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ELIMINATING POTATO SEED TUBER STORAGE FOR ISFAHAN AREA

A. SEPAHI AND A. ISLAMI[1]

Potato Research Project of Isfahan University. Department of Biology. University of Isfahan, Isfahan, Iran.

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ABSTRACT

Three experiments were carried out at the university farm 24 km east of Isfahan to investigate the possibility of eliminating potato seed tuber storage in the area. Twenty five potato cultivars were planted in single-row observation plots in the fall of 1985. The high percent emergence and yield of some of the cultivars indicated the feasibility of fall planting in Isfahan. In the fall of 1986, twenty three cultivars were planted in a split-plot design with three replications. The main plots were assigned to the dates of initial irrigation in the following spring. Date of initial irrigation had no effect on percent emergence and yield. In 1987-88, fall planting was compared with spring planting in a split-plot design with five replications, using twelve cultivars from the previous experiment. Fall and spring plantings were assigned to the main plots and cultivars to the sub-plots. Fall planting resulted in earlier emergence, slightly lower percent emergence and no change in yield. However, there were significant interactions between date of planting and cultivar, regarding some of the components, measured. Cultivars Baraka, Atzimba, Prima, Spartan, Marfona and Aola showed no decrease in percent emergence due to fall planting. Baraka and Romano had higher yields per plant when planted in the fall. Cultivars Romano, Baraka, Aola, Atzimba, Anosta and Cosima seem to be suitable for fall planting.

1- *Assistant Professor and Instructor, respectively.*

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حذف انبارداری غده بذری سیب‌زمینی در منطقهٔ اصفهان

علیرضا سپاهی و عبدالحسین اسلامی
به ترتیب استادیار اصلاح نباتات و کارشناس گروه زیست‌شناسی دانشگاه اصفهان، اصفهان، ایران.

چکیده

جهت بررسی امکان حذف انبارداری غده بذری در منطقه از طریق کاشت پاییزه، سه آزمایش در مزرعهٔ تحقیقاتی دانشگاه در ۲٤ کیلومتری شرق اصفهان صورت گرفت. در پاییز ۱۳٦٤ بیست و پنج رقم در کرت‌های یک ردیفه مشاهداتی کاشته شد. درصد سبز شده و عملکرد بالای برخی از ارقام حاکی از امکان موفقیت این روش کاشت برای منطقه اصفهان بود. در پاییز ۱۳٦۵ بیست و سه رقم طبق یک طرح اسپلیت پلات در سه تکرار کاشته شد. کرت‌های اصلی به تاریخ شروع آبیاری در بهار و کرت‌های فرعی به ارقام اختصاص داده شد. تاریخ شروع آبیاری اثری روی درصد سبز شدن و عملکرد نداشت. در سالهای ٦٦ و ٦۷ بین کاشت پاییزه و بهاره مقایسه به عمل آمد. دوازده رقم انتخاب شده از آزمایش سال قبل در یک طرح اسپلیت پلات در پنج تکرار کاشته شد. کرت‌های اصلی به تاریخهای کاشت و کرت‌های فرعی به ارقام اختصاص داده شد. کاشت پاییزه منجر به جوانه‌زدن زودتر، تقلیل درصد سبز شده و عدم تغییر در عملکرد گردید. اثرات متقابلی بین تاریخ کاشت و رقم در رابطه با برخی از صفات وجود داشت. در مورد ارقام باراکا، آتزیمبا، پریما، اسپارتن، مارفونا و آنولا کاشت پاییزه تقلیلی در درصد سبزشده را موجب نشد. کاشت پاییزه در رابطه با ارقام باراکا و رومانو منجر به عملکرد در بوته بیشتر گردید. ارقام رومانو، باراکا، آنولا، آتزیمبا آنوستا و کوزیما برای کاشت پاییزه مناسب به نظر می‌رسند.

