.1	17.6	20.1	21.1	23.6
48 kg K_2O/fad	8.7	9.6	11.5	14.0	17.9	24.9	7.3	11.8	16.3	18.8	19.8	22.3
72 kg K_2O/fad	7.5	8.4	10.4	12.9	17.0	24.3	7.0	11.6	16.1	18.6	19.6	21.6
96 kg K_2O/fad	5.8	6.7	8.1	10.7	14.5	21.5	6.1	10.5	15.0	17.5	18.5	20.5
120kg K_2O/fad	4.3	5.2	7.0	9.5	13.5	20.5	4.2	9.3	14.0	16.8	17.8	19.6
48 kg.K_2O+spr.once	11.0	11.9	13.9	16.4	20.4	27.5	8.0	12.5	17.0	19.3	20.3	21.8
48 kg.K_2O+spr.twice	9.7	10.5	12.5	15.0	19.0	26.3	6.9	11.4	15.9	18.1	19.1	20.2
48 kg.K_2O+spr. 3 times	6.5	7.4	9.3	11.8	15.8	22.8	6.9	11.2	15.7	18.2	19.2	20.2
48 kg.K_2O+spr. 4 times	4.6	5.5	7.5	10.0	14.0	21.0	4.7	9.5	14.0	16.7	17.7	19.0
L. S. D 5%	2.5	1.6	1.5	1.3	1.3	2.1	1.1	0.8	1.1	1.4	1.0	0.8



1 = control 2 = 48 kg K2O/ fad 3 = 72 kg K2O/ fad 4 = 96 kg K2O/ fad 5 = 120 kg K2O/ fad
6 = 48 kg K2O/ fad + Spr. Once 7 = 48 kg K2O/ fad + Spr. Twice
8 =48 kg K2O/ fad + Spr. 3 times 9= 48 kg K2O/ fad + Spr. 4 times

Fig. (1): Effet of potassium fertilization rate and application method on weight loss percentage of potato tubers during the storage period in 1996-1997

both seasons. Such results may be due to high temperature during storage period. Moreover, it is obvious that there were significant differences among the used treatments during both growing seasons in this respect. Obtained results indicate also that increasing K - rates up to 120 kg K_2O / fad. led to a gradual and constant decrease in weight loss percentage during storage period. Similar, results were obtained also by using K_2O solution as foliar sprays plus 48 kg K_2O / fad. as basal soil addition, whereby repeated sprays up to four times showed the best response in this respect as it tended to show the least weight loss percentages after 90 days of storage. Obtained results are in agreement with those of Fivkov (1976); Shehata et al (1990) and Negrila et al (1994), who indicated that K - application decreased weight loss of tubers during storage. Meanwhile, obtained results are not in agreement with those of Songin and Paja (1974); Grzeskiewicz et al (1985); Kuzniewicz (1985); Rogozinska and Pinska (1991) and Rabie (1996) as they indicated that increasing NPK or K fertilizers levels increased weight loss of potato tubers during storage period. Furthermore, Sharma and Ezekiel (1993) working on various potato varieties, supplemented with 0, 40, 80 or 120 kg K_2O/ha. and after harvest tubers were stored in cloth bags at room temperature, found that percentage of tuber weight loss was not significantly affected by K_2O application.

B. Sprouting and dry weight:

Data presented in Table (10) show the effect of potassium fertilization rate and application method on sprouting parameters

Table (10): Effect of potassium fertilization rate and application method on some of potato tubers sprouting measurements during and after storage period.

Seasons	1996				1997			
Characters / Treatments	No. of days for sprouting	No. of sprouts /tuber	dry weight % after 90 days storage	% increase in DW. After 90 days storage	No. of days for sprouting	No. of sprouts /tubers	dry weight % after 90 days storage	% increase in DW. After 90 days storage
0 kg. K_2O/fed	31.5	4.7	29.6	43.6	47.7	5.3	25.9	56.9
48 kg. K_2O/fed	48.7	3.7	30.9	45.7	56.0	4.0	28.4	61.3
72 kg. K_2O/fed	34.5	4.2	28.3	31.6	55.3	5.0	27.3	44.4
96 kg. K_2O/fed	31.5	4.7	28.2	18.9	53.7	5.0	25.3	25.8
120kg.K_2O/fed	30.0	4.5	26.6	14.2	52.7	4.3	27.7	45.7
48 kg.K_2O+spr.once	31.5	4.2	29.5	29.9	48.0	5.0	25.7	43.5
48 kg.K_2O+spr.twice	31.5	4.0	27.1	11.5	48.3	4.0	26.6	34.3
48 kg.K_2O+spr. 3 times	43.5	3.5	29.4	36.1	53.0	5.0	26.8	41.7
48 kg.K_2O+spr. 4 times	30.0	4.0	29.3	38.8	52.3	6.0	25.6	40.6
L.S.D 5%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

and dry weight content of potato tubers at the end of storage period . It is clear from such data that non-significant effects among all treatments were detected on all studied characters in this respect except number of days for sprouting in the first season which was significantly affected. It is evident from such data that K - fertilization at 48 kg K_2O fad. as soil application showed the best results in this respect, whereas it led to intercept the appearance of sprouts for the longest stage possibility (13 and 8 days as average of 1996 and 1997 seasons, respectively). Meanwhile, increasing K - fertilization from 48 to 120 kg K_2O/fad. reduced number of days for sprouting, dry weight content of tubers after the end of storage period and increased number of sprouts/ tuber. Moreover, it is obvious from the same data in Table (10) that repeated sprays 3 times with K_2O solution accompanied with 48 kg K_2O / fad. as soil application showed the best results as compared to control treatment. However, dry weight percentages at the end of storage period increased as compared with dry weight at harvest (Table, 7). These results held true during both growing seasons in this concern. Obtained results are in agreement with the findings of Shehata et al (1990), who mentioned that the percentage of tuber sprouting was not significantly affected by potassium fertilizer level. Also, Sharma and Ezekiel (1993) reported that percentage of sprouting after 30 and 60 days storage were not significantly affected by K_2O rate at 40, 80 or 120 kg K_2O / ha . On the other hand, obtained results are not in agreement with those of Rabie (1996) who found that increasing NPK levels increased sprouting percentage.

C. Sugars and Starch Content

Data on sugars and starch contents of potato tubers after 90 days storage under room condtiions are presented in Table (11) and Fig. (2) It is clear from such data that increasing K-fertilizer rate from 0 up to 96 kg K_2O/fad. significantly and gradually increased all sugar fractions as well as tuber starch contents after storage period. Similar trend was observed with spraying potato plants by K_2O solution once up to four times (one liter/fad. 36% K_2O, each time) plus the addition of 48 kg K_2O/fad as soil basal application. Generally, all studied carbohydrates fractions decreased at the end of storage period under room conditions compared with tuber starch content at harvest (Table 8). These results may be due to increasing respiration rate, growth of sprouts and storage tubers for long period (90 days) beside the favourable effects of potassium fertilization on respiration rate and sprouting. These results held true during both growing seasons in this respect. Generally, using either 120 kg K_2O/fad. as soil application or 48 kg K_2O/fad. as basal soil application plus four times foliar sprays with potassium solution 36% K_2O (one liter/fad., each time) showed best responses on potato storage process in this respect. Obtained results are in agreement with those of Rogozinska and Pinska (1991), Negrila et al. (1994) and Rabie (1996), who found that NPK fertilizers imporved keeping quality and decreased reducing, non-reducing and total sugars at the end of storage period. As for the effect of K-fertilizer rates on starch content, obtained results disagreed with those of

Table (11): Sugars and starch cantents (% of dry weight) of potato tubers at the end of storage peiod (90 days)as affected by potassium fertilization rate and application method.

Season	1996								1997							
Characters	Sugars						Starch		Sugars						Starch	
Treatments	Reducing	% decrease after 90d storge	non-reducing	% decrease after 90d storge	Total sugars	% decrease after 90d storge	after storage period	% decrease after 90d storge	Reducing	% decrease after 90d storge	non-reducing	% decrease after 90d storge	Total sugars	% decrease after 90d storge	after storage period	% decrease after 90d storge
0Kg K_2O/fad.	0.120	16.7	0.486	16.5	0.606	16.5	14.8	29.8	0.113	17.7	0.446	17.9	0.559	17.9	10.7	42.2
48Kg K_2O/fad.	0.133	15.0	0.530	15.1	0.663	15.1	14.9	31.9	0.126	15.9	0.493	16.2	0.619	16.2	11.7	38.7
72Kg K_2O/fad.	0.156	15.4	0.620	19.3	0.776	18.5	15.2	33.0	0.153	24.7	0.610	23.4	0.763	23.4	12.9	36.4
96Kg K_2O/fad.	0.156	21.8	0.623	20.9	0.779	21.1	17.1	26.6	0.156	23.7	0.623	23.6	0.779	23.6	13.9	32.5
120Kg K_2O/fad.	0.160	22.5	0.626	23.9	0.786	23.7	16.7	32.4	0.160	22.5	0.633	22.1	0.793	22.2	12.8	39.9
48Kg K_2O+Spr once	0.150	10.7	0.593	12.3	0.743	12.0	14.4	31.7	0.150	6.7	0.590	7.8	0.740	7.7	12.0	36.2
48Kg K_2O+Spr twice	0.150	17.3	0.613	14.7	0.763	15.2	15.2	31.2	0.150	20.0	0.593	24.1	0.743	23.3	12.3	34.6
48Kg K_2O+Spr 3 times	0.153	17.6	0.616	19.0	0.769	18.7	16.3	29.4	0.150	24.0	0.603	22.7	0.753	23.0	12.8	35.0
48Kg K_2O+Spr 4 times	0.156	20.5	0.616	20.6	0.772	20.6	17.7	24.7	0.153	24.2	0.620	21.4	0.773	22.0	13.6	31.3
L. S. D. 5%	**0.004**	-	**0.032**	-	**0.041**	-	**1.7**	-	**0.007**	-	**0.029**	-	**0.043**	-	**0.9**	-

