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Screening Potato Varieties for Cultivation in Arid Regions: Effect of Planting Date on Emergence of Imported and Locally-Produced Seeds

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تقييم أصناف البطاطس لزراعتها في المناطق الجافة: تأثير موعد الزراعة على إنبات بذور البطاطس المستوردة والمنتجة محليا

اقرار خان ومايكل ديدمان وخميس الحبسي

خلاصة: يعتبر البطاطس من أهم المحاصيل الجديدة والاستراتيجية الموجودة في عمان. ويرجع السبب في ذلك لقيمته الغذائية والتوسع في الإنتاج وإرتفاع الطلب عليه من المستهلك. يعتمد إنتاج درنات البطاطس في عمان على الاستيراد السنوي لبذور البطاطس من أوروبا. يمكن زيادة إنتاجية البطاطس من خلال اختيار أصناف ملائمة للمناخ العماني ومن خلال المحافظة على البذور خالية من الأمراض. وجد أن وقت زراعة البذور غير مناسب لنمو المحصول بصورة مثالية مما ينتج عنه خسارة فادحة في الإنتاجية. ووجد أيضا أن العمر الوظيفي الصغير والسبات الدائم للبذرة يمنعان الإنبات المبكر للبراعم في منتصف شهر نوفمبر لموعد الزراعة. وعندما تم زرع المحصول على أحد عشر تاريخاً مع تأخير موعد الزراعة أظهرت النتائج تحسناً معنوياً ملحوظاً في معدلات الإنبات كما تضاعفت نسبة بزوغ البادرات مع تأخر مواعيد الزراعة من منتصف شهر نوفمبر إلى منتصف شهر ديسمبر. تم التأكد من نتائج الإنبات لدرنات بطاطس المستوردة على فترة ثلاث فصول متتالية وقد قورنت هذه النتائج مع بيانات الإنبات لدرنات البطاطس المنتجة محلياً والتي زرعت في نفس الموعد أو قبله.

ABSTRACT: Potato is new as a major crop in arid regions. Due to its food value, expanding production and increasing consumer demand, it is being considered as a strategic crop. Production is based on yearly import of seed potatoes from Europe. Productivity of potato could be increased by targeted selection of varieties for local adaptation, by choosing the adequate conditions for planting and through proper seed management. The seed and its imposed planting time were found to be incompatible with optimum stand development for the crop, resulting in a loss of potential yield. The young physiological age and persisting dormancy of seed prevented early emergence of sprouts from a mid-November planting time. When planted on 11 consecutive dates, varieties showed a significant improvement of emergence rates with delayed planting time. Emergence rate doubled as planting was delayed from mid November to mid December. Emergence rate results for imported tubers were confirmed over three consecutive growing seasons and contrast with emergence data for locally produced seed planted at the same or earlier dates.

Keywords: sprout emergence, physiological age, chitting, rate of emergence.

Potato is a recent introduction as a vegetable in the Arabian Gulf. Annual per head consumption of potato is about 25kg, which is among the highest reported for tropical countries (Van der Zaag and Harton, 1983). Oman, for example, is a net importer of staple food items and therefore needs to increase the productivity of potatoes as a local food supplement to rice, wheat and vegetables. The local potato processing industry is dependent on imported raw material. These imports could be substituted by local production, and the potato has been identified as a crop of strategic importance.

In the Arabian Gulf, mid November has been adopted as the usual planting time for potato. This has been imposed by the availability of imported seed but has not been scientifically evaluated. Information on the most suitable planting time is lacking. Due to the extreme summer heat, the main cropping season is

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limited to the period between September and March for most annual crops. Thus, November does not appear to be the ideal time for sowing crops. To maximize the cropping intensity within the limited cropping season, it could be possible to adjust the planting date for potato to allow for two crops (potato + potato or a vegetable crop preceded by, or following potato) within the available season. Most land under other vegetable crops produces two harvests per season; in some cases, such as snap beans, three harvests can be taken per season. This has proved to be a disincentive to further expansion of the potato crop.

