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Screening Potato Varieties for Tuber Production in Arid Regions: Effect of Planting Date on Yield Potential

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تصنيف البطاطس لإنتاج الدرنات: تأثير موعد الزراعة على مدى القدرة على زيادة الإنتاج

إقرار خان ومايكل ديدمان وخميس الحبسي

خلاصة: تم اختبار تأثير موعد زراعة درنات البطاطس خلال ثلاثة فصول. واتضح أن موعد الزراعة كان له تأثيرا معنويا على زراعة البطاطس بالرغم من وجود بعض الاختلافات بين الأصناف في كمية المحصول عند زراعتها في مواعيد مختلفة. ويرجع السبب في ذلك إلى الاختلاف في درجات الحرارة أثناء مواسم الزراعة. كما أتضح أن زيادة المحصول في بعض الأصناف يعزى إلى كثرة عدد الدرنات أما في الأصناف الأخرى فيعزى إلي وزن الدرنة. ومن الأصناف التي تم انتخابها فيفالدي وكارليتا وباي داند ودونالد وأسترلنج لما لها من المقدرة على تحمل المناخ الجاف في منطقة الخليج العربي. وقد تمت مناقشة نتائج التجربة في إطار إستراتيجية وطنية لإنتاج البطاطس وذلك من خلال التأخير في موعد الزراعة بحيث يكون من منتصف نوفمبر إلى منتصف ديسمبر وذلك لاستغلال مساحات أوفر من الأراضي الزراعية وبكفاءة عالية خلال موسم زراعي قصير .

ABSTRACT: The effect of tuber planting date on yield of potato cultivars was examined during three seasons. Planting date had a significant effect on yield, although cultivars showed significant variation in yield potential at the different dates. Varietal yield was significantly correlated with planting date and thus was probably a response to changing temperatures during the growing season. The yield increase in some cultivars was attributable to greater tuber number; in others it was because of greater tuber weight. Cultivars Vivaldi, Carlita, Bydand, Donald and Sterling were identified as having the potential for general cultivation in the arid climate of the Arabian Gulf. The results are discussed in terms of a national strategy for potato production, possibly involving a delay in planting date from mid November to mid December, allowing greater land use efficiency during the short cropping season.

Keywords: adaptation, cultivar trial, cropping season, cropping intensity, Sultanate of Oman.

As a commercial crop, potato was introduced into the Arabian Gulf in the 1980's. A large increase in area and crop yield was achieved during the years that followed (FAO statistical database: http://apps.fao.org). Over the last ten years however, production has remained level as production has shifted from small, government-subsidized farmers to large commercial operations capable of producing yields of 35-45 t ha^{-1}.

For potato producers in the Arabian Gulf, mid November is the imposed planting time due to the availability of seed tubers, usually from European harvests. On arrival seed tubers have widely differing physiological ages and dormancy statuses. This influences tuber emergence, growth and yield (Khan *et al.*, 2000, 2001). The mid-November planting date not only causes farmers to plant tubers that are still in a state of dormancy, but also reduces cropping intensity, as it requires land to remain fallow between September and mid November.

Potato is a crop of cool climates that is adversely affected by exposure to high temperatures (Ewing, 1981; Ben Khader and Ewing, 1985). The crop grows best at temperatures around 20°C. Most of the commercial potato cultivars grown in Oman were produced from breeding programmes in temperate climates. Therefore, rigorous testing of cultivars for

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TABLE 1

Planting dates and cultivars used to evaluate yield performance at different planting dates for imported seed potatoes.

Trial Year	Planting Date	Potato Cultivars
197/98	02/11/97	Diamant, Estima, Arinda, Turbo, Spunta
(imported seed)	09/11/97	Diamant, Estima, Arinda, Turbo, Spunta
	16/11/97	Diamant, Estima, Arinda, Turbo, Spunta
	23/11/97	Diamant, Estima, Arinda, Turbo, Spunta
	30/11/97	Diamant, Estima, Arinda, Turbo, Spunta
	07/12/97	Diamant, Estima, Arinda, Turbo, Spunta
	14/12/97	Diamant, Estima, Arinda, Turbo, Spunta
	21/12/97	Diamant, Estima, Arinda, Turbo, Spunta
	28/12/97	Diamant, Estima, Arinda, Turbo, Spunta
	04/01/98	Diamant, Estima, Arinda, Turbo, Spunta
	11/01/98	Diamant, Estima, Arinda, Turbo, Spunta
1998/99	15/11/98	Columbus, 91-41-78, Donald, 90-23-28, Ajiba,
(imported seed)		90-35-08, Kirrie, Claret, 91-2-101, Spey, Maris Peer, Charlotte, Sterling, 91-13-2, Bydand, 85-2-501, 90-40-1, Nicola, Cycloon, Accord, Fambo, Lady Rosetta, Lady Claire, Mirakel, Lady Cristle, Turbo
	7/12/98	Columbus, 91-41-78, Donald, 90-23-28, Ajiba, 90-35-08, Kirrie, Claret, 91-2-101, Spey, Maris Peer, Charlotte, Sterling, 91-13-2, Bydand, 85-2-501, 90-40-1, Nicola, Cycloon, Accord, Fambo, Lady Rosetta, Lady Claire, Mirakel, Lady Cristle, Turbo
1999/00	15/11/99	Vivaldi, Spunta, Durby, Cantate, Diamant, Carlita,
(imported seed)		Caesar, Latona
	30/11/99	Vivaldi, Spunta, Durby, Cantate, Diamant, Carlita, Caesar, Latona
	15/12/99	Vivaldi, Spunta, Durby, Cantate, Diamant, Carlita, Caesar, Latona