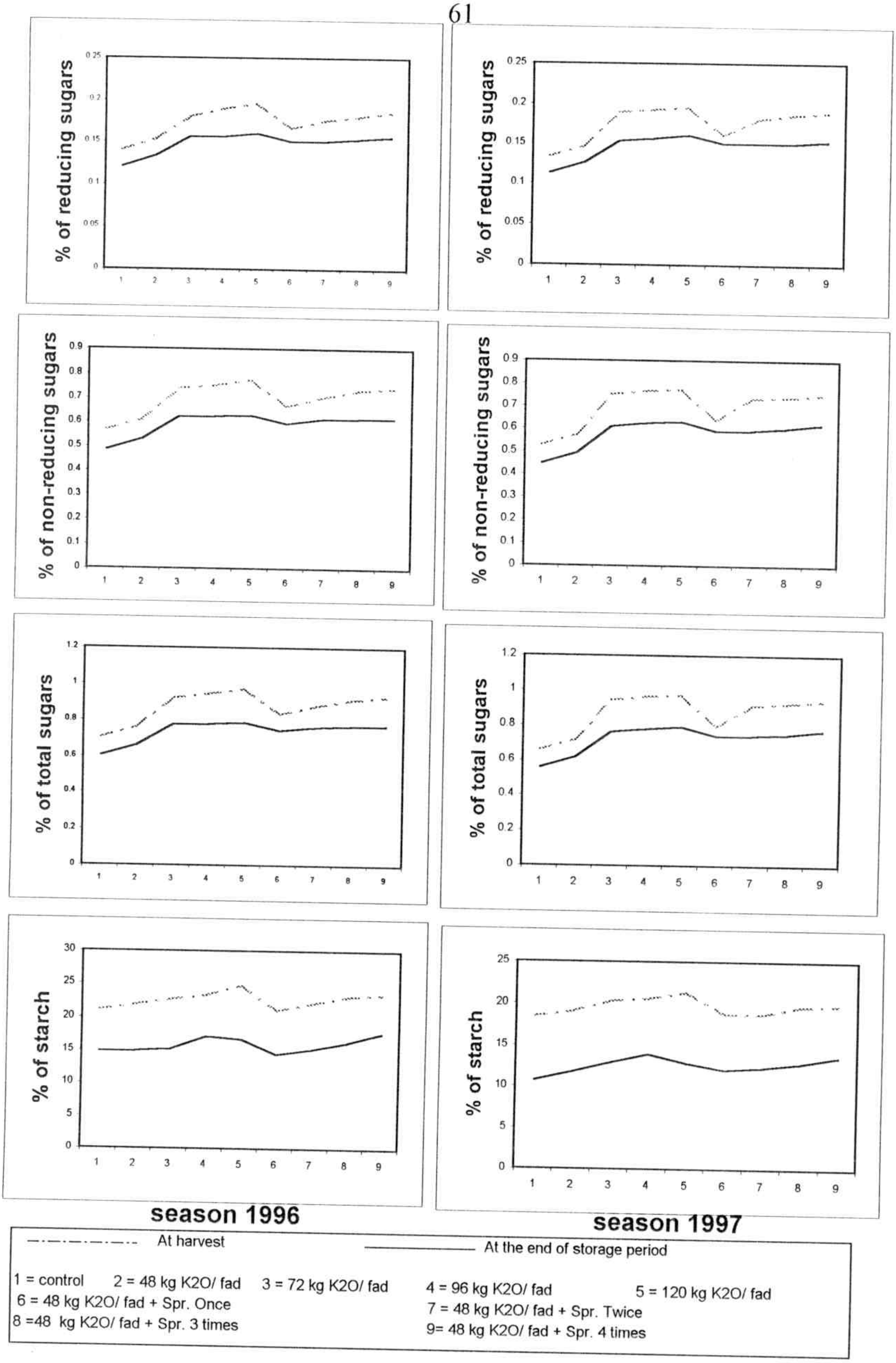


Fig. (2) : Reducing , non-reducing , total sugar and starch potato tubers content as affected by K-fertilization rate and application method at harvest and the end of storage period

Rabie (1996) who found that increasing NPK fertilizer level decreased starch percentage at the end of storage period (90 days). Also, Rogozinska and Pinska (1991) found that K-fertilizer had negative effects on tuber quality during storage only at rate above 240 kg K/ha.

In conclusion, to obtain high yield of potato tubers with good quality and storageability after harvest under room conditions, it was found that the potassium fertilization at rate of 96 kg K_2O/fad. alone or 48 kg k_2O/fad as soil addition plus spraying potato plants four times by potassium solution (36% K_2O/liter each time) offered a good potato tubers yield and its quality, chemical composition and storageability for 90 days under room conditions. The obtained results proved that, the potassium fertilization at 48 kg K_2O/fad with spraying for 4 times excerted a good influence on reducing the using of high soil addition which is of significantly higher economical coasts, and subsequently, reflects on the expected profit. Also, keeping on the public health and surrounded environment from the hazard of chemical fertilizers addition at high rates is considered as a very important advantage of this conclusion.

4.2. Second Experiment:

Effect of plant spacing, growth retardants and their interactions on different studied characteristics of potatoes.

4.2.1. Vegetative growth characteristics:

Data presented in Table (12) show the main effects of plant spacings and growth regulators as well as their interactions on vegetative growth characteristics of potato plants during 1996 and 1997 seasons. It is evident from such data that 15 cm spacing tended to improve slightly all studied vegetative growth parameters as compared with 20 cm, however differences did not reach the 5% level of significance during both seasons of this study. The only exception was in case of dry weight of leaves as differences were significant between both spacing treatments in the first season. Obtained results are in agreement with those of Barry et al. (1990); Vecchio et al. (1991) and Hossain (1995), where they reported that increasing plant density increased plant height and number of stems per plant.

Concerning the effect of growth regulators on plant vegetative growth characteristics, it is evident from the same data in Table (12) that plant height as well as dry weight of leaves were significantly affected, meanwhile, number of stems per plant was not significantly affected in both seasons. Moreover, using growth regulators "CCC or PP_{333}" decreased plant height and number of stems per plant and increased dry weight of leaves as compared with untreated plants. On the other hand, increasing

Table (12): Vegetative grewth of potato plants as affected by plant spacing, growth regulator treatments and their interaction (90 days after planting).

Season / Characters / Treatments	1996 Plant height (cm.)	1996 No. of stems / plant	1996 % of D.W. of plant leaves	1997 Plant height (cm.)	1997 No. of stems / plant	1997 % of D.W. of plant leaves
15 cm	37.5	3.2	15.1	49.7	2.7	13.5
20 cm	35.9	3.1	14.3	49.4	2.4	12.7
L. S. D. 5%	**n.s**	**n.s**	**0.6**	**n.s**	**n.s**	**n.s**
Control 0 ppm	46.0	3.4	13.9	54.3	2.3	11.9
CCC 500 ppm	39.0	3.4	15.2	51.3	2.8	13.4
1000 ppm	35.5	3.0	14.2	49.0	2.4	12.7
PP_{333} 25 ppm	32.4	3.2	15.5	46.6	2.5	13.6
50 ppm	30.9	2.8	14.6	46.4	2.6	13.9
L. S. D. 5%	**3.5**	**n.s**	**0.4**	**3.5**	**n.s**	**0.5**
Growth regulators	**15 cm Spacing**					
Control 0 ppm	46.2	3.2	14.2	53.3	2.6	12.5
CCC 500 ppm	39.2	3.3	15.7	50.0	2.8	13.8
1000 ppm	36.3	3.4	14.6	49.3	2.9	13.2
PP_{333} 25 ppm	33.2	2.9	15.9	473	2.4	14.0
50 ppm	32.7	3.1	15.3	48.6	3.0	13.8
	20 cm Spacing					
Control 0 ppm	45.8	3.5	13.6	55.3	2.0	11.3
CCC 500 ppm	38.7	3.5	14.7	52.6	2.9	13.1
1000 ppm	34.7	2.7	13.9	48.6	2.0	12.2
PP_{333} 25 ppm	31.6	3.3	15.1	46.0	2.6	13.2
50 ppm	29.1	2.6	14.1	44.3	2.3	13.9
L. S. D. 5%	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**

either CCC or PP_{333} concentrations decreased plant height and number of stems/plant, meanwhile dry weight of leaves increased with increasing growth regulator concentration compared with the control treatment. Cycocel at the rate of 500 ppm or Paclobutrazol at the rate of 25 ppm showed the highest dry weight of leaves during both seasons. In this connection, Midan et al. (1986) working on potato, found that CCC depressed plant height but increased leaves dry weight when using CCC at rates from 0 to 2000 ppm. Similar results were also reported by El-Sawy et al. (1988)[a]; Mattar and Abdul (1988)[a&b] and Khalil (1990). On the other hand, Govindakrishnan and Sahota (1984) and Ferenadez et al. (1991) working on potato found that cycocel had no effect on plant height as well as its dry weight. As for the effect of PP_{333}, obtained results are in harmony with those of El-Masry and Barakat (1991), who found that spraying potato plants with 25 and 50 ppm PP_{333} reduced plant height compared with the control treatment. Similarly, Simko (1993); Li-YQ and Zhu-Lm (1994) and Bandara and Tanino (1995), indicated that increasing PP_{333} concentrations decreased potato plant height.

With regard to the interaction between plant spacings and growth regulator treatments on plant vegetative growth, the same data presented in Table (12) show insignificant effects in both seasons. Nevertheless, potato plants spaced at either 15 or 20 cm and not treated with any of studied growth regulators proved to be the tallest ones. Meanwhile, plants sprayed with 50 ppm PP_{333} came last in this respect. Moreover, plants spaced at 15 cm and sprayed with 25 ppm PP_{333} showed superiority in leaves dry matter content. On the other hand no clear trend could be detected in case of the number of stems per plant.

4.2.2. N, P and K content of leaves:

Data dealing with the effect of plant spacing, growth retardants "CCC or PP_{333}" and their interaction on the N, P and K percentages of potato leaves are presented in Table (13). It is evident from such data that, plants spaced at 20 cm apart in the row contained significantly higher N and K percentages than those spaced at 15 cm apart during both seasons of the experiment. Meanwhile, P leaves content was insignificantly increased in this respect during both seasons of this work. Obtained results are not in complete agreement with those of Singh et al. (1996), who indicated that there was an increase in either N or K% with the higher density (83333, compared to 47619 – 60606 plant densities/ha.).

With regard to the effect of growth regulators in this respect, significant increases in N, P and K contents in potato leaves of treated plants over those of the untreated control ones were detected in both seasons of this work as shown by data in Table (13). It is also evident that the higher the concentration used of both CCC (from 500 up to 1000 ppm) and PP_{333} (from 25 up to 50 ppm) the higher the percentages of N, P and K in potato leaves could be found with an unique exception in case of CCC regarding its effect on P content. In this regard, Midan et al. (1986) and Khalil (1990) found that CCC application at rates from 0 to 2000 ppm increased the percentage and total minerals

Table (13): N, P and K percentages in potato leaves as affected by plant spacing, growth regulators treatments and their interaction.

