Yield of Six Potato Cultivars after Two Cycles of Local Propagation in Libya

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ABSTRACT

The adaptability of six potato cultivars for repeated local propagation in Libya has been tested. Soaking seed tubers in gibberellic acid solution was tried to break the dormancy in tubers taken from the fall crop (harvested in January) to plant the next spring crop (planted in February). The effect of alar foliar spray on plants grown from GA-treated seed tubers was also tested.

Wide variation in yield was noted among different cultivars. The highest yield was obtained in cultivar Bintje without GA soaking, and the cultivars Redbad, Stania and Claudia whether unsoaked or soaked in 10 ppm GA for 15 minutes. The superiority of these three cultivars over the other tested cultivars (Jaerla and Aniel) could be due to resistance to virus diseases common in Libya.

INTRODUCTION

Potato is an important vegetable crop in Libya. It is grown in two main seasons. The first is the spring crop, planted during January to March using imported seed tubers and harvested during May and June. The second is the fall crop, planted in September by local seed tubers taken from the preceding spring crop after storing the tubers for about 3 months, and harvested during December and January. The yield of the fall crop is generally lower than that of the spring crop because of higher infection with virus diseases and some other factors.

Attempts to grow potatoes in the spring season by local seed tubers taken from the preceding fall crop are usually confronted by many problems. The most important problem is the dormancy of tubers. Actually there is no enough time left between date of lifting the fall crop and planting the next spring crop for breaking bud dormancy in the tubers. This is a problem not only in Libya, but also in all warm countries where two plantings are made in the same year (4).

The ability of gibberellic acid to break dormancy of the potato buds has been studied by several investigators (1,2,3,5,7,8,9). Dipping excised eyes of potato tubers in GA solutions is a convenient and rapid technique for use with large numbers of samples as a routine work for testing virus infection in tubers during the certification procedures

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of potato seed. Bruinsima *et al.* (3) described a method for breaking dormancy of potato tuber buds and for regulating the growth of the subsequent plants, particularly for use in inspection for the incidence of virus diseases. The methods consisted of dipping excised eyes in GA solution, usually 1 ppm for 10 minutes. In varieties with a naturally long dormancy period the concentration could be increased to 5 ppm, but when dormancy is only superficial and slender growth is anticipated, 100 to 500 ppm N-dimethylaminosuccinamic acid (B9) could be added to the soaking solution to suppress stem elongation. They also tested spraying the foliage with B9 solution to prevent etiolated growth in cultivars with superficial dormancy.

Imam and Butt (7) found that soaking of freshly harvested tubers of the cultivars, Sientje, Bintje, Patrones, King Edward, Alpha and Grata improved stand, increased length of stem and gave higher yields over the control.

Bodlaender (1) showed that GA shifted the tuber size distribution in favour of the smaller tuber sizes and increased the yield of seed tuber fractions (size 28–45 mm) substantially. Similar results were also obtained by Holmes (5).

The purpose of the present investigation is to study the growth and yield of six potato cultivars through successive cycles of local propagation. The effect of GA seed treatment and alar foliar spray on growth of plants was also tested when dormant seed tubers were used for planting.

MATERIALS AND METHODS

This investigation was conducted in the experimental farm of Faculty of Agriculture, Alfateh University in Tripoli, L.A.P.S.J. Six potato cultivars showing a range in earliness of maturity were used in the present investigation. Jaerla and Aniel are early maturing, Bintje and Claudia are medium, while Stania and Redbad are medium-late maturing under our local conditions. The spring crop of 1975 was planted on February 7 using imported seed tubers of class A, and was harvested on June 4, 1975. The fall crop was planted on October 2, 1975 by seed tubers taken from the spring crop of 1975. Harvest of the fall crop was done on January 14, 1976. The design used in these two plantings was randomized complete blocks with 6 replications. Each plot consisted of one row 5 meters long and 70 cms wide and containing 17 holes spaced at 30 cm apart in spring 1975, while plots were 6 meters long and containing 20 plants in fall 1975–76. Measurements on number of stems per plant, length of stems and number of nodes per stem were taken from 10 plants after 80 days from planting in both seasons.