local adaptation and yield potential is essential. The cropping season in this country covers the period September – April. The temperature during this period varies from night minima of 10°C to daytime maxima of 40 °C.

Heat stress at an early stage of potato growth influences the ability of cultivars to grow vegetatively and to commence tuberization (Levy, 1986b; Reynolds and Ewing, 1989a,b). Heat stress at any stage of growth also limits the tuberization capacity (Struik *et al.*, 1989a,b,c; Ewing and Struik, 1992), bulking capacity and tuber quality (Levy, 1986a; Struik *et al.*, 1990, 1991).

The objective of the present study was to provide an evaluation of the yield potential of potato cultivars in an arid country such as Oman. Cultivars were tested under the varying temperature conditions imposed by different planting dates. The study also allowed the effects of planting date on yield to be assessed, with the objective of formulating a strategy for improved cropping intensity within a system of maximum land use efficiency.

Materials and Methods

A three-year study was carried out at The Sultan Qaboos University to measure the yield of potato cultivars originating from imported seed. Various planting dates were used in order to assess the optimum planting times. All experiments, with the exception of the first trial, were performed in a randomized complete block design with three replicates. All experiments were conducted in the same field over consecutive years. The growing conditions comprised marginal alkaline soil with drip irrigation. Tubers were ridged after planting and twice thereafter for weed control. The seedbed was presoaked before planting, subsequent irrigation intervals and water volumes were adjusted according to crop requirements based on weekly evapo-transpiration data. The planting distances were 75 cm between rows and 50 cm within rows. Tubers were planted approximately 10 cm deep. All experimental plots were uniformly fertilized with NPK and micronutrient fertilizers, according to minimal recommended rates. A spray programme included application of insecticides and protective fungicide as required.

The planting dates used for the different treatments are shown in Table 1. All plots were harvested 100 days after planting at, or close to foliage senescence. Data on tuber weight and tuber number per plant were analyzed from a random sample of ten plants in all experimental plots.

Results

During Year 1 (1997-98), five cultivars were planted on 11 planting dates. The results (Table 2) showed differences in the weight and number of tubers per plant. From the first planting date there was no sprout emergence and consequently no tuber yield. In contrast tubers planted on the second date produced the highest number of tubers for cv. Spunta and the greatest tuber weight for cvs Diamant and Spunta. For all of the cultivars the greatest numbers of tubers and the highest tuber weights were produced from plantings made on or before 7/12/97. Thereafter, tuber number

TABLE 2

The effect of planting date on tuber number and tuber weight per plant from five potato cultivars planted at 11 different dates.

Planting Date	Tuber Number Per Plant					Tuber Weight Per Plant				
	Diamant	Arinda	Estima	Turbo	Spunta	Diamant	Arinda	Estima	Turbo	Spunta
02/11/97	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
09/11/97	6.53	5.73	5.90	6.13	7.73	563	370	523	473	684
16/11/97	7.43	5.33	6.86	9.06	6.03	525	388	595	685	578
23/11/97	5.80	5.00	7.00	8.43	6.43	530	408	566	610	575
30/11/97	6.13	5.00	5.63	5.70	5.03	508	401	480	430	501
07/12/97	8.03	7.10	6.36	6.53	5.36	430	388	353	360	430
14/12/97	7.86	5.23	3.76	6.96	5.80	503	315	203	391	525
21/12/97	7.90	5.00	5.86	6.23	4.43	450	301	408	359	438
28/12/97	5.63	4.83	4.30	5.06	3.96	356	235	263	360	288
04/01/98	6.33	4.90	4.13	8.16	3.80	270	218	231	336	276
11/01/98	6.80	4.50	3.90	7.33	3.43	298	188	170	261	230

and tuber weight declined. Tubers planted on 11/1/98 produced the lowest number of tubers for cvs Estima, Arinda and Spunta and the lowest tuber weight for cvs Estima, Arinda, Turbo and Spunta.