INTRODUCTION

Production costs per hectare of potato for 26 African, Latin American and Far Eastern countries were estimated as 7.5 and 4.5 times those of wheat and rice, respectively. For some of the South American countries, 31.3% and for

some of the Asian countries 44.2% of the production costs were attributed to seed (11). In Iran cold storage costs are about 20,000 Rls. per ton, *i.e.* about 25% of the seed cost. Seed tubers frequently need to be stored for up to nine months resulting in high storage losses due to maintaining the seed well beyond its natural dormancy (9). Reduction in yield due to advanced physiological age as a result of high storage temperature (5,6,10), more infection with *Alternaria solani* due to low storage temperature (7), and higher weight losses under diffused light storage conditions (4) have been reported. Eight fungal and one bacterial diseases (2) and potato tuber moth (8) have been reported as some of the major causes of storage losses. This study was carried out to investigate the possibility of fall planting of potatoes in Isfahan region, thus avoiding storage costs and losses and taking advantage of the more convenient fall planting and making use of the favorable soil temperature for commencement of growth late in winter when the fields are too wet for planting.

MATERIALS AND METHODS

The study consisted of three experiments which were carried out at the university farm 24 km east of Isfahan.

Experiment I, 1985-86

This was a preliminary experiment to investigate the possibility of fall planting of potatoes in Isfahan area. Twenty five cultivars were planted in 5-m single dash row observation plots with no replications on Nov. 3, 1985. Three hundred kg of ammonium phosphate and 100 kg of urea per hectare were applied to the field at planting. Fifteen tubers were planted per row. The rows were 75 cm apart and left to overwinter with no irrigation till next spring. The first irrigation was done on March 3, 1986. Weed control and other cultural practices common to the area were carried out. At the time of last hilling, 200 kg ha^{-1} of urea was applied as side dressing. The plots were harvested on July 13, 1986. Percent emergence and yield per plant were determined.

Experiment II, 1986-87

This experiment was carried out to screen the cultivars suitable for fall planting and also to determine the date of initial irrigation in spring. Twenty six cultivars including 23 cultivars from the first experiment, were compared in a split-plot design with three replications. The two main plots in each replication were assigned to two dates of initial irrigation, i.e. Feb. 7, and March 4, 1987. Cultivars were assigned to sub-plots. The plots were planted on Nov. 10, 1986. The size of plots, spacings, fertilizer application and other cultural practices were as explained in Experiment I. Plots were harvested on Aug. 3, 1987. Date of 50% emergence and flowering, the percent of plants emerged and yields per plant were determined.

Experiment III, 1987-88

In this experiment, fall planting was compared with spring planting. Twelve cultivars selected from the last experiment were compared in a split plot design with five replications with the two main plots assigned to fall and spring plantings. The 7.5 m single-row plots contained 25 tubers. The fall and spring plantings were done on Nov. 11, 1987 and March 5, 1988, respectively. The plots were irrigated on March 5, 1987. Fertilizer application and other cultural practices were carried out as previous experiments. Dates of 50% emergence, 50% flowering and maturity; percent emergence and number of stems per plant were determined. To compare the growth rate in different treatments, two randomly selected plants were staked in each, per plot and the average diameter (D) and height (H) for each of them were measured at 5 different dates. The relation between these two measurements and haulm dry weight (W) was determined through the following method.

Throughout the growing season, the average diameter and height of 32 border plants were measured. The tops were cut off, dried in the oven and weighed. The volume of the haulm was estimated as $V=[{}^{4}/_{3}\prod ({}^{D}/_{2})^{2} H]/2$ which

can be simplified as $V=0.25D^2H$. The regression of haulm dry weight (W) on volume was calculated and used to estimate the haulm dry weight of the staked plants within the plots. The plots were harvested on July 17, 1988. Yield per plant and per m^2, number of tubers per plant and average weight of tuber were determined.

RESULTS AND DISCUSSION

Experiment I, 1985-86

Percent emergence and yield per plant for the twenty five cultivars are presented in a descending order in Table 1. The high percent emergence and yield per plant for some of the cultivars indicate a good chance of success for this method of planting in Isfahan.