In the spring season of 1976, planting was done on February 21, 1976 using seed tubers taken from the previous fall crop. Since these tubers were still dormant soaking in GA solutions of different concentrations before planting was tried. Spraying of foliage with alar (N-dimethylaminsuccinamic acid) to counteract etiolated growth that might occur from GA treatment was also tested. For each cultivar, the experiment was laid down in a split-plot design with seed soaking treatments as main plots and foliage spraying as subplots, with four replications. Each subplot consisted of one row 2.5 meters long and 70 cm wide and containing 8 plants spaced at 30 cm apart. Tubers from the six cultivars of average weight 50 gm were cut longitudinally and treated with one of the following treatments: 1) non-soaked; 2) soaked in 10 ppm GA for 15 minutes; 3) soaked in 10 ppm GA for 30 minutes; 4) soaked in 50 ppm for 15 minutes. After soaking, the solution was drained and the seed pieces were planted immediately. After 60 days from planting a solution of 2,500 ppm alar was sprayed on the foliage of plants in the sub-

plots devoted for this treatment. The number of plants in each whole plot was counted after 60 days from planting (just before spraying) to estimate the stimulation of sprouting by GA soak-treatments. The number of stems per whole plot was also counted and the average number of stems per plant was calculated. The length of stem and number of nodes per stem were recorded in all plots after 60, 90 and 110 days from planting. The average length of internode was calculated. Harvesting was done on June 24, 1976. Total weight and number of tubers per subplot were recorded and the average weight of tuber was calculated.

Data of all experiments were subjected to analysis of variance and means were compared using the LSD method as described by Steel and Torrie (10).

RESULTS AND DISCUSSION

1. Growth and yield during spring 1975

Table 1 shows some growth measurements and the yield of tubers for the six cultivars during the spring season of 1975. The yield of the cultivars under investigation ranged from 34.44 in cultivar Aniel to 41.67 (ton/ha) in cultivar Jaerla. The cultivar Aniel was significantly lower in yield than cultivars Jaerla and Redbad while no significant differences were obtained in other comparisons. The low yield of Aniel could be due to its early maturity which resulted from its growth type, in addition to its susceptibility to early blight disease on the foliage which resulted in early death of leaves and accordingly earlier maturity. The average number of stems per plant ranged from 2.8 in cultivar Claudia to 5.2 in cultivar Bintje. The lower number of stems per plant in Claudia could be due to planting physiologically young seed tubers as compared with other cultivars. No significant differences were noted among different cultivars with regard to number of nodes per stem.

2. Growth and yield during the fall 1975–76

The yield of tubers and some growth measurement for the plants in the fall season 1975–76 are also shown in Table 1. It is clear that a sharp drop in yield occured in all cultivars tested as compared with the spring planting. The lowest yields were obtained in cultivars Bintje and Aniel and the highest in Stania, Claudia and Redbad. The severe

Table 1 Growth measurements and yield in six potato cultivars in spring 1975 and fall 1975–76.

	Spring 1975				Fall 1975–76			
Cultivar	No. of stems/ plant	Stem length cm	No. of modes/ stem	Average yield (Ton/ha)	No. of stems/ plant	Stem length cm	No. of nodes/ stem	Average yield (Ton/ha)
Jaerla	4.4	47.4	10.4	41.72	2.67	30.50	11.00	14.80
Aniel	3.2	31.0	10.0	34.44	3.33	32.50	10.66	11.97
Bintje	5.2	43.3	9.0	38.12	4.17	36.58	9.33	11.73
Claudia	2.8	39.4	12.6	38.10	4.17	38.17	10.66	16.59
Stania	5.2	47.8	9.2	40.94	2.42	39.33	10.33	16.43
Redbad	3.8	48.8	10.4	38.84	2.42	35.50	10.00	21.54
L.S.D. 0.05	1.45	6.51	n.s.	5.48	1.62	5.82	n.s.	4.89