Season	1996			1997		
Characters / Treatments	N	P	K	N	P	K
15 cm	2.69	0.305	1.36	2.89	0.318	1.46
20 cm	2.79	0.312	1.40	2.98	0.325	1.57
L. S. D. 5%	**0.06**	**n.s**	**0.03**	**0.07**	**n.s**	**0.04**
Control 0 ppm	2.45	0.278	1.24	2.64	0.292	1.33
CCC 500 ppm	2.74	0.317	1.45	2.94	0.331	1.55
1000 ppm	2.90	0.312	1.47	3.11	0.326	1.61
PP_{333} 25 ppm	2.73	0.306	1.37	2.92	0.319	1.47
50 ppm	2.89	0.327	1.50	3.09	0.339	1.61
L. S. D. 5%	**0.07**	**0.012**	**0.07**	**0.10**	**0.012**	**0.05**
Growth regulators	**15 cm Spacing**					
Control 0 ppm	2.42	0.273	1.21	2.62	0.288	1.30
CCC 500 ppm	2.56	0.313	1.37	2.76	0.328	1.46
1000 ppm	3.12	0.330	1.52	3.32	0.345	1.62
PP_{333} 25 ppm	2.61	0.302	1.28	2.81	0.314	1.39
50 ppm	2.76	0.305	1.40	2.95	0.312	1.51
	20 cm Spacing					
Control 0 ppm	2.47	0.284	1.27	2.67	0.296	1.36
CCC 500 ppm	2.93	0.332	1.52	3.12	0.333	1.66
1000 ppm	2.67	0.295	1.43	2.87	0.307	1.59
PP_{333} 25 ppm	2.84	0.310	1.46	3.04	0.325	1.55
50 ppm	3.03	0.348	1.60	3.23	0.362	1.72
L. S. D. 5%	**0.13**	**0.017**	**0.10**	**0.14**	**0.020**	**0.07**

uptake of N, P and K in potato plants. On the other hand, obtained results are not in agreement with that of El-Sawy et al. (1988)[b], who reported that N and P leaves contents were insignificantly affected by CCC application at 500 ppm but K content of leaves was decreased at the same concentraton.

The interactional effect (Table, 13) show that PP_{333} at 50 ppm significantly improved leaves contents of NPK in both seasons compared with other used treatments, specially when combined with the 20 cm. spacing . On the other hand, untreated potato plants, (control), especially when planted at 15 cm apart accumulated the least contents of N, P and K in their leaves.

4.2.3. Yield and its components:

Data concerned with the effect of plant spacings, growth regulators and their interaction on yield and its components of potato tubers during summer seasons of 1996 and 1997 are presented in Table (14). It is obvious from such data that, increasing plant spacings significantly increased tubers yield per plant in both seasons. In addition, number of tubers/plant as well as tuber/top ratio were also increased as spacings increased from 15 to 20 cm, hoswever, differences reached the 5% level of significance only in the first season. Although, tubers yield/plot as well as total yield/fad were increased due to wider plant spacing (20 cm) compared to narrower planting (15 cm), differences were insignificant during both seasons of the experiment. It is worthy to mention herein that the significant higher tubers yield per plant observed by plants spaced at 20 cm. apart was abolished to

Table (14): The potato tubers yield and its components as affected by plant spacing, growth regulator treatments and their interaction.

Season	1996					1997				
Characters / Treatments	No. of tubers/ plant	tuber /top ratio	yield / plant (g)	yield / plot (kg)	Total yield /fad (tons)	No. of tubers/ plant	tuber /top ratio	yield / plant (g)	yield / plot (kg)	Total yield /fad (tons)
15 cm	4.3	1.98	362.3	19.928	11.387	3.9	2.21	429.9	23.591	13.470
20 cm	5.1	2.10	471.2	20.261	11.577	4.2	2.24	480.0	24.000	13.702
L. S. D. 5%	**0.4**	**0.11**	**24.1**	**n.s**	**n.s**	**n.s**	**n.s**	**39.5**	**n.s**	**n.s**
Control 0 ppm	4.2	1.87	316.4	15.252	8.715	3.6	2.02	393.8	20.632	11.780
CCC 500 ppm	4.7	2.0	414.5	19.985	11.419	4.3	2.43	510.0	26.693	15.239
1000 ppm	4.4	1.93	388.8	18.747	10.712	3.8	2.18	442.6	23.121	13.202
PP_{333} 25 ppm	5.4	2.25	532.8	25.691	14.680	4.4	2.27	480.3	25.443	14.527
50 ppm	4.7	2.13	431.3	20.797	11.883	3.9	2.22	440.5	23.087	13.182
L. S. D. 5%	**0.3**	**0.11**	**26.9**	**1.306**	**0.747**	**n.s**	**0.11**	**23.4**	**1.236**	**0.708**
Growth regulators	15 cm Spacing									
Control 0 ppm	3.7	1.76	275.0	15.125	8.642	3.6	1.98	376.3	20.698	11.818
CCC 500 ppm	4.1	1.89	360.3	19.818	11.324	4.1	2.44	477.3	26.253	14.990
1000 ppm	3.9	1.86	338.0	18.590	10.628	3.8	2.15	395.3	21.743	12.415
PP_{333} 25 ppm	5.1	2.27	463.3	25.483	14.561	4.1	2.31	470.7	25.886	14.781
50 ppm	4.5	2.12	375.0	20.625	11.785	3.7	2.18	425.0	23.375	13.347
	20 cm Spacing									
Control 0 ppm	4.6	1.99	357.7	15.379	8.788	3.7	2.06	411.3	20.566	11.743
CCC 500 ppm	5.3	2.11	468.7	20.152	11.515	4.5	2.43	542.7	27.133	15.489
1000 ppm	4.9	2.01	439.6	18.905	10.803	3.9	2.22	490.0	24.500	13.989
PP_{333} 25 ppm	5.6	2.23	602.3	25.900	14.799	4.7	2.23	5.00.0	25.000	14.274
50 ppm	4.9	2.15	487.6	20.969	11.982	4.1	2.26	456.0	22.800	13.018
L. S. D. 5%	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**

some extent as total yield was calculated either per plot or faddan. This can be ascribed to the higher plant population density in case of 15 cm (44444 plant/fad.) compared with (33333 plant/fad.) in case of 20 cm. The results of this work are in agreement with that of Nel et al. (1991)[a] who found that increasing plant density from 105000 to 525000 plants/ha. had no effect on total yield. The obtained results are in disagreement with that observed by Krishnappa (1991) as he planted potato plants at intra-row spacing of 15, 20, 25, 30 or 35 cm in rows 60 cm apart. He concluded that the highest yield (44.14 t./ha) was obtaiend from tubers planted at an intra-row spacing of 20 cm. Contra results were also reported by those of Barry et al. (1990) and Rykbost and Maxwell (1993) and Sharama and Sahab (1996) on potato who indicated that decreased plant density increased tuber yields. On the other hand, Gronowicz et al. (1990); Vinay Singh et al. (1990); Kabir (1991); Nel et al. (1991)[b]; Pawlowski and Pomykalska (1991); Rhaman and Gaffer (1991); Zielinska and Gronowicz (1991); Sawicka and Skalski (1992); Plodowska et al (1993); Khan (1993); Mettei et al. (1993); Mollerhagen (1994) and Rajadurai (1994), indicated also that increasing plant population density increased potato tubers yield.

As for the effect of CCC and PP_{333} foliar spray on yield and its components, data presented in Table (14) indicate obviously that application of such growth retardants tended to improve significantly the yield and its components compared to the control treatment. However, increasing the level of CCC from 500 to 1000 ppm and that of PP_{333} from 25 to 50 ppm show deleterious effects on studied tubers yield and its components, although it was still better than that of untreated control. Consequently, the best results regarding yield parameters could be obtained by using either PP_{333} at 25 ppm or CCC at 500 ppm as compared with other growth regulator treatments or control. Obtained results with the main effect of growth regualtors are in agreement with those reported by Shadeque and Pandita (1982); Midan etal. (1986); El-Sawy et al. (1988)[a]; Fernandez et al. (1991) and Dimttrov and Stoinova (1992) on potato, who indicated that CCC application increased tuber yield but using CCC at 500 ppm was the most effective. However, obtained results are not in complete agreement with those of Govindakrishnan and Sahota (1984); Mattar and Abdul (1988)[b]; Sharma and Sahota (1988); Sahota (1990) and Rex (1992) on potato, who reported that application of cycocel at different rates had no significant effects on tubers yield. Furthermore, results on the effect of PP_{333} on potato tuber yield are parallel to that reported by El-Masry and Barakat (1991), who found that PP_{333} at 25 ppm led to significant increases in total yield. However, the obtained results are not in agreement with those reported by Bandara and Tanino (1995), who indicated that PP_{333} application had no effects on tubers yield.

Concerning the interaction effect between plant spacings and growth regulator treatments, data in Table (14) indicate that non-significant differences were obtained in this respect. As average of both seasons, potato plants sprayed with the lowest used concentration of PP_{333} (25 ppm) and spaced at 15 cm or 20 cm produced the highest total yield (14.671 or 14.536 ton/fad.), respectively, as compared with the other used treatments. In this respect, the least total yield was detected by plants that did not receive any growth regulators (control) and spaced at 15 or 20 cm (10.230 or 10.266 ton/fad.), respectively.

4.2.4. Physical characteristics of potato tubers:

a. Tubers size :

Data dealing with the effect of plant spacings, growth regulator treatments and their interaction on tubers size are presented in Table (15). It is evident from such data that increasing plant spacing from 15 cm up to 20 cm. significantly decreased the total number of tubers/plot that of both small and medium tuber size, meanwhile, it increased large tuber either by absolute number or their corresponding percentages. This result held true during both growing seasons in this experiment. Obtained results are in agreement with those reported by Pawlowski and Pomykalska (1991), and Cepl and Vokai (1995), who found that decreasing potato stand increased number of big tubers (> 5 cm in diameter). Moreover, results showing effect of plant spacing on total tubers number in this study are in agreement with those obtained by Vecchio et al. (1991), who indicated that closer spacing increased number of seed tubers (28-55 mm). Nevertheless, obtained results are not in agreement with those found by krishnappa (1991), who reported that all treatments (intra-row spacing of 15, 20, 25, 30 or 35 cm in rows 60 cm apart) produced a similar percentage of large (> 51 mm) and small (< 25 mm) tubers.

Table (15): Tuber grading as affected by plant spacing, growth regulatore treatments and their interaction.