Table 1. Percent emergence and yield plant^{-1} for 25 potato cultivars. Experiment I, 1985-86

Cultivar	Percent emergence	Yield plant^{-1} g	Cultivar	Percent emergence	Yield plant^{-1} g
Heidrum	60	1240	Prima	73	830
Isola	80	1180	Anosta	53	830
Cosima	75	1170	Wega	66	780
Spartan	80	1070	Monalisa	93	780
Romano	93	1070	Gloria	60	780
Marfona	73	1070	Alpha	66	750
Rheinhart	40	1000	Astarte	100	730
Montzama	100	950	Esta	73	700
Marijke	33	940	Franzi	93	700
Civa	60	935	Feresteling	33	680
Atzimba	80	910	Pirola	93	500
Forelle	60	880	Pashandi	93	150
Baraka	60	860			

Experiment II, 1986-87

The analyses of variance showed no significant difference between dates of initial irrigation regarding any of the characteristics measured. Cultivars, however, showed highly significant differences regarding these characteristics except for percent emergence which was significant at 5% level. The corresponding mean comparisons are presented in Table 2. For 13 of the cultivars, the characteristics of which are listed in the Netherlands catalogue of potato varieties (3), the multiple regression equations of percent emergence (PE) on maturity (M), foliage development (F), tuber size (T), yield (Y), dry matter content (D), length of dormancy period (P), and shallowness of the eyes (S), all evaluated by rating in the catalogue, were determined as follows:

$$PE = -178 + 6.0M - 12.6F + 26.0T - 2.2Y + 11.6D + 0.4P + 6.4S$$
$$(1.0) \quad (-0.9) \quad (1.5) \quad (-0.2) \quad (1.8) \quad (0.1) \quad (0.5)$$

The figures in parentheses represent the corresponding standard partial regression coefficients. Due to the nonparametric characteristics of the independent variables, no test of significance was done and the standard partial regression coefficients were merely used to evaluate the relative importance of the variables in relation to percent emergence. Thus it seems that percent emergence, i.e. the capacity of the cultivars to overwinter in the soil, is mostly related to the dry matter content, which is understandable.

Experiment III, 1987-88

The monthly mean, absolute minimum and monthly mean minimum temperatures for the past eight years along with the corresponding figures for the duration of this experiment are presented in Fig. 1. The analyses of variance showed highly significant differences between dates of planting regarding time and percent of emergence, date of flowering, number of

Table 2. Means for different characteristics regarding dates of initial irrigation in the spring. Experiment II, 1986-87.

Level of factor	Days to 50% emergence†	Percent emergence§	Days to 50% flowering	Yield plant^{-1} g
Initial irrigation				
Feb. 7	65	63	116	660
March 4	64	64	115	650
Cultivar				
Atzimba	65 ab¶	63 ab	106 c	940 ab
Montzama	62 b	53 ab	105 c	300 cd
Rheinhart	69 a	36 b	141 a	740 abcd
Forelle	67 ab	57 ab	111 c	420 bcd
Prima	66 ab	74 ab	110 c	770 abcd
Wega	68 ab	57 ab	115 c	530 abcd
Esta	66 ab	66 ab	115 c	630 abcd
Heidrum	64 ab	60 ab	106 c	560 abcd
Franzi	64 ab	72 ab	109 c	550 abcd
Baraka	63 ab	80 ab	115 c	510 abcd
Astarte	63 ab	61 ab	108 c	680 abcd
Spartan	63 ab	63 ab	111 c	750 abcd
Marijke	63 ab	68 ab	111 c	780 abc
Civa	63 ab	79 ab	147 a	1050 a
Romano	68 ab	40 ab	131 b	530 abcd
Marfona	65 ab	61 ab	131 b	860 abc
Monalisa	98 ab	55 ab	113 c	570 abcd
Fersteling	63 ab	73 ab	147 a	660 abcd
Anosta	64 ab	89 a	108 c	810 abc
Cosima	62 b	51 ab	112 c	1080 a
Alpha	60 b	78 ab	110 c	530 abcd
Isola	66 ab	56 ab	126 b	630 abcd
Pashandi	64 ab	71 ab	113 c	170 d
Draga	68 ab	65 ab	126 b	820 abc
Aola	64 ab	64 ab	109 c	810 abc
Desire	64 ab	74 ab	109 c	490 abcd

† Days from the date of the initial irrigation.
§ Analysis of variance were done after the arc sine transformation of data.
¶ Means with the same letters are not significantly different at 5% level.