drop in yield could be due to several factors among which the higher rate of virus infection, partial dormancy in seed tubers and the short days may be the most important. The cultivars Stania, Claudia and Redbad which showed the least reduction in yield may be considered more resistant to the unfavorable conditions of the fall crop. The adaptability of Redbad to these conditions was previously reported (6). Although Jaerla showed adaptability to the fall planting in previous years, its yield in the fall season of the present investigation was not in the top.

3. Growth and yield during spring 1976

A. Effect of GA Soak-treatments on Number of Sprouting Plants

As shown in Table 2 and Figure 1, soaking the seed tubers in GA solutions resulted in a significant increase in number of successful holes per row in cultivars, Jaerla and Stania. In these two cultivars, highly significant increase in number of plants over the control was obtained when seed tubers were soaked in 10 ppm GA for either 15 or 30 minutes. Increasing the concentration to 50 ppm gave better sprouting over the control but the effect was not as high as the 10 ppm concentration. In cultivar Claudia, there were no significant differences between the control and soaking in 10 ppm GA for either 15 or 30 minutes. However, soaking in 50 ppm GA gave significant decrease in number of sprouting plants. The cultivars Aniel and Redbad showed no significant differences among all the tested soak-treatments, with a slight increase in number of plants in 10 ppm treatment over both 50 ppm treatment and the control. The cultivar Bintje, Although not significantly affected with regard to number of sprouting plants, it showed a noticeable reduction in number of plants in all GA treatments as compared to the control. It seems that the 10 ppm and 50 ppm GA concentrations had a deletrious effect on sprouting in tubers of the cultivar Bintje under the conditions of the present investigation (tubers stored for one month in temperature ranging between 6 and 20°C). These results may also indicate that the cultivars Aniel, Bintje and Redbad either have a relatively short dormancy period, or that the sprouting of tubers in these cultivars is not efficiently enhanced by GA treatment.

As an overall average of all the GA soak treatments, the cultivars Claudia, Bintje, Stania and Redbad were higher than the cultivars Jaerla and Aniel with respect to number of sprouting plants. This may indicate that the tubers of the former four cultivars had a better sprouting ability after two cycles of local propagation.

B. Effect of GA Soak-treatments on Elongation of Plants

Measurements of stem length at different intervals during the growing period as affected by the different GA soak-treatments in the six cultivars (Fig. 2) have indicated

Table 2 Average number of plants per whole plot (16 holes) after 60 days from planting in spring 1976.

	GA treatment				L.S.D.	
Cultivar	Control	10 ppm 15 min.	10 ppm 30 min.	50 ppm 15 min.	0.05	0.01
Jaerla	9.75	13.75	14.75	11.50	1.653	2.254
Aniel	11.50	12.75	12.25	11.25	n.s.	—
Bintje	15.00	12.75	12.25	13.50	n.s.	—
Claudia	14.75	14.50	14.22	11.50	1.390	1.890
Stania	10.50	15.00	15.00	13.25	1.043	1.422
Redbad	13.00	13.25	13.75	13.00	n.s.	—