The physiological status of seed potatoes at the time of planting is critical for rapid crop establishment (Khan *et al.*, 1980; Jenkins *et al.*, 1993). The physiological stage of the tubers varies with the seed production conditions, age of seed or length of storage, storage temperature, tuber size and genetics of the varieties (Morris, 1966; Wurr, 1978, 1979; Susnoschi, 1981; Hartmans and Van Loon, 1987). The effects of physiological aging are seen in the breaking of dormancy and emergence of sprouts during storage and after planting. Physiologically young tubers tend to show a strong apical dominance resulting in single, or few stems per plant. Younger seed has delayed emergence due to the time required for the mobilization of metabolites required to meet the energy requirements of emerging sprouts (Khan *et al.*, 1980; Khan and Gill, 1984; Khan, 1993). Old seed tubers have a greater number of stems and quicker emergence, but this may not always translate into excessive vigor. Therefore, it is essential that seed tubers are sown at the right physiological age. The extent of sprout growth is usually related to the physiological age of seed potatoes (Krijthe, 1962). It is also influenced by length of storage and storage conditions, production history of the seed crop and to the soil environment under which the seed has been planted.

The objectives of the present study were to evaluate imported and locally produced seed of potato varieties by using different planting dates. Response was evaluated in terms of emergence rates. Determination of the optimum planting dates for imported and local seed would be the logical outcome of this study.

Materials and Methods

POTATO CULTIVATION: A three-year study was carried out at the Agricultural Experiment Station, Sultan Qaboos University, Muscat, Sultanate of Oman to test the emergence of imported and locally produced seed potatoes of various varieties. Each year the imported seed arrived by the first week of November.

All experiments were performed using a randomized complete block design with three replications in the same field for three consecutive years. Variety - planting date combinations are summarized in Table 1. The growing conditions comprised marginal alkaline soil, with drip irrigation and plantings on raised beds. The irrigation intervals and water volumes were adjusted according to crop requirements based on weekly evapo-transpiration data excepting the first irrigation/presoaking which was continued to a fully wet condition. The maximum and minimum temperatures from September to November ranged from 36 to 26°C and 25 to 15°C, respectively. The planting distances were 75 cm from row to row and 50 cm within rows. The tubers were planted approximately 10 cm deep. The plant population ranged from 30–60 tubers per row. The rows were ridged twice after germination to provide sufficient soil cover. All experimental plots were uniformly fertilized with NPK and micronutrients according to minimum recommended doses. The spray program included application of insecticides and protective fungicide as needed. All plots were harvested 100 days after planting, at nearly 100% senescence of the vines.

EFFECT OF PLANTING DATE ON EMERGENCE: Year 1 (1997-1998) - Seed potatoes of five varieties: Diamant, Estima, Arinda, Turbo and Spunta, obtained from the commercial suppliers were planted on 11 consecutive dates (one-week intervals) starting on 2-11-1997 and ending on 11-1-1998 (Table 1). Data were collected on emergence after two, three, four and five weeks after planting, the time when emergence was near completion. In order to establish experimental planting dates for subsequent years' experiments, mean emergence data for the five varieties was calculated for each planting date. From this data the emergence rate [1/days to 50% emergence (Jenkins *et al.*, 1993)] was derived.

Year 2 (1998-1999) - Two experiments were established. In experiment 1, seed of 26 potato varieties imported from Europe, which arrived in the last week of October 1998 was planted in mid November and early December (Table 1). These dates were selected on the basis of the Year 1 results. A second experiment was planted using imported seed of the five varieties of Year-1 plus cv. 'Sante'. This was planted on 15/11/98 and 7/12/98 (Table 1), again on the basis of the year 1 results. Emergence data were collected for 21 and 35 days after planting and analyzed as for Year 1.

Year 3 (1999-2000) - The third year trial used seed of 20 varieties harvested from the year 2 experiment and planted in early and late September (Table 1). Emergence data were collected and analyzed as for Year 2.

Results

YEAR 1: For all varieties there were significant differences in the percent emergence after 21 days for the various planting dates (Table 2). After 21 days of the earliest planting there was no emergence for any of

TABLE 1

Planting dates and varieties used to evaluate emergence after different planting dates for imported and locally produced seed potatoes.