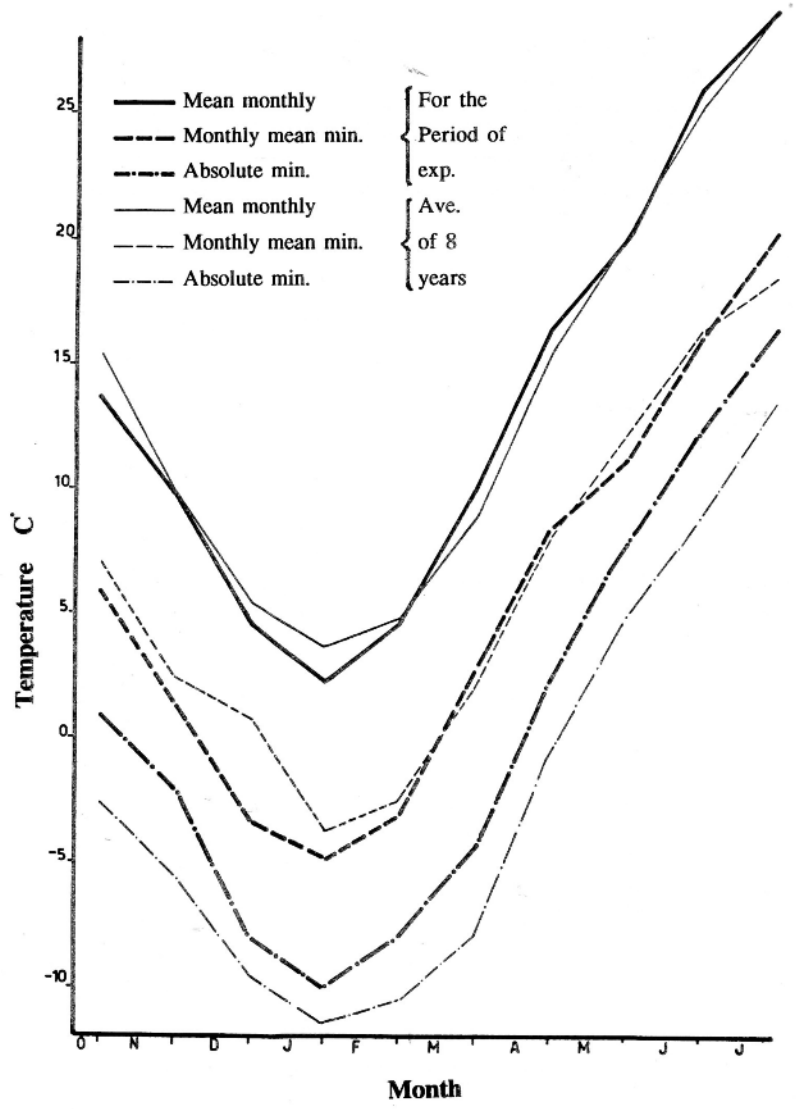

Fig. 1 Different temperature characteristics, averaged over the past eight years and for the period of the experiment.

stems per plant and average weight of tubers. Cultivar had highly significant effect on all characteristics measured. The means are presented in Tables 3 and 4.

Emergence was about nine days earlier for the fall planting. This was due to the favorable conditions for growth already existing in the soil early in the spring which led to a head start for the fall planted tubers (Fig. 2). A good part of this favorable period is usually lost in spring planting due to the unworkability of the wet fields. There was a highly significant interaction between date of planting and cultivar regarding days to 50% emergence. All the cultivars emerged earlier when fall planted, except for Draga which emerged 4.3 days earlier when planted in the spring. This could be due to the fact that this cultivar has one of the longest periods of dormancy (3) which could bave been further extended by the cooler conditions in the soil.

In general there was about 8% loss in emergence due to fall planting. However, there was a highly significant interaction between planting date and cultivar. "Atzimba", "Prima", "Spartan", "Marfona" and "Aola" showed no reduction in percent emergence with "Baraka" even having higher percent emergence in the fall.

Date of flowering was advanced by only 3 days due to fall planting. There was a highly significant interaction between date of planting and cultivar. "Baraka", "Prima", "Spartan", "Bomana", "Marfona" and "Aola" flowered earlier when spring planted. This could also be due to the cultivar's long period of dormancy mentioned above.