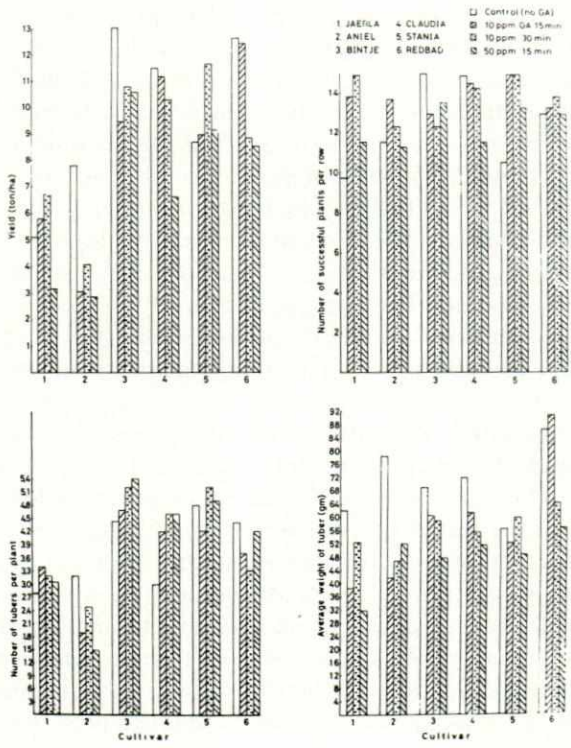

Fig. 1. Yield and yield components in six potato cultivars as affected by different GA soak treatments.

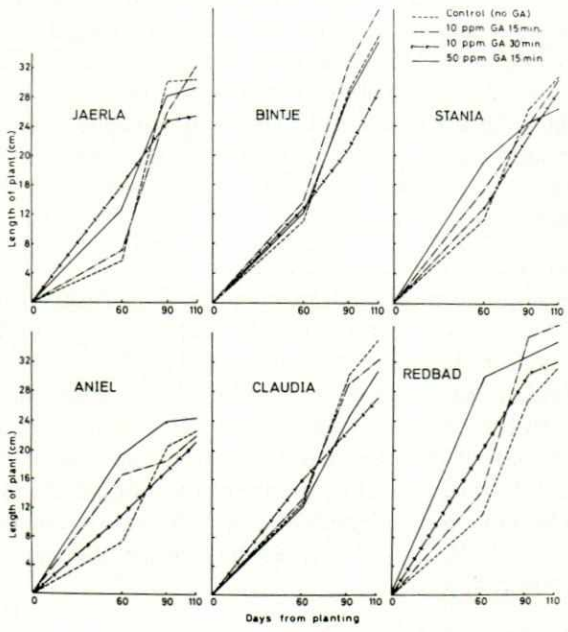

Fig. 2. Length of plants in six potato cultivars after 60, 90, and 110 days from planting as affected by different GA soak treatments.

that GA soak treatments resulted in significant elongation of the stems during the first 60 days from planting in the cultivars Jaerla, Aniel, Stania and Redbad, while the cultivars Bintje and Claudia did not show increased elongation by GA treatments. The highest rate of elongation during this early period was observed in the 50 ppm soaking treatment in the cultivars Aniel, Stania and Redbad, Observations on the general shape of plants in the field showed that some plants of the cultivars Jaerla, Aniel and Redbad grown from GA-soaked tubers had etiolated growth with very slender stems and either scale leaves or small compound leaves with very narrow leaflets. However, these abnormal symptoms gradually disappeared and such plants approximated normal growth in later stages of development. Photographs of plants from the GA soak treatments are shown in Figure 3 for cultivars Jaerla, Bintje and Stania after 65 days from planting.

During the period 60 to 90 days from planting, the rate of elongation of the control plants showed a considerable acceleration over most of the soaked treatments especially in Jaerla, Claudia and Stania. In Redbad, the control showed slower elongation in this period as compared to the other treatments. Cultivars Bintje and Aniel showed intermediate situation. Slowing of growth after initial rapid elongation resulting from GA treatment in most of the tested cultivars is in general agreement with the findings of Madec and Perennec (8) who noted that enhanced sprouting and stimulated early growth induced by eye excision and GA soaking may be nullified at later stages.

Near the end of the growing period (June 5, 1976), the length of the stem in different GA treatments within each cultivar became close to each other especially in cultivars Aniel and Stania. This would indicate that the high rate of elongation in early stages of growth induced by GA soaking was completely nullified near the end of the growing period.