Trial year	Planting Date	Potato Varieties
1997/98 (imported seed)	02/11/97	Diamant, Estima, Arinda, Turbo, Spunta
	09/11/97	As for 02/11/97 planting date
	16/11/97	As for 02/11/97 planting date
	23/11/97	As for 02/11/97 planting date
	30/11/97	As for 02/11/97 planting date
	07/12/97	As for 02/11/97 planting date
	14/12/97	As for 02/11/97 planting date
	21/12/97	As for 02/11/97 planting date
	28/12/97	As for 02/11/97 planting date
	04/01/98	As for 02/11/97 planting date
	11/01/98	As for 02/11/97 planting date
	11/11/98	Cyclone, Accord, Fambo, Lady Rosetta, Lady Claire, Mirakel, Lady Cristl, Turbo
	15/11/98	Columbus, 91-41-78, Donald, 90-23-28, Ajiba, 90-35-08
	18/11/98	Kirrie, Claret, 91-2-101, Spey, Maris Peer, Charlotte, Othello, Sterling, Roscor, 91-13-2, Bydand, GI85-2-501, 90-40-1, Nicola
1998/99 (imported seed)	15/11/98	Diamant, Estima, Arinda, Turbo, Spunta, Sante
	07/12/98	As for 15/11/98 planting date
1999/00 (local seed)	29/09/99	Turbo, Lady Cristl, Estima, Diamant, Mirakel, Lady Rosetta, Lady Claire, Cyclone, Spunta, Accord, Bydand, Maris Peer, Roscor, Columbus, Kirrie, Fambo, Sante, Nicola

the varieties. The percentage emergence at 21 days increased with later planting dates, reaching an asymptote at 23/11/97 and 30/11/97 for Diamant, Arinda and Turbo and Estima and Spunta, respectively. The percentage emergence after 35 days was less variable, reaching close to the peak values for the 23/11/97 planting date for each of the varieties; thereafter there was little change in the percentage emergence for later planting dates.

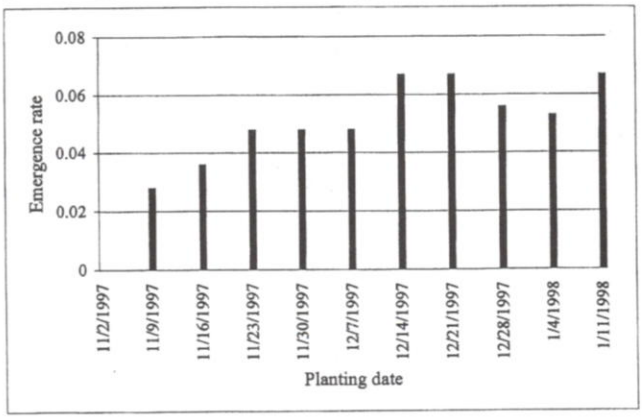

Figure 1. Average rate of emergence for five potato varieties sown on 11 dates in 1997/98 (Year 1).

TABLE 2

The effect of planting date on emergence of imported seed of 5 potato varieties 14, 21, 28, and 35 days after planting (Year 1).

Date of Planting	Days after Planting	Emergence				
		Diamant	Estima	Arinda	Turbo	Spunta
02/11/97	14	0.0	0.0	0.0	0.0	0.0
	21	0.0	0.0	0.0	0.0	0.0
	28	60.0	0.0	8.3	8.3	0.0
	35	63.0	5.0	10.0	8.3	0.0
09/11/97	14	0.0	0.0	0.0	0.0	0.0
	21	56.7	20.0	68.3	51.7	36.7
	28	76.7	20.0	70.0	70.0	60.0
	35	78.3	23.3	71.6	71.6	60.0
16/11/97	14	6.65	10.0	30.0	5.0	0.0
	21	40.0	25.0	63.3	63.3	10.0
	28	71.6	55.0	66.6	80.0	61.7
	35	81.6	58.3	68.3	83.3	76.7
23/11/97	14	13.3	1.7	35.0	13.3	1.7
	21	86.6	48.3	90.0	96.6	68.3
	28	96.6	76.6	91.7	98.3	95.0
	35	99.9	88.3	93.3	98.3	98.3
30/11/97	14	28.3	11.7	61.7	50.0	18.3
	21	88.3	71.7	96.7	78.3	86.6
	28	90.0	86.7	100.0	80.0	91.6
	35	90.0	86.7	100.0	80.0	91.6
07/12/97	14	30.0	50.0	33.3	30.0	45.0
	21	88.3	83.3	85.0	78.3	80.0
	28	88.3	83.3	85.0	80.0	81.7
	35	88.3	83.3	85.0	80.0	81.7
14/12/97	14	55.0	26.7	66.7	65.0	65.0
	21	93.3	76.7	83.3	96.7	93.3
	28	96.6	90.0	83.3	98.3	95.0
	35	96.6	90.0	83.3	98.3	95.0
21/12/97	14	56.7	13.3	46.7	66.7	51.7
	21	93.3	73.3	76.7	96.7	90.0
	28	95.0	80.0	86.7	98.3	96.6
	35	95.0	80.0	86.7	98.3	96.6
28/12/97	14	30.0	20.0	53.3	43.3	43.3
	21	93.3	70.0	86.6	90.0	86.6
	28	93.3	70.0	86.6	90.0	86.6
	35	93.3	70.0	86.6	90.0	86.6
04/01/98	14	60.0	26.7	56.5	61.7	56.7
	21	90.0	83.3	83.2	98.3	88.3
	28	93.3	86.6	89.8	100.0	95.0
	35	93.3	86.6	89.8	100.0	95.0
11/01/98	14	78.3	23.3	60.0	68.3	71.7
	21	93.3	73.3	83.3	95.0	98.3
	28	93.3	73.3	83.3	95.0	98.3
	35	93.3	73.3	83.3	95.0	98.3