During Year 2 (1998-99), two planting dates, three weeks apart were used for an evaluation of 26 cultivars (Table 3). For 21 of the cultivars there was no significant difference in tuber number between the two planting dates. Of the other cultivars Charlotte and 90-40-1 had higher tuber numbers from the earlier planting date whilst Maris Peer, Lady Claire and Turbo produced higher tuber numbers from the later planting date. Cvs 91-2-101, Spey and Charlotte produced a higher tuber weight from the first planting date, whilst Accord, Lady Claire, Mirakel, Lady Cristle and Turbo yielded a higher tuber wieght from the second planting date. For 16 of the cultivars there was no difference in either tuber number or tuber weight between the two planting dates.

The results for Year 3 (1999-2000) showed significant differences between the cultivars for number of tubers per plant for each of the planting dates. There were significant differences between the cultivars for tuber weight for the first two planting dates only (Table 4). Cv. Vivaldi produced the highest number of tubers (10.46 per plant) and the highest tuber weight (753.3 g) from the first planting date. From the second planting date cv. Diamant produced the highest tuber number (11.33 per plant) whilst cv. Spunta produced the highest tuber weight (776.7 g). From the third planting date cv. Latona had the highest tuber number (10.00 tubers per plant). For six of the cultivars there were no significant differences between the planting dates for tuber number. For cvs Spunta and Latona the second and first planting dates respectively produced significantly higher tuber numbers than at least one of the other planting dates used. For cv. Vivaldi the first planting date produced a higher tuber weight per plant than both of the other two planting dates used.

TABLE 3

The effect of planting date on tuber number and tuber weight per plant for 26 potato cultivars planted on two dates.

Cultivar	Planting Date				t_{TN} (4 df)[3]	t_{TW} (4 df)[4]
	15/11/98		7/12/98			
	TN[1]	TW[2]	TN[1]	TW[2]		
Columbus	3.67	282.7	3.93	403.3	0.30	1.42
91-41-78	5.10	416.7	6.60	513.3	1.15	0.98
Donald	5.27	428.0	7.00	460.0	1.97	0.29
90-23-28	4.47	400.0	5.80	433.3	2.37	0.52
Ajiba	4.67	384.7	5.40	340.0	1.61	1.02
90-35-08	3.67	256.7	4.40	326.7	1.39	2.14
Kirrie	4.40	266.7	6.00	350.0	1.57	1.11
Claret	4.00	173.3	3.00	133.3	2.73	0.60*
91-2-101	5.80	593.3	4.00	256.7	1.94	0.35**
Spey	5.93	373.3	5.33	303.3	1.30	1.94
Maris Peer	3.60	246.7	5.80	296.7	3.59*	0.66
Charlotte	4.27	400.0	3.93	203.3	3.39*	0.51*
Sterling	4.80	413.3	5.40	426.7	0.79	0.16
91-I3-2	4.20	233.3	3.40	155.0	1.12	0.89
Bydand	7.00	580.0	6.40	520.0	1.06	0.60
85-2-501	7.67	560.0	6.93	376.7	0.61	2.00
90-40-1	3.07	126.7	1.73	71.0	2.91*	2.60
Nicola	5.87	416.7	7.27	373.3	0.77	0.39
Cycloon	2.80	57.7	3.80	253.3	1.00	2.65
Accord	1.93	44.3	5.20	260.0	2.70	3.28*
Fambo	2.40	106.7	4.07	306.7	2.75	1.64
Lady Rosetta	3.27	166.7	4.27	320.0	1.09	2.40
Lady Claire	2.13	112.3	5.60	346.7	7.89**	10.32***
Mirakel	2.33	57.7	4.73	240.0	2.39	6.14**
Lady Cristle	2.20	75.7	4.40	290.0	2.03	4.01*
Turbo	1.87	74.7	5.87	426.7	3.66*	6.03**
LSD	1.28	111.6	2.13	172.2		

[1] Tuber number per plant
[2] Tuber weight (g) per plant
[3] *t* values for comparisons between tuber number per plant for different planting dates.
[4] *t* values for comparisons between tuber weight (g) per plant for different planting dates.

TABLE 4

The effect of planting date on tuber number and tuber weight (g) per plant for 8 potato cultivars.

Cultivar	Planting Date						LSD_{TN}	LSD_{TW}
	15.11.99		30.11.99		15.12.99			
	TN[1]	TW[2]	TN[1]	TW[2]	TN[1]	TW[2]		
Vivaldi	10.46	753.3	8.13	470.0	9.27	513.3	4.32	239.7
Spunta	6.60	673.3	10.13	776.7	6.00	650.0	3.86	268.0
Durby	7.40	530.0	7.53	520.0	6.73	493.3	2.61	194.5
Cantate	6.60	483.3	7.00	300.0	6.07	480.0	2.70	187.2
Diamant	9.70	573.3	11.33	523.3	9.93	590.0	2.93	219.1
Carlita	5.70	523.3	6.27	613.3	6.33	610.0	2.86	300.5
Caesar	8.20	520.0	8.40	590.0	8.47	546.7	4.17	308.5
Latona	9.20	596.7	5.27	386.7	10.00	583.3	2.89	257.7
LSD	3.51	251.0	2.53	213.6	3.16	177.6		

[1] Tuber number per plant.
[2] Tuber weight per plant (g).