As shown in Figure 4, soaking in 50 ppm GA for 15 minutes gave the highest internode length in all cultivars through all examination dates except in cultivar Claudia where no clear difference was obtained among the different treatments. On the other hand, the unsoaked control treatment gave the shortest internode length in all cultivars except Bintje and Claudia. The significant increase in internode length by GA treatment agrees with the present knowledge about the effect of GA on stem growth (11). The insignificant response of the cultivars Bintje and Claudia may be due to either a relatively less sensitivity of these cultivars to GA with regard to internode elongation, or that the concentrations used in the present investigation were outside the range that induces internode elongation in these two cultivars.

C. Effect of Alar Foliar Spray on Stem Elongation

Spraying the plants with alar after 60 days from planting arrested the elongation of the stems. The dwarfing effect lasted until the end of the growing period in all cultivars. As shown in Table 3, measurements of stem length after 110 days from planting clearly indicates that alar foliar spray significantly reduced stem length in all cultivars tested. Field observations on the deepness of the green color of the foliage showed that the sprayed plants were darker in color than the non-sprayed plants. These findings are in general agreement with the dwarfing nature of this compound (11).

Significant reduction in average length of internode was obtained by alar foliar spray in cultivars Jaerla and Redbad (Table 4). Such reduction did not reach the significant level in the other four cultivars.

D. Effect of GA Soaking on Number of Stems per Plant

As shown in Table 5, GA soak treatments gave significant increase in number of stems per plant over the control in cultivars Jaerla, Bintje, Stania and Redbad. On the

Fig. 3. Photographs of representative plants from the four tested GA soak treatments in cultivars Jaerla, Bintje, and Stania after 65 days from planting. 1) unsoaked control; 2) 10 ppm GA for 15 minutes; 3) 10 ppm GA for 30 minutes; 4) 50 ppm for 15 minutes.

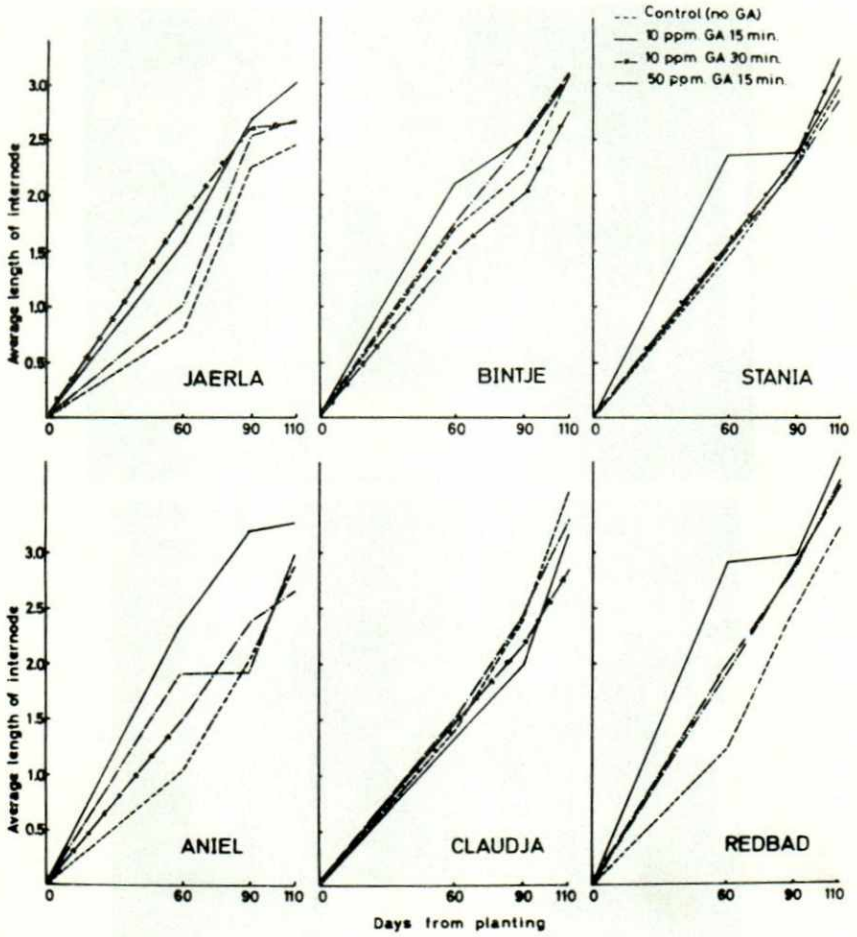

Fig. 4. Average length of internode in six potato cultivars after 60, 90, and 110 days from planting as affected by different GA soak treatments.