The overall mean emergence rates for the five varieties are shown in Figure 1. Emergence was zero for the first planting (2/11/97). The emergence rate rose between 9/11/97 and 14/12/97. After 14/12/97 there was no further increase in emergence rate. Analysis of variance (Table 3) shows the significant differences in average emergence for each week after each planting date, confirming the increase in rate of emergence with delayed planting of imported seed. However, it was clear that some varieties showed better emergence

TABLE 3

Analysis of variance for weekly emergence of five potato varieties planted over 11 dates during Year 1.

		Days After Planting											
		14			21			28			35		
	DF	MS	F	P	MS	F	P	MS	F	P	MS	F	P
Planting Date	10	295.3	46.9	.0001	163.5	22.4	.0001	40.8	24.1	.0001	2.9	7.5	.0001
Variety	4	107.5	17.1	.001	17.3	2.3	.0563	19.7	11.6	.0001	0.7	1.8	.1300
Date x Variety Interaction	40	17.8	28.3	.001	23.2	3.1	.0001	14.0	8.2	.0001	0.6	1.6	.0255

characteristics than others. Table 2 confirms that varieties Diamant, Arinda and Turbo each showed an emergence greater than 50% at 21 days after a planting date of 9/11/97.

YEAR 2: Emergence data for Year 2, experiment 1 is shown in Table 4. Except for variety Kirrie planted on 18/11/98 there was a low percent emergence for all of the varieties planted on each of the dates. After 35 days some varieties still showed zero emergence (Othello and 90-40-1 planted on 18/11/98), or very low emergence (Claret (1.0%) and 91-13-2 (1.0%) planted on 18/11/98). Other varieties showed greater than 75% emergence after 35 days (Cyclone, Lady Christl and Turbo planted on 11/11/98, 91-41-78 and Donald planted on 15/11/98 and Kirrie, 91-2-101, GI85-2-501 and Nicola planted on 18/11/98).

Emergence data for experiment 2 was taken on one date, three weeks after planting. For the first planting date (15/11/98) there was negligible emergence after three weeks. For the second planting date (7/12/98) the percent emergence data after three weeks were: Diamant (68%), Spunta (17%), Arrinda (98%), Estima (38%), Turbo (95%) and Sante (35%).

YEAR 3: The 29/9/99 planting in Year 3 was made using locally produced seed tubers. In all cases varieties showed greater than 25% emergence after 21 days (Table 5). In some cases (Turbo, Mirakel, Spunta and Maris Peer) emergence after 21 days was greater than 50%. After 35 days from planting only varieties Columbus, Kirrie and Santa showed less than 50% emergence. The varieties Estima, Mirakel, Lady Rosetta, Lady Claire and Maris Peer all showed emergence over 75%.

TABLE 4

The effect of planting date on emergence of imported seed of potato varieties 21 and 35 days after planting (Year 2, experiment 1).

Planting Date	Variety	Emergence (%)	
		21 dap[1]	35 dap[1]
11/11/98	Cyclone	9.5	97.2
	Accord	0.0	54.5
	Fambo	0.0	38.8
	Lady Rosetta	0.0	18.8
	Lady Claire	0.0	45.6
	Mirakel	0.0	26.1
	Lady Christl	3.9	96.7
	Turbo	5.6	98.3
15/11/98	Columbus	4.4	36.1
	91-41-78	11.7	75.0
	Donald	17.2	88.9
	90-23-28	6.1	73.8
	Ajiba	18.3	74.4
	90-35-08	0.0	15.0
18/11/98	Kirrie	67.8	94.4
	Claret	0.0	1.0
	91-2-101	23.3	83.3
	Spey	0.0	27.8
	Maris Peeer	0.0	10.0
	Charlotte	5.6	61.1
	Othello	0.0	0.0
	Sterling	0.0	68.9
	Roscor	0.0	17.8
	91-13-2	0.0	1.0
	Bydand	7.8	35.6
	G185-2-501	11.1	87.8
	90-40-1	0.0	0.0
	Nicola	10.0	82.2

[1]dap, Days after planting.