Discussion

PLANTING DATE COMPARISONS: During Year 1, there was no measurable yield from the first planting date. For the remaining planting dates, based on the average performance of the five cultivars, there was a small decline in the number of tubers per plant, from 6.40 to 5.19 between the second and final planting dates. But, there was a significant decline in the average tuber weight per plant, from 522.6 g to 229.4 g per plant between the second and final planting dates.

The performance of the potato crop in Oman is significantly limited by the climatic conditions. Between mid-November and mid-March the maximum temperature remains below 30°C and the minimum temperature remains below 20°C. Prior to mid November and after mid March the maximum and minimum temperature are above and below these thresholds. Tuberization in potato is a sequential process of initiation followed by bulking; temperature plays a critical role in both processes (Struik *et al.*, 1989; a,b,c; Struik *et al.*, 1990, 1991; Ewing, 1981; Ewing and Struik, 1992).The yield parameters for the 26 cultivars under trial in 1998-99 (Table 3) show that four of the 26 cultivars showed a significant reduction in yield with later planting, 10 cultivars showed a significant increase in yield. The average yield per plant increased from 278.5 g to 322.5 g from the first to the second planting date. The average number of tubers per plant also increased from 4.1 to 5.0. During the third year (1999-2000) there was a small reduction (8.0-7.9) in the average number of tuber per plant for the 8 cultivars between the first and third planting dates. There was also a small reduction in the average weight of tubers from 581.7 to 558.3 g per plant (Table 4).

An important aspect of variation in yield at different planting dates is the emergence behavior of potato cultivars at different planting dates (Khan *et al.*, 2001). Emergence of seed potato is a function of its dormancy status, storage conditions, chitting before planting and field conditions (Wurr, 1979; Jenkin *et al.*, 1993). The higher yields achieved for some cultivars, when later planting dates were used, could be attributable to an accelerated rate of emergence with delayed planting (Khan *et al.*, 2001). The differences could also reflect the changing temperature conditions during the growing season particularly during tuberization for the later sown plots. The differences could also be due to the varying levels of adaptation of the cultivars to local temperature and soil conditions. The combined results from all the three years suggests the possibility of incorporating a later planting time, mid-December, into the potato production system in Oman.

CULTIVAR COMPARISONS: Five cultivars were evaluated during Year 1. Based on the average performance over all planting dates cvs Spunta and Diamant produced the highest tuber weights per plant (453 and 443 g respectively). The Year 2 trial (1998-99) included 26 cultivars. The cultivars with the highest yields per plant based on the average of the two dates used were Bydand (550g), 85-2-501 (468g), 91-41-78 (465g), Donald (444g), 91-2-101 (425g), Sterling (420g) and 90-23-28 (417g). During Year 3 (1999-00) the highest yielding cultivars (expressed as average yield across all planting dates) were Spunta (700g), Carlita (582g), Vivaldi (579g) and Diamant (562g). The inability of some cultivars to produce a significant yield is possibly an indication that these cultivars were unable to adapt to the soil conditions and temperatures that occur in Oman. Earlier, preliminary trials have shown (Khan *et*

al., 2000, 2001) that potato cultivars in Oman exhibit significant differences both in the rate of plant emergence and in total yields.

Plant breeders introduce crop cultivars with specific adaptation features (Khan, *et al,* 1983, 1984; Reynolds and Ewing, 1989b). In Oman, potato cultivars have been introduced with little evidence for their local adaptation. The cultivars Spunta and Diamant are popular cultivars despite conflicting evidence for their satisfactory performance relative to other cultivars. The data from the 1997-98 trial showed that cvs Spunta and Diamant produced high yields relative to the other cultivars. The results from Year 3 showed that cvs Vivaldi and Carlita were capable of producing yields as good as the two widely accepted cultivars. The trial of 26 cultivars during Year 2 also provided evidence that cvs Bydand, Donald and Sterling and the breeding lines 85-2-501, 91-41-78, 91-2-101 and 90-23-28 could be of significant value.

These results represent the first detailed report on the yield performance of a wide range of potato cultivars in the Arabian Gulf. These trials not only suggest potential cultivars for inclusion in a possible recommended list of cultivars, but also indicates the opportunities for changing the tuber planting times to better utilize the available short cropping season. The results could form the basis of an empirical package for future recommendations concerning potato cultivars for general cultivation in the Gulf region.

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