Table 3 Effect of GA tuber soaking and alar foliar spray on length of stems (cm) after 110 days from planting in spring 1976.

	Sprayed with 2500 ppm alar				Non-sprayed				L.S.D. for spraying	
Cultivar	No GA	10 ppm 15 min.	10 ppm 30 min.	50 ppm 15 min.	No GA	10 ppm 15 min.	10 ppm 30 min.	50 ppm 15 min.	0.05	0.01
Jaerla	18.25	25.50	21.75	25.00	35.75	34.50	28.50	33.25	0.934	1.271
Aniel	19.75	18.75	18.75	19.00	25.50	25.25	23.75	25.00	1.323	1.801
Bintje	29.50	34.00	27.75	26.25	39.25	47.25	30.50	41.00	1.020	1.387
Claudia	31.00	26.25	24.25	28.25	39.00	38.00	30.50	33.50	0.987	1.339
Stania	27.25	24.25	27.50	22.50	34.50	37.25	33.00	31.00	0.805	1.096
Redbad	24.75	31.50	25.50	29.00	37.75	39.25	38.75	34.00	1.148	1.563

L.S.D. for soaking in cultivar Bintje = 2.038
L.S.D. for soaking in all other cultivars n.s.

Table 4 Average length of internode (cm) in plants after 110 days from planting as affected by GA tuber soaking and alar foliar spray in spring 1976.

	Sprayed with 2500 ppm alar				Non-sprayed				L.S.D. for spraying	
Cultivar	No GA	10 ppm 15 min.	10 ppm 30 min.	50 ppm 15 min.	No GA	10 ppm 15 min.	10 ppm 30 min.	50 ppm 15 min.	0.05	0.01
Jaerla	2.33	2.49	2.50	3.05	2.95	2.82	2.78	3.09	0.059	—
Aniel	2.81	2.90	2.80	2.97	2.92	3.08	2.70	3.71	n.s.	—
Bintje	2.75	3.06	3.93	2.78	3.42	3.41	2.48	3.38	n.s.	—
Claudia	3.25	2.77	2.49	3.00	3.47	2.98	2.78	3.19	n.s.	—
Stania	2.66	2.78	3.33	2.91	3.26	2.94	3.16	3.31	n.s.	—
Redbad	2.85	3.00	3.00	3.22	3.84	3.49	3.63	3.65	0.109	1.48

L.S.D. 0.05 for soaking in cultivar Claudia = 0.119.
L.S.D. 0.01 for soaking in cultivar Claudia = 0.162.
L.S.D. 0.05 for soaking in all other cultivars n.s.

other hand, cultivars Aniel and Claudia were not significantly affected. Insignificant reduction in number of stems per plant was noted in cultivar Aniel when soaked in either 10 ppm for 30 minutes or in 50 ppm as compared with the control. The increase in number of stems per plant by GA treatment in four cultivars in this investigation is in agreement with other reports (1,2,5,7,12).

It is noted that the average number of stems per plant in all treatments of spring 1976 was lower than that obtained in spring 1975 and fall 1975–76. This would indicate that the physiological age of tuber is the main factor affecting the number of stems per plant. The increase in number of stems per plant obtained by GA treatment of dormant tubers is far less than that obtained by storing the tubers for an adequate time to break the bud dormancy.