TABLE 5

The effect of planting date on emergence of locally produced seed of potato varieties 21 and 35 days after planting date of 29/9/99.

Variety	Emergence (%)	
	21 dap[1]	35 dap[1]
Turbo	56.4	73.4
Lady Christl	42.7	56.4
Estima	45.5	81.8
Diamant	47.7	73.3
Mirakel	50.0	90.0
Lady Rosetta	47.3	85.2
Lady Claire	45.3	86.6
Cyclone	46.5	70.2
Spunta	53.0	66.7
Accord	26.5	61.4
Bydand	48.5	60.6
Maris Peer	72.7	75.8
Roscor	47.0	60.6
Columbus	34.8	36.4
Kirrie	40.9	40.9
Fambo	47.0	68.2
Santa	25.8	37.9
Nicola	42.4	53.0

[1]dap, Days after planting.

Discussion

The differences in the emergence of the varieties in Year 1 could have arisen due to differences in the age of seed, in natural emergence rates, or to the differences in response to climatic conditions. There is no information available on the age of imported seed. However, the data from the plantings made of imported seed appear to show inconsistent emergence for all varieties when the planting date is prior to late November. Given that the imported seed has a European origin, it is likely that the chronological age of seed is approximately 3 months. This would suggest that tubers sown prior to late November (the normal planting time in the Arabian Gulf) are still dormant when planted under Omani conditions.

However, from the 1997/98 trial there was a higher rate of emergence after the fifth planting date; the data (Table 2) shows that emergence was high within three weeks of planting, giving a uniform crop. The improvement in emergence was probably the result of natural chitting, which occurred with later planting dates. Sprout emergence has been reported to improve with advanced physiological age and chitting practices (Iritani, 1968; Khan *et al.*, 1980; Hartmans and Loon, 1987).

The emergence rates for the locally produced seed planted in September 1999 (year 3) are a clear contrast to the emergence data for same varieties during November and December 1998 (year 2). The reason for difference is probably a reflection of the physiological age of the seed at the time of planting: 3 months for the 1997 and 1998 plantings and 6-7 months for the September 1999 planting. Similar results have been reported by Krijthe (1962), Morris (1966), Claver (1973), Madec (1978) and Khan *et al.* (1980).

Overall, the results show that potato seed available to farmers and the assumed planting time of mid November is sub-optimal. The physiologically young seed from European suppliers is slow to emerge when planted in November. Thus, the farmer is unable to utilize his land for the two crops per year that would be possible from an earlier first planting.

The results suggest the suitability of some varieties for cultivation in arid climates such as Oman. Comparisons can be made of the emergence figures for varieties planted using both imported and locally produced seed. Locally produced seed of varieties Turbo and Diamant planted on 29/9/99 achieved emergence of 56.4% and 47.7% respectively at 21 days, and 73.4% and 73.3% respectively at 35 days (Table 5). Equivalent emergence figures were reached by the same varieties from seed planted on 9/11/97 (Table 2). In contrast locally produced seed of varieties Estima and Spunta planted on 29/9/99 achieved emergence figures of 45.5% and 53.0% respectively at 21 days, and 81.8% and 66.7% respectively after 35 days (Table 5). Equivalent emergence figures were reached, by the same varieties, from seed planted on 23/11/97, two weeks later than for varieties Diamant and Turbo. This indicates better adaptation potential in Turbo and Diamant for growth under arid environmental conditions. Currently, for example, production in Oman is dominated by the varieties Diamant and Spunta. On the basis of the emergence data, the results for the other varieties indicate that Kirrie Maris Peer, Mirakel, Lady Rosetta, Lady Claire and Cyclone (Table 4, Table 5) may have potential for cultivation.

The current seed supply mechanism mitigates against an expansion of the potato acreage in the Arabian Gulf. The results from the present study show that there is the potential to alter the dynamics of the production cycle to bring about an increase in the area and volume of production. The available options include changing the planting time from mid November to mid December allowing more than three months from September onwards for growing an early crop. Early potato crops, planted in September are currently being evaluated. Alternatively, seed could be sourced from harvests earlier than August, perhaps from within the Near East/West Asia region. Another possibility is to develop a local seed multiplication and storage system. This could be supported by the importation of virus-free seed stock from Europe as occurs in many other countries in the region. Finally, there is the potential to develop a local tissue culture propagation system for the production of micro/mini tubers.

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