Season / Characters / Treatments	1996 Tubers size grades as No./plot			1996 Tubers size grades as number %			1996 Total tubers No./plot	1997 Tubers size grades as No./plot			1997 Tubers size grades as number %			1997 Total tubers No./plot
Size	S*	M**	L***	S	M	L		S	M	L	S	M	L	
15 cm	86.3	93.0	59.2	36.2	39.0	24.8	238.5	79.0	93.3	59.6	34.1	40.2	25.7	231.9
20 cm	65.0	68.0	83.6	30.0	31.4	38.6	216.6	57.5	65.2	65.9	30.5	34.6	34.9	188.6
L. S. D. 5%	**9.2**	**3.0**	**14.5**	**3.0**	**1.2**	**5.3**	**8.4**	**1.2**	**5.9**	**6.2**	**1.7**	**2.2**	**2.6**	**6.6**
Control 0 ppm	48.3	60.3	88.6	24.4	30.5	449	197.2	48.6	61.3	82.3	25.3	31.9	42.8	192.2
CCC 500 ppm	72.4	73.4	71.6	33.1	33.6	33.2	217.4	67.3	78.3	66.6	31.7	36.9	31.4	212.2
1000 ppm	75.0	80.4	61.8	34.5	37.0	28.4	217.2	69.8	87.6	56.8	32.6	40.9	26.5	214.2
PP_{333} 25 ppm	95.5	99.3	64.6	36.7	38.1	25.2	259.4	79.8	878	48.4	36.9	40.6	22.4	216.0
50 ppm	87.1	89.1	70.1	34.9	36.7	29.3	246.3	75.5	81.0	59.5	34.9	37.5	27.5	216.0
L. S. D. 5%	**5.0**	**5.3**	**4.9**	**2.0**	**2.0**	**2.0**	**8.0**	**1.9**	**2.5**	**4.2**	**1.0**	**1.1**	**1.6**	**3.8**
Growth regulators	**15 cm Spacing**													
Control 0 ppm	54.3	67.0	77.3	27.3	33.8	28.9	198.6	60.0	75.0	83.0	27.5	34.4	38.1	218.0
CCC 500 ppm	84.3	87.3	52.3	37.6	39.0	23.4	223.9	84.3	99.6	63.6	34.1	40.2	25.7	247.5
1000 ppm	79.6	89.3	48.6	36.6	41.0	22.3	217.5	74.0	100.0	52.0	32.7	44.2	23.0	226.0
PP_{333} 25 ppm	108.0	111.0	54.0	39.6	40.6	19.8	273.0	85.3	93.6	42.6	38.5	42.2	19.2	221.5
50 ppm	105.3	110.6	63.6	37.6	39.6	22.8	279.0	91.3	98.0	56.6	37.1	39.8	23.0	245.9
	20 cm Spacing													
Control 0 ppm	42.3	53.6	100.0	21.6	27.3	51.0	195.9	37.3	47.6	81.6	22.4	28.6	49.0	166.
CCC 500 ppm	60.6	59.6	91.0	28.7	28.2	43.0	211.2	50.3	57.0	69.6	28.4	32.2	39.4	176.9
1000 ppm	70.3	71.6	75.0	32.4	33.1	34.6	216.9	65.6	75.3	61.6	32.4	37.2	30.4	202.5
PP_{333} 25 ppm	83.0	87.6	75.3	33.8	35.6	30.6	245.9	74.3	82.0	54.3	35.3	38.9	25.8	210.6
50 ppm	69.0	67.6	76.6	32.3	31.8	35.9	213.2	59.6	64.0	62.3	32.1	34.4	33.5	185.9
L. S. D. 5%	**7.1**	**7.5**	**7.0**	**2.7**	**2.8**	**2.8**	**11.4**	**2.7**	**3.5**	**5.9**	**1.4**	**1.6**	**2.3**	**5.4**

* S = Small size (28-35 mm) ** M = Medium size (36-45 mm) *** L = Large size (over than 46 mm)

Concerning the effect of growth regulators on tuber size, it is evident from data shown in Table (15) that all growth regulator treatments significantly increased the total number of tubers/plot and also absolute number as well as corresponding percentages of small (28 – 35 mm) and medium (36 – 45 mm) tubers and decreased that of large tubers (>46 mm), when compared with the untreated control treatment. Moreover, it is clearly shown from the same data at Table (15) that during both seasons. PP_{333} at 25 ppm showed the highest number of tubers/plot and also of both small and medium tubers (seed sized tubers) as well as their percentages of whole tubers when compared to other growth regulator treatments or untreated control. Obtained results are not in complete agreement with those of Shadeque and Pandite (1982); Midan et al. (1986) and El-Sawy et al. (1988)[a], where they indicated that CCC application significantly increased large and medium grades of tuber sizes. As for the effect of PP_{333}, El-Masry and Barakat (1991) reported that PP_{333} led to a significant increase in yield of tubers above 60 mm diameter compared with control. Such discrepances between obtained results and those previously puplished may be due to varietal differences, climatical conditions and or other aspects prevailed during the procedure of such experiments.

Data on the effect of the interaction between plant spacing and growth regulator treatments on tubers size during both seasons 1996 and 1997 are presented in Table (15). Growth regulator treatments with different spacings significantly increased total tubers number per plot as well as that of small and medium sized tubers and their percentages in both seasons compared with the control treatment. Spraying either cycocel at 500 ppm or PP_{333} at 50 ppm on potato plants spaced at 15 cm produced the highest total tubers number as average of both seasons (235.7, 262.4 tubers), respectively, in this respect. Moreover, all growth regulator treatmetns combined with either 15 or 20 cm spacings increased small and medium tubers size as well as total tubers number. In addition, using PP_{333} at rate of 25 ppm with either 15 or 20 cm spacings significantly increased small, medium, total tubers number and their percentages in both seasons.

B - <u>Dry weight, Specific gravity and Feathering of tubers:</u>

Data presented in Table (16) show the main effect of plant spacing, growth regulator treatments and their interaction on dry weigth, specific gravity and feathering of potato tubers. It is clear from such data that incresing plant density from 33333 plant /fad to 44444 plant/fad. had no significant effect on all studied parameters during both growing seasons. Obtained results are in agreement with those of White et al (1974) and Rykbost and Maxwell (1993) working on potato, who reported that specific gravity of tubers was not affected by plant spacings.

Concerning the effect of growth regalators on dry weight, specific gravity and feathering of tubers, data in Table (16) cleary show that growth regultors application significantly increased dry weight and specific gravity of tubers as compared with the

Table (16): Dry weight, specific gravity and feathering of potato tubers as affected by plant spacing, growth regulatøors treatments and their interaction.

Season / Characters / Treatments	1996 Dry weight %	1996 specific gravity	1996 feathering	1997 Dry weight %	1997 specific gravity	1997 feathering
15 cm	21.0	1.070	1.8	20.0	1.151	1.8
20 cm	21.1	1.073	1.9	20.0	1.148	1.8
L. S. D. 5%	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**
Control 0 ppm	19.7	1.063	2.0	19.2	1.141	1.8
CCC 500 ppm	22.1	1.076	1.6	20.9	1.153	1.6
1000 ppm	21.7	1.070	1.8	20.3	1.148	1.6
PP_{333} 25 ppm	20.7	1.074	2.0	19.6	1.152	2.0
50 ppm	21.1	1.070	2.0	20.2	1.150	1.8
L. S. D. 5%	**0.7**	**0.012**	**n.s**	**0.8**	**0.009**	**n.s**
Growth regulatørs			**15 cm Spacing**			
Control 0 ppm	19.7	1.064	2.3	19.6	1.142	2.0
CCC 500 ppm	21.9	1.071	1.6	20.9	1.155	1.7
1000 ppm	21.4	1.069	2.0	20.1	1.150	1.7
PP_{333} 25 ppm	20.6	1.072	1.6	19.0	1.154	2.0
50 ppm	21.5	1.071	1.6	20.6	1.152	1.7
			20 cm Spacing			
Control 0 ppm	19.7	1.063	1.6	18.7	1.140	1.7
CCC 500 ppm	22.3	1.081	1.6	20.8	1.152	1.7
1000 ppm	22.0	1.072	1.6	20.5	1.147	1.7
PP_{333} 25 ppm	20.8	1.077	2.3	20.2	1.151	2.0
50 ppm	20.6	1.070	2.3	19.9	1.148	2.0
L. S. D. 5%	**0.7**	**0.017**	**n.s**	**0.6**	**0.011**	**n.s**

control treatment during both seasons. Moreover, increasing CCC from 500 to 1000ppm decreased dry weight and specific gravity but PP_{333} increased dry weight and decreased specific gravity as used rates increased from 25 to 50 ppm. Although, increasing growth regulator concentrations decreased specific gravity it was still higher than the untreated plants. Obtained results are in agreement with those reported by El-Sawy et al (1988)[b], who found that CCC at 500 ppm increased tuber dry matter. Meanwhile, Mattar and Abdul (1988)[a] and Fernandez et al (1991) reported that CCC had no significant effect on dry matter. Moreover, Shadeque and Pandita (1982) and Midan et al (1986) found that increasing CCC concentrations increased specific gravity but El-Sawy et al (1988)[a] reported that CCC application had no effect on specific gravity of tubers . As for the effect of PP_{333}, obtained results are not in agreement with those of Deng and Prange (1988); El-Masry and Barakat (1991) and Mica and Zrust (1991), who found that PP_{333} had no effects on potato tubers dry weight .

As for feathering of tubers, insignificant effects could be detected due to growth regultaors application. In this respect, CCC at 500 ppm showed the best feathering values i.e. (the best degree is equal 1 and the worst is equal 5) among all used treatments in this study during both seasons .

Concerning the effect of interaction between plant spacings and growth regulator treatments on dry weight, specific gravity and feathering of tubers, data in Table (16) indicate that potato plants spaced at 20 cm. and sprayed with CCC at 500 ppm showed the highest dry weight and specific gravity (21.5 g/100g. and 1.116 as average of both seaseons), respectively. On the other hand, however feathering of tubers was not significantly affected by interaction between plant spacings and growth regalators in both seasons, the same treatment was of low values (good quality) in this respect.

4.2.5. Chemical composition of potato tubers :

a. N, P, and K, content :

Data in Tables (17 and 18) show that increasing plant spacing from 15 up to 20 cm significantly increased P, and K, tubers content. Meanwhile, N tubers content was not significantly affected in this respect. Such trend held true during both seasons of this study. Obtaned results are not in complete agreement with those of Singh et al (1996), who reported that N, P and K, uptake in tubers were increased with increasing plant density.