E. Effect of GA Tuber-soaking and Alar Foliar-spray on Yield of Tubers

Significant effects of GA soak treatment and alar foliar spray on yield of tubers were obtained in cultivars Jaerla, Aniel and Redbad (Table 6). In these cultivars, no significant beneficial response in yield was achieved by soaking in 10 ppm GA solution, while significant reduction in yield was obtained by soaking in 50 ppm GA. However, in the cultivar Jaerla, slight increase in yield was obtained by soaking tubers in 10 ppm GA for

Table 5 Number of stems per plant in different GA soak treatments.

					L.S.D.	
Cultivar	Control	10 ppm 15 min.	10 ppm 30 min.	50 ppm 15 min.	0.05	0.01
Jaerla	1.023	1.330	1.480	1.418	0.1864	—
Aniel	1.478	1.325	1.10	1.120	n.s.	—
Bintje	1.070	1.443	1.170	1.610	0.2500	—
Claudia	1.350	1.230	1.158	1.288	n.s.	—
Stania	1.075	1.420	1.183	1.425	0.0864	0.1178
Redbad	1.045	1.418	1.160	1.508	0.2080	—

Table 6 Effect of GA tuber soaking and alar foliar spray on yield (ton/ha) in spring 1976.

	No. GA		10 ppm 15 min.		10 ppm 30 min.		50 ppm 15 min.		L.S.D. for soaking[a]	
Cultivar	Spray	Non-	Spray	Non-	Spray	Non-	Spray	Non-	0.05	0.01
Jaerla	4.492	5.603	5.985	5.643	7.068	6.356	2.822	3.523	2.274	—
Aniel	7.353	8.322	3.363	2.793	4.532	3.648	2.138	3.494	0.688	0.936
Bintje	11.970	14.022	7.581	11.343	11.856	9.690	9.918	11.172	n.s.	—
Claudia	11.172	11.742	11.856	11.001	10.602	9.861	7.410	5.871	n.s.	—
Stania	9.405	7.923	10.517	7.581	11.970	11.280	9.462	8.778	n.s.	—
Redbad	14.136	12.141	12.540	13.053	10.317	7.353	7.923	9.063	3.877	—

[a] L.S.D. for alar spraying in all cultivars n.s.

30 minutes. The response to GA soaking was not significant in cultivars Bintje, Claudia and Stania. The general trend in the cultivar Stania was a slight increase in yield over the control by soaking in 10 ppm solution and a reduction in yield below the control in the 50 ppm soaking. Cultivars Bintje and Claudia showed insignificant decrease in yield in all GA-soak treatments as compared to the control.

It may be concluded that the slight increase in yield obtained in cultivars Jaerla and Stania by 10 ppm GA soaking could be mainly due to an increase in number of successful holes per row which resulted from enhancing the sprouting of tubers in these two cultivars by GA in these two cultivars (Table 2).

The analysis of variance for the effect of alar foliar spray at a concentration of 2,500 ppm after 60 days from planting did not give any significant change in yield in all cultivars tested.

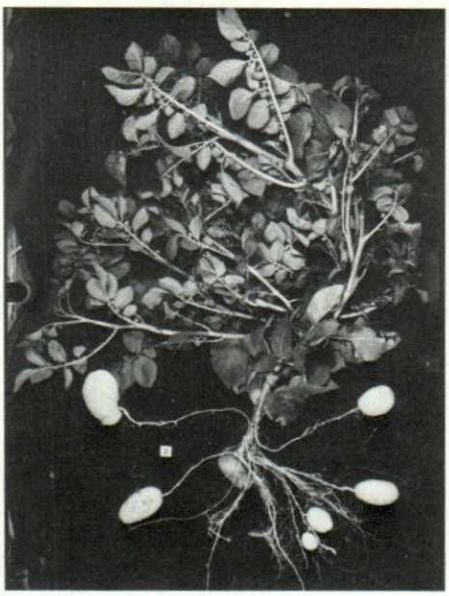

Fig. 5. Photograph of a plant from cultivar Redbad treatment with 10 ppm GA for 15 minutes and unsprayed with alar, after 100 days from planting, showing good vegetative growth, good tuber development, and excessive long stolons.