Fall planting resulted in fewer stems per plant. This could be due to prevention of the physiological aging by over storage beyond dormancy reported by others (1,5,6). Considering the reduction in yield due to physiological ageing of the seed (5,6,10), an increase in yield due to fall

Table 3 Means for different characteristics regarding dates of planting and cultivars. Experiment III, 1987-88

Levels of factors	*Days to 50%* emergence†	*Percent* emergence§	*Days to 50%* folowering†	*Days to* maturity†	*No. of stems* plant^{-1}	*No. of tubers* plant^{-1}	*Wt. of tubers* g
Planting							
Fall	34 b	87 b	78 b	122	1.8 b	6.8	112 a
Spring	43 a	95 a	81 a	125	2.5 a	7.6	90 b
Cultivar							
Cosima	38 cde	88 ab	73 e	135 a	2.8 a	8.9 b	94 cde
Baraka	40 c	89 ab	86 b	135 a	1.9 c	6.3 de	105 bcd
Atzimba	35 fg	95 a	73 e	115 d	2.3 bc	11.3 a	71 e
Prima	39 cd	90 ab	80 c	116 d	1.8 c	4.8 e	118 bc
Spartan	40 c	94 a	83 b	126 b	1.9 c	5.6 de	105 bcd
Marijke	40 c	95 a	84 b	129 b	2.1 bc	5.6 de	103 bcd
Civa	36 efg	93 a	90 a	115 d	2.0 bc	6.4 de	75 e
Romano	43 b	94 a	85 b	123 c	1.9 c	5.9 de	124 b
Marfona	37 def	93 a	79 cd	115 d	2.1 bc	8.5 bc	88 de
Anosta	35 fg	92 a	77 d	118 d	2.2 bc	6.4 de	147 a
Draga	47 a	79 b	85 b	128 b	2.1 bc	7.2 cd	88 de
Aola	38 cde	95 a	73 e	132 a	2.4 b	8.5 bc	94 cde

† Days from the date of the initial irrigation.

§ Analysis of variance was done after the arc sine transformation of data.

¶ Means with the same letters in each level of factors are not significantly different at 5% level.

Table 4 Yield per plant and per m^2 for the fall and spring plantings of 12 potato cultivars. Experiment III, 1987-88.

Cultivar	Yield plant^{-1} (g)				Yield m^{-2} (kg)			
	Fall planting	*Spring* planting	Difference	Average	*Fall* planting	*Spring* planting	Difference	Average
Cosima	858 ab†	790 ab	68	824 ab	2.93 a	3.42 ab	-0.49	3.18 a
Baraka	880 a	460 d	420**	670 bc	3.34 a	1.31 f	2.03**	2.32 bc
Atzimba	844 ab	728 abc	116	786 ab	3.25 a	2.47 cd	0.78*	2.86 ab
Prima	570 cd	578 cd	-8	579 cd	2.02 c	2.30 cde	-0.28	2.16 cd
Spartan	576 cd	564 cd	12	570 cd	2.15 bc	2.17 de	-0.02	2.16 cd
Marijke	578 cd	584 cd	-6	581 cd	2.13 bc	2.25 cd	-0.39	2.33 bc
Civa	434 d	468 d	-34	451 d	1.48 c	1.78 ef	-0.30	1.63 d
Romano	856 ab	612 bcd	244*	734 abc	3,39 a	2.64 bcd	0.75*	3.01 a
Marfona	740 abc	728 abc	12	734 abc	2.27 ab	2.94 bc	-0.22	2.83 ab
Anosta	894 a	908 a	-14	901 a	3.20 a	3.70 a	-0.50	3.45 a
Draga	670 bc	582 cd	88	626 bcd	2.04 bc	2.36 cde	-0.32	2.20 cd
Aola	848 ab	754 abc	94	801 ab	3.32 a	3.25 ab	-0.07	3.29 a
Average	729	646		688	2.68	2.57		2.62

† Means with the same letters are not significantly different at 5% level.
** Significantly different at 1% level.
§ Significantly different at 5% level.