Concerning the effect of growth regulators, it is evident from data in Tables (17 and 18) that growth regulators significantly increased N, P and K tubers content. Moreover, increasing CCC from 500 to 1000 ppm or PP_{333} from 25 to 50 ppm showed the highest values in this respect. In general, PP_{333} at rate of 50 ppm was the best treatment among all other tested growth regulators and control treatments during both seasons. Obtaned results are in agreement with those of Khalil (1990), who found that CCC at

Table (17): Effect of plant spacings, growth regulators and their interaction on chemical composition of potato tubers as % in 1996 season.

Characters / Treatments	N	P	K	Sugars reducing	Sugars non-reducign	Sugars Total	Total protein	Starch
15 cm	2.02	0.185	2.34	0.176	0.705	0.881	12.64	20.5
20 cm	2.02	0.203	2.49	0.186	0.738	0.924	12.63	19.4
L. S. D. 5%	**n.s**	**0.005**	**0.09**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**
Control 0 ppm	1.76	0.154	1.88	0.158	0.635	0.793	10.97	19.0
CCC 500 ppm	1.88	0.179	2.09	0.176	0.702	0.878	11.77	21.1
1000 ppm	2.13	0.212	2.91	0.195	0.778	0.973	13.29	19.3
PP_{333} 25 ppm	1.90	0.197	2.52	0.186	0.736	0.922	11.90	20.5
50 ppm	2.44	0.228	2.66	0.190	0.755	0.945	15.26	20.0
L. S. D. 5%	**0.09**	**0.021**	**0.08**	**0.011**	**0.025**	**0.029**	**0.55**	**0.4**
Growth regulators				**Spacing 15 cm**				
Control 0 ppm	1.68	0.130	1.82	0.126	0.673	0.799	10.47	19.4
CCC 500 ppm	1.91	0.169	2.03	0.146	0.730	0.876	11.91	21.7
1000 ppm	2.12	0.210	2.86	0.156	0.776	0.932	13.24	19.6
PP_{333} 25 ppm	1.93	0.194	2.38	0.153	0.763	0.916	12.01	23.0
50 ppm	2.49	0.224	2.60	0.146	0.746	0.892	15.54	18.8
				Spacing 20 cm				
Control 0 ppm	1.84	0.179	1.94	0.150	0.596	0.746	11.46	18.6
CCC 500 ppm	1.86	0.189	2.15	0.166	0.673	0.839	11.62	20.5
1000 ppm	2.13	0.215	2.97	0.193	0.780	0.973	13.33	18.9
PP_{333} 25 ppm	1.88	0.201	2.66	0.180	0.710	0.890	11.73	18.1
50 ppm	2.40	0.241	2.73	0.193	0.763	0.956	14.98	21.1
L. S. D. 5%	**0.12**	**0.013**	**n.s**	**n.s**	**0.035**	**0.042**	**n.s**	**0.6**

Table (18): Effect of plant spacings, growth regulators and their interaction on chemical composition of potato tubers as % in 1997 season.

Characters / Treatments		N	P	K	Sugars reducing	Sugars non-reducign	Sugars Total	Total protein	Starch
15 cm		2.11	0.195	2.54	0.156	0.625	0.781	13.21	19.6
20 cm		2.13	0.211	2.69	0.164	0.657	0.821	13.31	18.6
L. S. D. 5%		**n.s**	**0.009**	**0.10**	**n.s**	**n.s**	**n.s**	**n.s**	**0.7**
Control	0 ppm	1.86	0.162	2.08	0.138	0.555	0.693	11.60	18.1
CCC	500 ppm	1.98	0.189	2.29	0.156	0.622	0.778	12.39	20.2
	1000 ppm	2.23	0.222	3.11	0.170	0.703	0.873	13.91	18.4
PP_{333}	25 ppm	2.00	0.207	2.72	0.166	0.652	0.818	12.51	19.6
	50 ppm	2.54	0.236	2.87	0.170	0.673	0.843	15.88	19.1
L. S. D. 5%		**0.12**	**0.009**	**0.07**	**0.010**	**0.024**	**0.032**	**0.54**	**0.6**
Growth regulators		**Spacing 15 cm**							
Control	0 ppm	1.77	0.140	2.02	0.146	0.593	0.739	11.04	18.4
CCC	500 ppm	2.00	0.179	2.23	0.166	0.650	0.816	12.48	20.9
	1000 ppm	2.21	0.220	3.06	0.166	0.700	0.866	13.81	18.7
PP_{333}	25 ppm	2.02	0.204	2.58	0.173	0.673	0.846	12.60	22.1
	50 ppm	2.58	0.234	2.80	0.166	0.673	0.839	16.10	17.9
		Spacing 20 cm							
Control	0 ppm	1.95	0.185	2.14	0.130	0.516	0.646	12.16	17.7
CCC	500 ppm	1.97	0.199	2.35	0.147	0.593	0.739	12.31	19.6
	1000 ppm	2.24	0.225	3.17	0.173	0.706	0.879	14.02	18.1
PP_{333}	25 ppm	1.99	0.211	2.86	0.160	0.630	0.790	12.42	17.2
	50 ppm	2.51	0.238	2.93	0.173	0.683	0.856	15.66	20.3
L. S. D. 5%		**n.s**	**0.012**	**n.s**	**0.012**	**0.035**	**0.045**	**n.s**	**0.8**

750 ppm increased N, P and K tuber contents. On the other hand, El-Sawy et al. (1988)[b] found that CCC at 500 ppm had no effect on N and P tuber contents. As for the effect of PP_{333}, El-Masry and Barakat (1991) found that increasing PP_{333} level up to 50 ppm significantly increased NPK tuber contents.

Concerning the effect of the interaction between plant spacing and growth regulators on N, P and K tubers content, it is clear from data in Tables (17 & 18) that growth regulators treatments either with 15 cm or 20 cm spacings increased N, P and K tuber contents. Variations reached the 5% level of significance only in case of N at the first season and P during both seasons. Generally, potato plants spaced either at 15 cm or 20 cm and sprayed with CCC at 1000 ppm or PP_{333} at 50 ppm produced the highest N, P and K tuber contents during both seasons as compared with other used treatments in this experiment.

B. Sugar Content :

Data presented in Tables (17 and 18) show the main effects of plant spacings, and growth regulators as well as their interaction on the content of reducing, non-reducing and total sugars of potato tubers at harvest time. It is clear from such data that although the 20 cm spacing tended to improve slightly reducing, non-reducing and total sugars tuber contents as compared with 15 cm spacing, differences did not reach the 5% level of significance mostly during both seasons of this study. Furthermore, spraying potato plants with tested growth regulators significantly increased reducing, non-reducing and total sugars content in their tubers compared with those of the control treatment. In this respect, using either CCC at 1000 ppm or PP_{333} at 50 ppm showed the highest values. This trend held true during both seasons in this experiment. Obtained results are in coincidence with those of Khalil (1990), who indicated that increasing CCC from 0 to 750 ppm increased reducing and total soluble sugars, meanwhile CCC at 500 ppm increased non-reducing content in the potato tubers. As for the effect of PP_{333}, obtained results are not in complete agreement with those of Zrust and Mica (1992), who found that PP_{333} at 250 g./L. decreased sucrose contents in tubers of potatoes.

Concerning the effect of the interaction between plant spacing and growth regulator treatments on reducing, non-reducing and total sugars content in tubers, data presented in Tables (17 & 18) show that increasing the concentrations of both CCC (from 500 to 1000 ppm) or PP_{333} (from 25 to 50 ppm) combined with planting either at 15 cm or 20 cm spacings significantly increased reducing, non-reducing and total sugars content in tubers at the two growing seasons. Data indicate also that the highest reducing, non-reducing and total sugars content were obtained in tubers of the plants spaced at 20 cm and sprayed with either CCC at 1000 ppm or PP_{333} at 50 ppm.

C. Total protein and Starch content:

Data in Tables (17 and 18) indicate that plant spacings did not induce any significant effects on total protein content in potato tubers in both growing seasons. Obtained results are in agreement with results reported by Vinay Singh et al. (1990), who found that protein content of tubers was unaffected by plant density. Meanwhile, tubers starch contents were significantly increased by increasing plant density (planting at 15 cm as compared with 20 cm) in both seasons. Obtained results are in agreement with those of Gronowicz et al. (1990) and Zielnska and Gronowicz (1991), who indicated that tuber starch content was increased with increasing plant density. On the other hand, obtained results are not in agreement with those of Chadchan et al. (1990) and Vinay Singh et al. (1990), who found that starch content of tubers was unaffected by plant density.

Concerning the effect of growth regulators application on total protein and starch content of tubers, data in Tables (17 and 18) indicate that using of all growth regulator treatments significantly increased total protein and starch contents of tubers in both seasons compared to the control. Moreover, potato plants sprayed with higher used rates of either CCC (1000 ppm) or PP_{333} (50 ppm) showed the highest total protein content. Meanwhile, using the lower used rate of both CCC (500 ppm) or PP_{333} (25 ppm) produced the highest starch content compared with other growth regulator treatments as well as untreated control treatments. Obtained results are in agreement with those of Khalil (1990), who found that increasing CCC up to 750 ppm increased tubers starch content. Meanwhile, Dimttrov and Stoinova (1992) found that spraying plants with 0.1% CCC had little effect on tuber starch content. Obtained results are supported by the finding of Shadeque and Pandita (1982), who reported that CCC at rate from 100 to 1000 ppm increased tubers protein content.

Concerning the effect of the interaction between plant spacing and growth regulator treatments on total protein and starch contents, data in Tables (17 and 18) clear that growth regulators with any concentrations combined with either low or high plant densities significantly increased tubers starch content. Meanwhile, total protein was not significantly affected in this respect during both seasons. Generally, plants spaced either at 15 cm or 20 cm and sprayed with PP_{333} at 50 ppm showed the highest total protein content of tubers. Moreover, plants spaced at 15 cm and sprayed with the lower used levels of either CCC (500 ppm) or PP_{333} (25 ppm) showed the highest tubers starch content as compared with all other treatments.

4.2.6. __Storageability studies:__

a. Weight loss:

Concerning the effect of plant spacing, growth regulator treatments and their interaction on percentages of weight loss during storage period, data presented in Table (19) and Fig. (3) clarify that increasing storage period generally increased

Table (19): Effect of plant spacing, growth regulators and their interaction on potato tubers weight loss percentages during the storage period.