Table 7 Effect of GA tuber soaking and alar foliar spray on average weight of tuber (gm) in spring 1976.

	No. GA		10 ppm 15 min.		10 ppm 30 min.		50 ppm 15 min.		L.S.D. for soaking[a]	
Cultivar	Spray	Non-	Spray	Non-	Spray	Non-	Spray	Non-	0.01	0.05
Jaerla	78.33	65.62	54.88	42.35	52.29	49.79	33.79	29.83	7.072	9.625
Aniel	76.05	58.85	37.35	46.04	42.03	51.85	58.68	45.78	7.448	10.138
Bintje	76.03	62.27	61.23	60.19	67.58	50.37	49.74	45.73	n.s.	—
Claudia	65.37	49.05	57.22	65.99	59.04	52.97	55.33	48.37	n.s.	—
Stania	91.86	81.48	95.33	86.97	76.12	52.70	54.92	58.93	n.s.	—
Redbad	58.05	55.63	59.65	45.15	53.76	66.57	52.31	45.53	6.460	8.793

[a] L.S.D. for spraying in all cultivars n.s.

Wide variation in yield was noted among different cultivars. The highest yield was obtained in cultivar Bintje without GA soaking, and the cultivars Redbad and Claudia whether unsoaked or soaked in 10 ppm GA for 15 minutes. This could be due to less virus infection in these cultivars as compared with the other tested cultivars. This may suggest that the cultivars Bintje, Claudia and Redbad could be promising varieties when growing a spring crop from locally produced seed taken from the preceding fall crop is intended. A plant representing the 10 ppm soak for 10 minutes treatment and unsprayed with alar in the cultivar Redbad after 110 days from planting is shown in Figure 5. It shows good vegetative growth and good tuber development, but with excessively long stolons. The elongation of stolons may be a result of GA treatment and/or high temperature prevailing during tuber development.

The average weight of tuber showed a highly significant response to GA soaking in cultivars Jaerla, Aniel and Redbad (Table 7). Tuber weight was drastically reduced in these cultivars by GA treatment. The reduction was more pronounced in 50 ppm treatment than in the other two treatments. The average weight of tuber in the cultivars Bintje, Claudia and Stania was less affected by GA soaking. Other investigators (1,5) have indicated that, in most cases, total yield was not affected by GA soaking but the fraction of small-size tubers was significantly increased.

Soaking seed tubers in different concentrations of GA did not have any significant effect on number of tubers per plant in all cultivars tested (Table 8).

Table 8 Effect of GA tuber soaking and alar foliar spray on average number of tubers per plant in spring 1976.

	No. GA		10 ppm 15 min.		10 ppm 30 min.		50 ppm 15 min.		L.S.D. 0.05 for
Cultivar	Spray	Non-	Spray	Non-	Spray	Non-	Spray	Non-	spraying[a]
Jaerla	2.270	2.990	3.393	3.405	3.290	3.040	3.043	3.685	n.s.
Aniel	3.460	3.903	2.423	1.768	1.445	3.428	1.798	1.180	n.s.
Bintje	3.840	5.143	4.095	5.880	4.768	4.953	4.390	7.508	0.3494
Claudia	4.050	4.213	5.100	3.960	4.355	4.430	4.265	4.520	n.s.
Stania	4.453	5.360	4.693	3.730	5.668	4.510	4.655	5.115	n.s.
Redbad	4.105	3.905	3.498	3.923	3.413	3.203	4.490	3.833	n.s.

[a] L.S.D. for GA soaking in all cultivars n.s.

Although foliar spray with alar did not have significant effect on either total yield or overage weight of tuber, it was noted that alar foliar spray resulted in a significant decrease in number of tubers per plant in the cultivar Bintje. The other five cultivars did not show significant response to alar foliar spray with regard to yield or yield components.

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