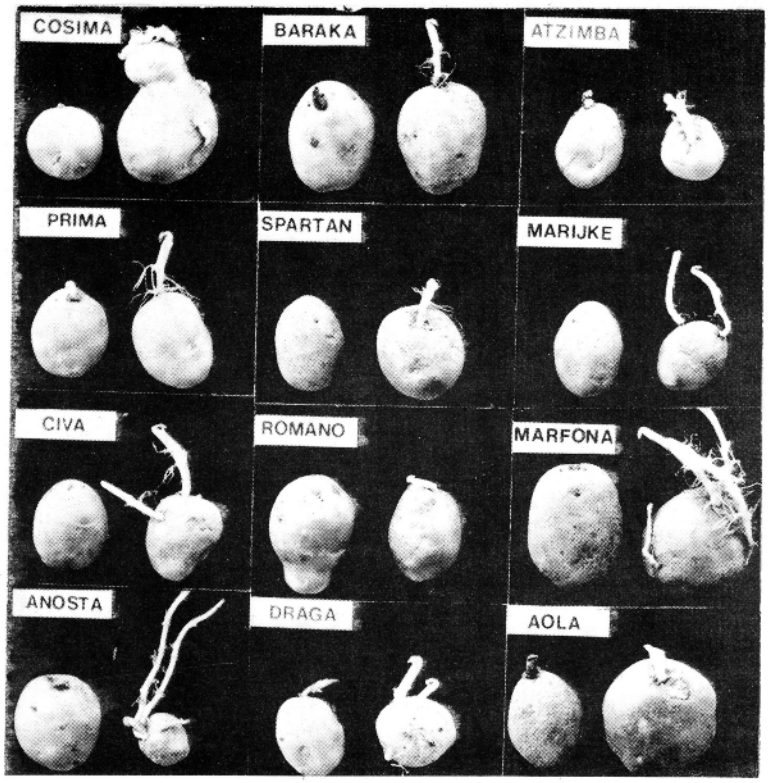

Fig. 2 Sprout and root growth for the fall planted (right) and spring planted (left). Tubers photographed at the time of spring planting.

planting was expected. However, although some increase in yield per plant and per m^2 was observed (Table 3), the differences were not significant. This could be due to the fact that the spring sown seed was at a good condition regarding physiological age (Fig. 2). There was a highly significant interaction between planting date and cultivar for yield per plant and per m^2 (Table 4). "Baraka" and "Romano" had higher yields per plant and per m^2 and "Atzimba" higher yield per m^2 when fall planted. This was more noticeable with "Baraka" (a late cultivar) and could be due to a longer growing season provided through out fall planting.

Fewer tubers per plant due to fall planting (although not significant) resulted in highly significant increase in tuber size. Number of stems was positively correlated to the number of tubers ($r=0.70^{**}$). Similar results were obtained by Iritani *et al.* (6), who had also indicated a negative correlation between the number of stems and tuber size. A negative correlation, though not significant ($r=0.27$) was obtained in this experiment. The regression of the haulm dry weight (W) on volume (V) for the 32 plants sampled was calculated as, $W=14.6+0.43V$, where W and V are in g and 1000 cm^3, respectively. Then the regression of growth on time was calculated for each cultivar planted in the fall and in the spring, using different transformations of data. The best lines of fit were obtained by the regression of log W on time. The rate of growth, represented by the regression coefficients for the fall and spring plantings for each cultivar were compared using a t-test. There was no significant difference between the coefficients for all the cultivars except for "Draga", in which spring planting showed a slightly higher growth rate. The regression equations of growth on time for the average of all the cultivars planted in the fall and in the spring were calculated and the two regression coefficients were

compared. There was no difference between the fall and spring planting regarding the rate of growth. The correlation coefficients for the rate of growth and yield per plant calculated as 0.75** and 0.52, respectively. The non-significant and relatively low correlation coefficient for spring planting could be due to some increase in haulm growth (1) accompanied by reduction in yield (5,6,10) due to physiological aging.

CONCLUSION

Earlier emergence resulted from fall planting; however, its effect gradually disappeared as the season advanced resulting in little difference in date of flowering and no difference in maturity and yield. The slight reduction in percent emergence could be overcome through the use of suitable cultivars, probably those with higher dry matter content, a point which requires further investigation.

Eliminating seed storage through fall planting is feasible for Isfahan, and cultivars Romano, Baraka, Aola, Atzimba and Cosima showed relatively better performances in this respect. Further research is required for determining more suitable cultivars for this region and screening out other areas of suitable climates for this method of planting.

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