Seasons / Characters / Treatments	1996						1997					
	% of weight loss on fresh weight basis after (days)											
	15	30	45	60	75	90	15	30	45	60	75	90
15 cm.	5.2	7.9	10.0	14.8	17.9	22.2	4.1	8.1	12.6	17.4	20.7	25.2
20 cm.	4.3	6.8	7.4	10.4	17.4	21.5	3.3	7.4	11.4	15.8	20.3	24.4
L.S.D. 5%	n.s	0.1	0.4	0.5	n.s	n.s	n.s	0.6	0.1	0.3	n.s	n.s
Control 0 ppm.	6.8	10.2	12.8	18.8	22.5	26.4	5.8	11.9	16.2	22.2	26.7	30.5
CCC 500 ppm.	5.3	7.8	10.1	15.1	18.5	24.1	4.2	8.2	12.2	17.1	20.9	25.8
1000 ppm.	3.4	5.7	7.5	11.4	15.6	19.5	2.4	6.1	10.4	14.4	18.3	23.1
PP_{333} 25 ppm	4.4	6.8	8.4	12.9	16.6	21.0	3.4	7.2	11.4	15.9	19.6	23.7
50 ppm	3.6	6.4	7.5	10.9	14.8	18.4	2.7	5.5	9.7	13.2	16.9	20.8
L.S.D. 5%	0.4	0.5	0.3	0.4	0.7	0.9	0.4	0.2	0.6	0.7	0.9	0.8
15 cm. Spacing												
Control 0 ppm.	7.8	11.5	14.1	20.1	23.6	27.0	6.8	12.1	16.6	22.6	26.7	30.2
CCC 500 ppm.	5.7	8.2	10.9	15.9	19.2	24.8	4.7	9.1	13.6	18.6	21.6	26.6
1000 ppm.	3.9	6.4	8.2	12.2	15.8	19.8	2.9	6.2	10.7	14.7	18.3	23.5
PP_{333} 25 ppm	4.8	7.5	9.1	14.1	16.3	21.1	3.8	7.4	11.9	16.9	19.7	23.7
50 ppm	3.5	6.0	7.5	11.5	14.4	18.4	2.5	5.7	10.2	14.2	17.5	22.0
20 cm. Spacing												
Control 0 ppm.	5.9	9.0	11.5	17.5	21.5	25.8	4.9	11.8	15.8	21.8	26.8	30.8
CCC 500 ppm.	4.8	7.5	9.2	14.2	17.8	23.4	3.8	7.3	10.9	15.7	20.2	25.0
1000 ppm.	2.9	5.1	6.7	10.7	15.4	19.2	2.0	6.0	10.2	14.2	18.3	22.7
PP_{333} 25 ppm	4.0	6.2	7.7	11.8	16.9	20.9	3.0	6.9	10.9	14.9	19.6	23.8
50 ppm	3.8	6.8	7.4	10.4	15.2	18.4	2.8	5.2	9.2	12.2	16.4	19.6
L.S.D. 5%	0.5	0.6	0.5	0.5	0.9	n.s	0.6	0.4	0.8	1.0	1.3	1.2

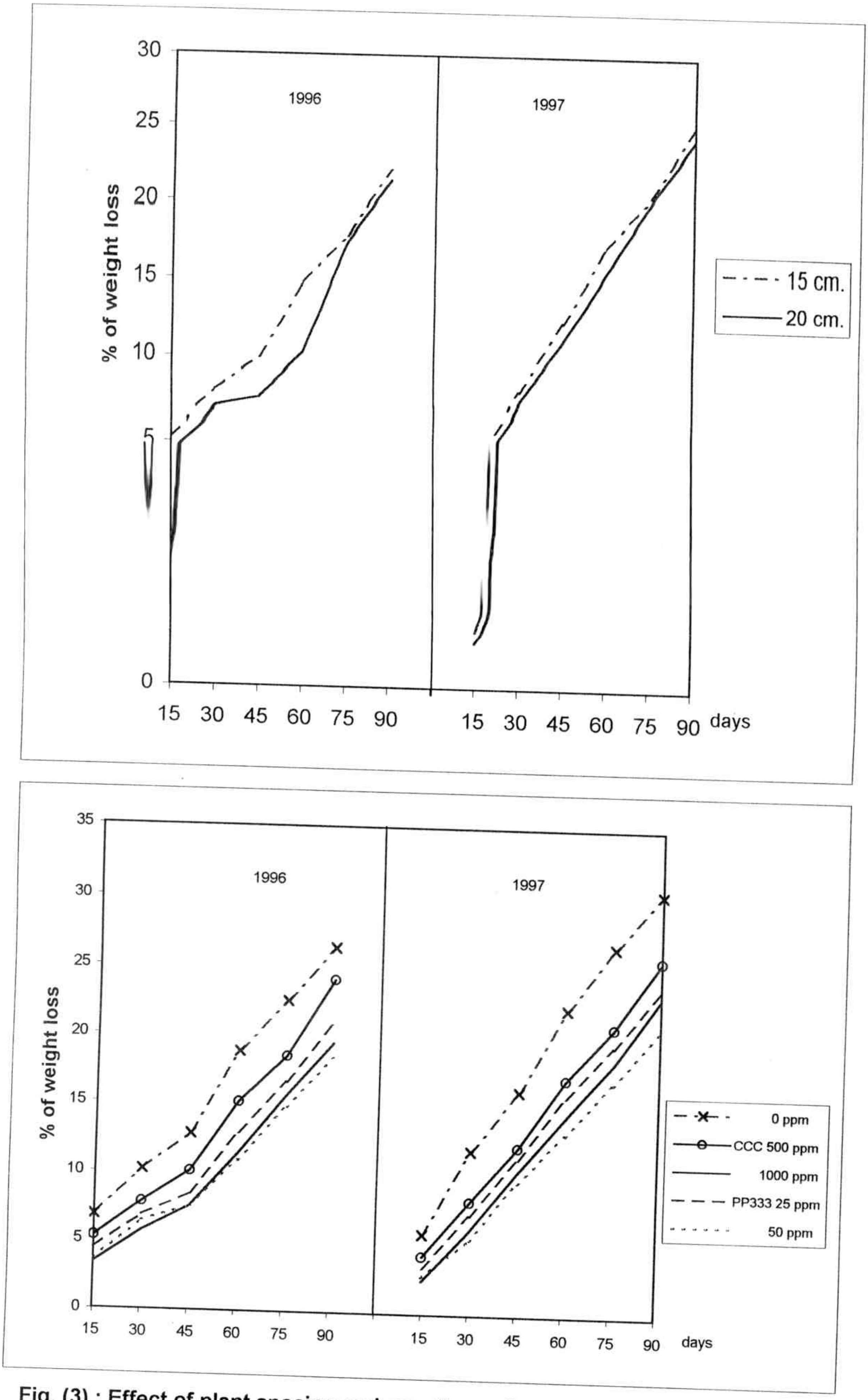


Fig. (3) : Effect of plant spacing and growth regulators on potato tubers weight loss percentages

percentages of tubers weight loss. It is evident from such data that increasing plant spacing from 15 to 20 cm decreased the percentages of weight loss during storage period. Moreover, variations reached the 5% level of significance after 30 days storage and continued until 60 days from storage beginning. This trend held true during both seasons of this investigation. Obtained results may be due to the favourable effect of wider spacing on tuber weight, and size [White et al. (1974), Pawlowski and Pomykalska (1991) and Cepl and Vokai (1995)]. Moreover, P, K and starch contents of tubers which were increased in tubers produced from wider spacing (20 cm) are considered as the main reason for improving tubers storageability [Gronowicz et al. (1990) and Zielnska and Gronowicz (1991)].

Concerning the effect of growth regualtor treatments on weight loss percentages of potato tuber during storage period, it is evident from the data in Table (19) and Fig. (3) that growth regulators previously applied to plants in the field significantly decreased weight loss percentages of produced tubers during storage compared with untreated ones. In this connection, although percentages of weight loss increased by increasing storage period, all growth regulator treatments tended to improve storageability of tubers. Moreover, the highest rate of both growth regulators (CCC at 1000 ppm or PP_{333} at 50 ppm) resulted in less weight loss percentages in this respect. Among all treatments, PP_{333} at 50 ppm showed the best results as compared with other growth regulator treatments and the control one. This trend held true in both seasons of this trial. Obtained agreement with those reported by El-Baz et al. (1979), who found that increasing CCC concentrations up to 1000 ppm decreased total loss during storage period.

As for the interactional effect between plant spacing and growth regulator treatments, data presented in Table (19) show that the plants spaced at 15 cm or 20 cm and sprayed with either CCC at 1000 ppm or PP_{333} at 50 ppm showed the lowest percentages of weight loss during storage period. Moreover, plants spaced at 20 cm and sprayed with PP_{333} at 50 ppm showed superiority concerning total loss percentages in their tubers at the end of storage period (90 days).

b. Sprouting and dry weight:

Data presented in Table (20) show the effect of plant spacing and growth regulator treatments as well as their interaction on sprouting and dry weight of potato tubers at the end of storage period. It is clear from such data that, although increasing plant spacing (20 cm) increased number of days for sprouting as compared with narrower spacing (15 cm), differences did not reach the 5% level of significance in this respect and in number of sprouts/tuber as well during both seasons in this investigation. Meanwhile, significant increases regarding tuber dry weight content as well as their percentages increase from the initial content before storage were detected at norrower spacing (15 cm) as compared wtih wider one (20 cm).

Table (20): Effect of plant spacing, growth regulators and their interaction on number of days for sprouting, No. of sprouts/tuber and dry weight at the end of storage period.

Seasons	1996				1997			
Characters / Treatments	No. of days for sprouting	No. of sprouts/ tuber	D.W %	% increase in dry weight	No. of days for sprouting	No. of sprouts/ tuber	DW %	% increase in dry weight
15 cm.	37.8	4.4	27.5	30.9	48.7	4.9	26.6	33.0
20 cm.	39.8	4.5	26.4	25.1	52.7	4.9	25.4	27.0
L.S.D. 5%	n.s	n.s	0.9	-	n.s	n.s	0.8	-
Control 0 ppm.	33.0	6.2	26.2	32.9	47.5	6.2	25.2	31.2
CCC 500 ppm.	39.3	4.3	28.2	27.7	50.0	4.3	27.2	30.1
1000 ppm.	42.6	4.7	25.8	18.8	49.2	5.3	24.8	22.1
PP_{333} 25 ppm	38.3	3.5	27.6	33.3	54.0	4.6	26.6	35.7
50 ppm	41.0	3.5	27.0	27.9	52.0	3.8	25.9	28.2
L.S.D. 5%	2.2	0.5	0.5	-	2.3	0.3	0.5	-
				15 cm. Spacing				
Control 0 ppm.	34.0	6.3	26.6	34.3	48.7	5.6	25.6	30.6
CCC 500 ppm.	39.3	4.3	28.8	31.5	44.7	4.3	28.0	33.9
1000 ppm.	42.6	4.6	26.2	22.4	45.7	5.3	25.2	25.3
PP_{333} 25 ppm	34.0	3.3	30.3	41.1	53.0	5.3	29.3	54.2
50 ppm	39.3	3.3	25.7	19.5	51.3	3.7	24.7	19.9
				20 cm. Spacing				
Control 0 ppm.	32.0	6.0	25.8	30.9	46.3	6.6	24.8	32.6
CCC 500 ppm.	39.3	4.3	27.5	23.3	55.3	4.3	26.5	27.4
1000 ppm.	42.6	4.6	25.4	15.4	52.7	5.3	24.4	19.0
PP_{333} 25 ppm	42.6	3.6	24.9	19.7	55.0	4.0	23.9	18.3
50 ppm	42.6	3.6	28.3	37.3	54.3	4.0	27.3	37.2
L.S.D. 5%	3.1	0.7	0.7	-	3.3	0.4	0.8	-

Concerning the effect of growth regulator treatments on number of days elapsed for sprouting appearance, number of sprouts/tuber and dry weight of potato tubers, it is evident from data in Table (20) that growth regulator treatments showed an improving effect on such parameters and consequently on storageability of potato tubers, hence it delayed the apperence of sprouts, reduced their number per each tuber and enhanced tubers content of dry matter. As a general conclusion, tubers produced from potato plants sprayed with either CCC at 1000 ppm or PP_{333} at 25 ppm showed superiority in this respect in most cases compared with other used treatments. This trend held true in both growing seasons of this experiment. Obtained results are in agreement with those of El-Baz et al. (1979) and Midan et al. (1986), who found that increasing CCC up to 1000 ppm reduced number of sprouts/tuber during storage. As for the effect of PP_{333}, Simko (1994) found that $PP_{333} > 100$ mg./L. totally inhibited sprouting. Also, Bandara and Tanino (1995) reported that PP_{333} at 450 mg/L. prolonged seed tuber dormancy by 3 weeks over the control.

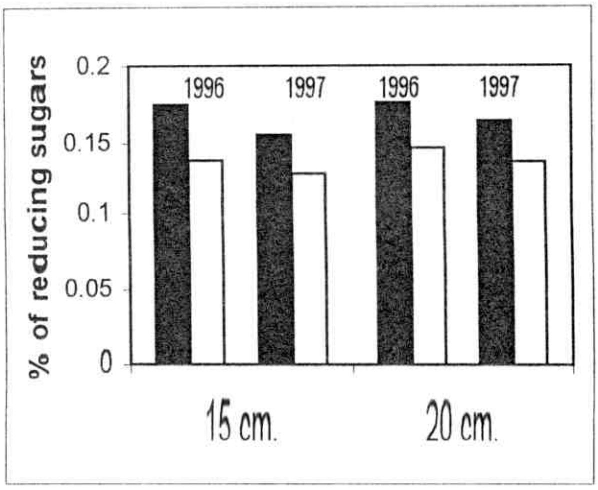
Concerning the effect of interaction between plant spacing and growth regulator treatments, data presented in Table (20) indicate that all used growth regulators treatments combined with either 15 cm or 20 cm spacings significantly delayed sprouts appearence, decreased number of sprouts/tuber and increased dry weight of potato tubers at the end of storage period as compared with the control treatment. Plants sprayed by PP_{333} 50 ppm combined with 20 cm spacing increased number of days for sprouting about 9.3 days, reduced number of sprouts/tuber about 40% and increased tubers dry weight about 14.2% as average during both seasons over than the control when potato plants were sprayed by PP_{333} 25 ppm combined with 15 cm spacing.

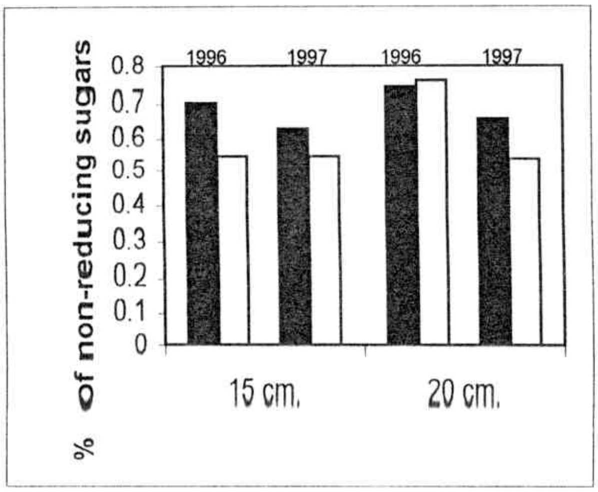
c. *Sugars and Starch content :*

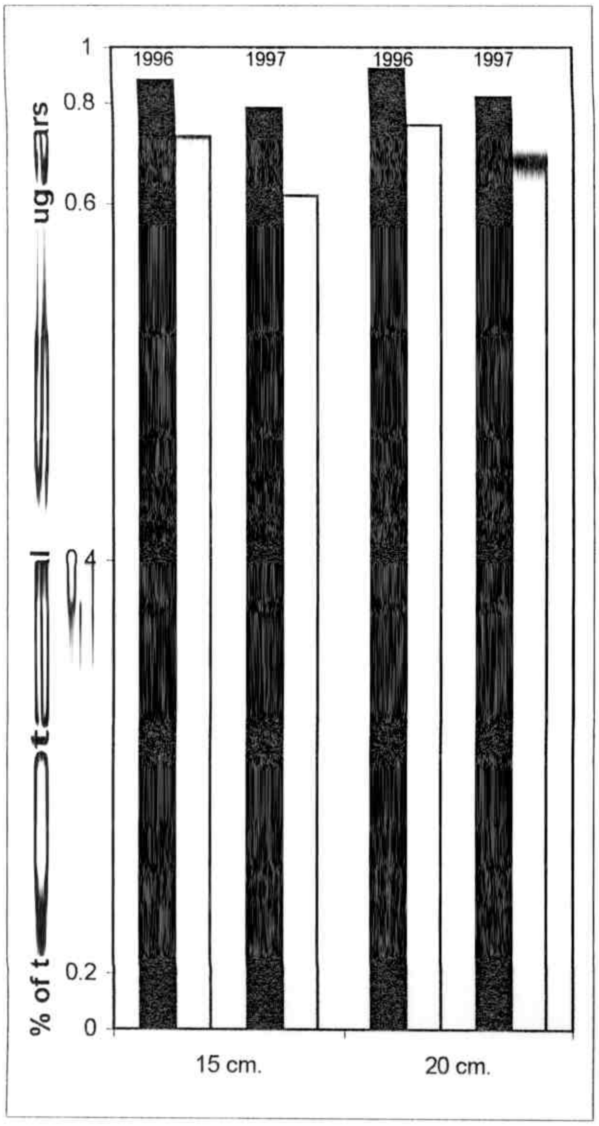
Data dealing with the effect of plant spacing, growth regulator treatments and their interation on percentages of reducing, non-reducing and total sugars as well as starch content of potato tubers, at 90 days after storage under room conditions, are presented in Table (21) and Fig. (4). It is evident that plant spacing had, in general, no significant effects on all sugar fractions as well as starch percentages during both seasons of this trial. Although, variations did not reach the 5% level of significance, planting at 20 cm tended to increase percentages of all sugar fractions and decrease those of starch as compared with 15 cm. It is worthy to mention herein that the amounts of all sugar fractions and starch as well (expressed as %) in potato tubers at the end of storage period i.e. 90 days (Table, 21) and Fig (4) were drastically reduced comparing with their corresponding initial values occured in tuber at harvest time (Tables, 17 and 18). This trend held true during both growing seasons of this study. Obtained results are in agreement with those of Gronowicz et al. (1990) and Zielnska and Gronowicz (1991), who reported that

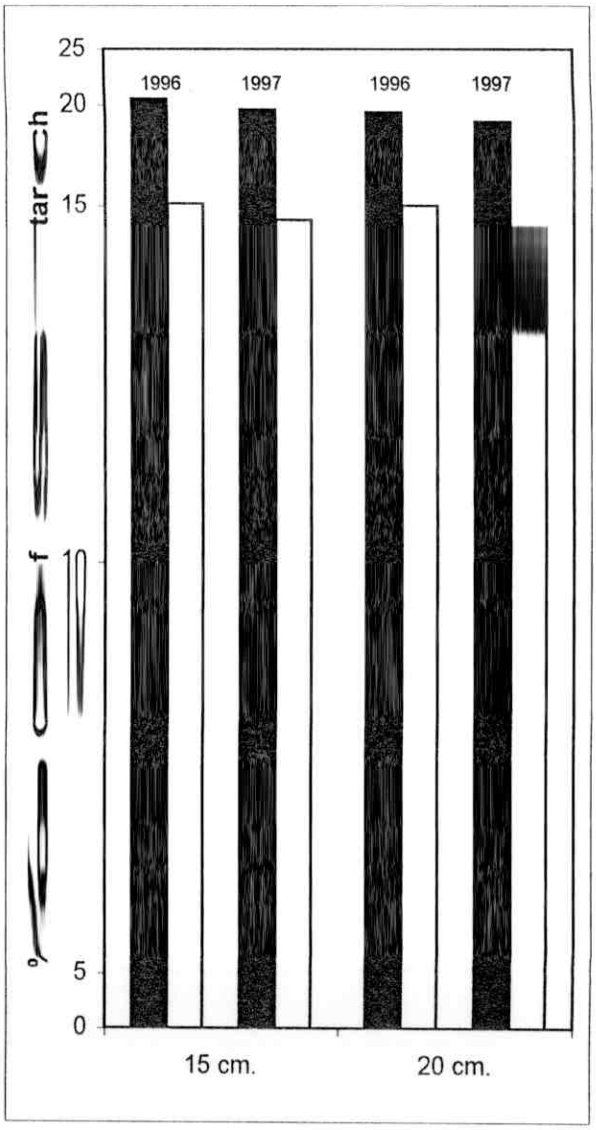
Table (21): Sugars and starch contents (% of dry weight) of potato tubers as affected by plant spacing, growth regua and their interaction at the end of storage period.

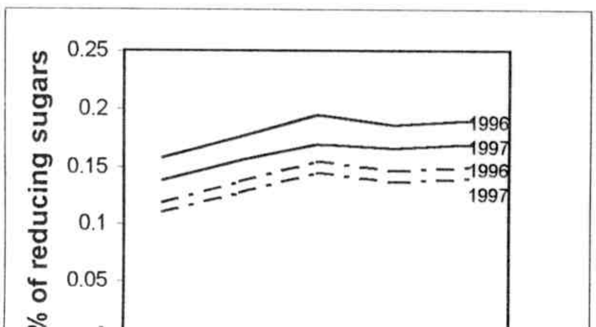
Seasons	1996				1997			
Characters / Treatments	Sugars			Starch	Sugars			Starc
	Reducing	Non-reducing	Total		Reducing	Non-reducing	Total	
15 cm.	0.137	0.545	0.682	15.2	0.127	0.504	0.631	13.8
20 cm.	0.146	0.577	0.723	15.1	0.136	0.537	0.673	13.3
L.S.D. 5%	n.s	n.s	n.s	n.s	n.s	n.s	n.s	0.4
Control 0 ppm.	0.118	0.475	0.593	14.4	0.110	0.433	0.543	12.8
CCC 500 ppm.	0.137	0.541	0.678	16.1	0.127	0.502	0.629	14.6
1000 ppm.	0.155	0.618	0.773	15.7	0.145	0.578	0.723	13.9
PP_{333} 25 ppm	0.147	0.576	0.723	14.9	0.137	0.536	0.673	13.4
50 ppm	0.150	0.593	0.743	14.7	0.140	0.553	0.693	13.2
L.S.D. 5%	0.007	0.024	0.030	n.s	0.008	0.024	0.032	0.7
15 cm. Spacing								
Control 0 ppm.	0.110	0.437	0.537	13.5	0.103	0.393	0.496	12.9
CCC 500 ppm.	0.126	0.513	0.639	16.4	0.117	0.473	0.590	14.6
1000 ppm.	0.153	0.620	0.773	15.9	0.143	0.580	0.723	14.3
PP_{333} 25 ppm	0.140	0.550	0.690	15.2	0.130	0.510	0.640	13.9
50 ppm	0.153	0.603	0.756	15.1	0.143	0.563	0.706	13.5
20cm. Spacing								
Control 0 ppm.	0.126	0.513	0.639	15.4	0.117	0.473	0.590	12.7
CCC 500 ppm.	0.146	0.570	0.716	15.8	0.137	0.530	0.667	14.5
1000 ppm.	0.156	0.617	0.773	15.6	0.147	0.577	0.724	13.4
PP_{333} 25 ppm	0.153	0.603	0.756	14.6	0.143	0.563	0.706	13.0
50 ppm	0.146	0.583	0.729	14.4	0.137	0.543	0.680	13.9
L.S.D. 5%	0.010	0.035	0.041	n.s	0.011	0.040	0.050	n.s

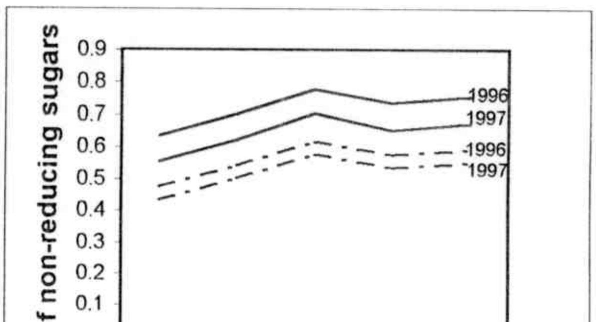

% of reducing sugars
0.2
0.15
0.1
0.05
0
1996
1997
1996
1997
15 cm.
20 cm.


% of non-reducing sugars
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1996
1997
1996
1997
15 cm.
20 cm.


1
0.8
0.6
0.4
0.2
0
1996
1997
1996
1997
15 cm.
20 cm.


25
20
15
10
5
0
1996
1997
1996
1997
15 cm.
20 cm.


% of reducing sugars
0.25
0.2
0.15
0.1
0.05
1996
1997
1996
1997


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1996
1997
1996
1997

increasing plant density increased tuber starch content which affects the tuber storageability.

Concerning the effect of growth regulators, data in Table (21) and Fig. (4) show that foliar application of CCC or PP_{333} significantly increased percentage of all sugar fractions during both seasons and starch content only in the second one as compared with the control treatment. Moreover, reducing, non-reducing as well as total sugars percentages were increased drastically with icnreasing CCC concentrations from 500 to 1000 ppm and to some extent from 25 to 50 ppm in case of PP_{333}. Meanwhile, opposite trend was obtained regarding tuber starch content which tended to decrease with increasing levels of both growth regulators, but it was still being over untreated control. Obtained results are in agreement with those of El-Baz et al. (1979) and Midan et al. (1986), who reported that CCC application improved specific gravity and prolonged the rest period of tubers which increased tuber storageability. Also, Simko (1994) and Bandara and Tanino (1995) found that PP_{333} improved tuber quality such as increasing starch content which affected storgeability.

Concerning the effects of the interaction between plant spacing and growth regulator treatments on reducing, non-reducing and total sugars as well as starch contents of potato tubers, data presented in Table (21) show, apart from spacing treatments, that potato plants sprayed with 1000 ppm CCC showed superiority in all sugar fractions in their tubers at storage end compared with other tested treatments during both seasons of this experiment. Meanwhile, insignificant effects were obtained in case of starch content. However, the highest values of starch tubers content was obtained with tubers of potato plants spaced at 15 or 20 cm and sprayed with 500 ppm CCC.

4.2.7. Effect of growth retardants on the subsequent Nili crop:

This study aims to know the residual effect of the growth retardants on the productivity of Nili plantation that planted using the seed tubers produced from the summer planting. This experiment has been done instead of the chemical assay that of the high coast.

Data on fall (Nili) yield and its components as affected by the residual effect of CCC or PP_{333} applied on potato foliage during the early summer season are presented in Table (22). It is obvious from such data that growth regulators application in the early summer season significantly increaased tuber yield as well as number and weight of tubers per plant of the subsequent Nili planting during both years of 1996 and 1997 as compared with untreated control. Moreover, cycocel treatment at 1000 ppm showed the most favourable effects in this respect compared to other growth regulator treatments or untreated plants (control). Obtained results may clarify the view that the residual amounts in plants and consequently in tubers of plants treated with CCC at rate of 1000 ppm were greater than 500 ppm. Meanwhile, the

Table (22): Subsequent fall (Nili) yield and its components as affected by the residual effect of growth regulators sprayed in the summer seasons of 1996 and 1997.

Season	1996				1997			
Characters / Treatments	No. of tubers/plant	yield / plant (g.)	Yield / plot (kg)	Total Yield/fad (ton)	No. of tubers/plant	yield / plant (g.)	Yield / plot (kg)	Total Yield/fad (ton)
Control 0 ppm	3.2	364.3	16.393	6.557	3.0	398.5	17.932	7.675
CCC 500 ppm	4.8	404.1	18.454	7.381	4.2	462.9	20.817	8.910
1000 ppm	5.8	429.1	19.363	7.745	5.0	487.2	21.923	9.383
PP_{333} 25 ppm	4.8	413.8	18.899	7.559	4.3	459.9	20.695	8.857
50 ppm	4.9	411.2	18.674	7.469	4.5	446.3	20.083	8.596
L. S. D. 5%	**0.71**	**12.0**	**1.097**	**0.438**	**0.5**	**13.6**	**0.699**	**0.262**

residual effect of PP_{333} was not greatly differed between both used concentrations (25 or 50 ppm).

Concerning the tubers grading as affected by residual effect of CCC or PP_{333} which were used in summer season, data are presented in Table (23). It is evident from such data that either CCC or PP_{333} at different concetnrations significantly and gradually increased total tubers number. It is obvious from such data that the number of medium sized tubers (36–45 mm) and that of large sized ones, (over 46 mm) as well as the total tubers number were increased by increasing both CCC or PP_{333} concentrations which were sprayed in early summer season on potato foliage. Moreover, cycocel at rate of 1000 ppm or pacobutrazol at rate of 25 or 50 ppm showed the highest values in this respect. However, variations between both growth regulators may be due to that the residual effect of CCC at 1000 ppm was more effective than that of PP_{333} which did not show differences between both concentrations (25 or 50 ppm). This trend opposited the findings of the effect of growth regulators on tubers size during summer season (Table, 15). In addition, regarding the effect of the residual effect of growth regulators on grade percentages, it is clear from such data in Table (23) that the percentages of large and medium tubers size were increased by increasing growth regualtor concentrations. Cycocel at 500 ppm or PP_{333} at 25 ppm produced the highest large sized tubers percentages in this concern. This trend held true during both growing Nili seasons.

Table (23) : Tubers grading of the subsequent fall (Nili) yield as affected by residual effect of growth regulators sprayed in the summer seasons of 1996 and 1997.

Seasons	1996							1997						
Characters / Treatments	Tubers size grades as No./plot			Tubers size grades as number %			Total tubers	Tubers size grades as No./plot			Tubers size grades as number %			Total tubers
Size	S*	M**	L***	S	M	L	number	S	M	L	S	M	L	number
Control 0 ppm	32.7	36.8	47.5	22.7	25.5	51.7	144.0	36.0	40.8	58.2	26.6	30.5	42.8	135.0
CCC 500 ppm	47.5	69.2	102.5	21.7	31.5	46.8	219.2	33.2	50.5	105.0	17.8	26.6	55.5	188.7
1000 ppm	54.7	86.7	120.2	20.9	33.1	45.9	261.6	45.0	66.5	113.5	20.0	29.7	50.3	225.0
PP_{333} 25 ppm	48.0	78.2	93.0	21.9	35.6	42.4	219.2	32.0	57.7	103.8	16.3	30.0	53.7	193.5
50 ppm	49.2	82.2	91.0	22.1	37.0	40.9	222.4	57.2	50.8	94.5	28.2	25.3	46.4	202.5
L.S.D. 5%	9.6	13.6	15.7	n.s	2.4	3.5	34.3	13.2	n.s	15.6	5.5	n.s	5.8	25.0

* S = Small size (28/35 mm.)
** M = Medium size (36 / 45 mm)
*** L = Large size(over 46 mm)

It can be generally concluded that planting potato seeds in summer season at 15 cm apart in combination with three times foliar sprays with either CCC at 1000 ppm or PP_{333} at 50 ppm may be recommended. Such treatments are advisable, as it produced the highest number of small and medium sized tubers which are being preferable for using as potato seeds for the following Nili seasons planting. Furthermore, such treatments were recognized at the early summer planting with the best total yield, physical and chemical properties of produced tubers with the best storageability.