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Yield and Physical Properties of Potato Tuber as Influenced by Planting Depth

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Abstract. Two potato cultivars (*Solanum tuberosum* L. subsp. tuberosum), Ajax and korrigane, were selected to investigate the influence of two planting depths, 12 and 20 cm on yield and physical properties of tubers.

Planter was efficient in placing seed tubers, for both cultivars and missing tubers were less than 5%. Deep planting affected plant emergence in spring than in fall season. Korrigane had significantly higher yield in both growing seasons compared with Ajax. The best interaction for yield was Korrigane X 12 cm in spring and with 12 or 20 cm in fall. Static coefficient of friction was measured and it was found that the sliding coefficient was greater than rolling coefficient for both cultivars. There was no effect of planting depth on other physical properties for both cultivars.

Introduction

Potato acreage has increased dramatically during the last two decades in many regions of the world. In Saudi Arabia, the acreage has increased from 515 ha in 1983 to 2298 ha in 1990 [1, p. 22). Several cultivars were introduced and various cultivation techniques have been applied to improve yield and quality characteristics of the tubers. Planting depth is one of the important factors affecting yield and quality characteristics. The planting depth is chosen according to the soil condition. On lighter soils, deeper planting is usually possible and may be desirable in order to minimize the need for subsequent ridge building operation [2, p. 372]. Depth of 10 to 15 cm is recommended in most soil types in Saudi Arabia. [3, p. 4].

Planters can be classified into six basic types in accordance with their metering mechanism, i.e. hand-fed, cupfed, flat-belt-fed, moulded-belt-fed, multi-belt-fed, and finger-fed [4, p. 55]. On the other hand, the positive planter mechanism as cupfed, moulded-belt, and finger-fed will give the most even spacing assuming the seed is reasonably closely graded [4].

This study was undertaken to evaluate two planting depths using potato planter with positive feeding mechanism. Also, to investigate yield and tuber physical properties of two potato cultivars planted mechanically.

Materials and Methods

This study was carried out during two growing seasons (spring of 1990, and fall of 1990/91) in the Agricultural Research and Experiment Station, K.S.U., at Dirab, Riyadh, Saudi Arabia. Sandy loam soil plots were used in this study. Whole seed tubers, average seed weight, of 45 g for Ajax and 80 g for Korrigane were planted at two depths; 12 and 20 cm.

Seedbed preparation was done using mouldborad plowing disc harrowing and levelling. Planting was done on 21st. Jan. 1990 in the first season and on 24th Sept. 1990 in the second season. Seed tubers were supplied by the Ministry of Agriculture and Water (M.O.A.).

A split plot design was used with three replications in the first season and four replications in the second one. Main plots were devoted to planting depths and subplots were devoted to cultivars.

For both seasons, planting speed, seeding rate, and row spacing were kept constant at 4 km/hr, 2500 kg/ha, and 75 cm, respectively. Those variables were selected as they were normally recommended to potato growers by M.O.A. [3]. Other cultural practices, i.e., irrigation, fertilization, pests and weed control were performed as normally recommended [3].

Experimental data

The following measurements were made:

1. The planter efficiency was evaluated by measuring the distance between seed tuber in the row and the number of seed tubers in each row.
2. Plant emergence.
3. Tuber yield, harvesting was done by hand after 120 days from planting for both seasons.

After harvest, the total tuber yield was determined and the tubers were graded as follows:

a. size 1; tubers larger than 50 mm in diameter.

b. size 2; tubers of 35-50 mm diameter.

c. size 3; tubers of 28-35 mm diameter.

d. size 4; tubers less than 28 mm diameter.

(the marketable sizes are 1 and 2).

Total number and percentage of tubers in each size grading were determined.

Tuber density and moisture content [5, p. 105], and tuber physical properties; (length, width, thickness, and static coefficient of friction at different surfaces) were carried out according to the standard procedures [6, p. 328].

Data were statistically analyzed and the mean separation was done by the least significant difference at 0.05 level [7, p. 377].

Results and Discussion

The measurement of the distance between seed tubers within rows revealed that the mean distance was 32.9 ± 10.2 cm and 29.2 ± 3.5 cm for Ajax and Korrigane, respectively. This spacing reflected a good efficiency of the planter in placing tubers. High standard deviation for Ajax than Korrigane resulted from missing seed tubers during planting which could be attributed to clogging of the feeding housing and it was greater for Ajax than in Korrigane since the latter had reasonably larger seed tubers. However, the missing seed tubers during planting for both cultivars were less than 5%.

Percentages of plant emergence (Table 1) were affected by planting depth and cultivar in spring season. Seed tuber placed deeper resulted in lowering the plant emergence. In fall season, planting depth had, more or less, no effect on plant emergence, but Korrigane was better in this respect.

Cultivars reflected significant difference in tuber yield of both growing seasons (Table 2). Korrigane in both plantations produced more tuber yield/plant and yield per hectare compared with Ajax.

Planting depth had varied effect on total tuber yield according to growing season (Table 2). Depth of placing seed tubers did not reflect yield significance in spring. On

Table 1. Percentage of emerged plants after eight weeks from planting

Season	Cultivar	Depth, cm	
		12	20
Spring	Ajax	94.0 ± 11.51	90.0 ± 6.01
	Korrigane	85.0 ± 3.31	53.0 ± 6.76
Fall	Ajax	80.0 ± 3.71	84.0 ± 3.36
	Korrigane	99.0 ± 5.48	92.0 ± 5.13

Values represent mean ± sd

Table 2. Effect of planting depth on tuber yield per plant and yield per hectare of potato cultivars

Treatments	Spring		Fall	
	gm/plant	Ton/hectar	gm/plant	Ton/hectare
<u>Cultivar</u>				
Ajax	121.52 b	5.400 b	371.44 b	16.507 b
Korrigane	298.42 a	13.262 a	724.24 a	32.185 a
<u>Planting depth</u>				
12 cm	228.70 a	10.163 a	505.63 b	22.470 b
20 cm	191.24 a	8.499 a	590.06 a	26.222 a

Means with the same letter in each column are not significant at 0.05.

the other hand, significant effect of planting depth on potato yield was markedly observed in fall plantation. Deeper placement of seed tuber resulted in more tuber yield per plant and per hectare. This increase in tuber yield is probably due to seasonal changes during growing season [8, p. 67].

Significant cultivar X planting depth interaction was observed for tuber yield/plant and yield/ha of both growing seasons (Table 3). This interaction suggested that cultivars responded differently with regard to planting depth and growing season. Ajax productivity was not affected by planting depth in spring plantation, but deeper placement of tuber was significantly preferred for the cultivar in fall season. Korrigane at shallow planting (12 cm) produced higher yield than at deeper planting, in the spring. However, in fall there was no effect of planting depth on its yield. Gener-

Table 3. Effect of cultivar x planting depth interaction on tuber yield per plant and yield per hectare

Treatments	Spring		Fall	
	gm/plant	Ton/hectare	gm/plant	Ton/hectare
Planting depth (12 cm)				
Ajax	90.39 c	4.017 c	307.62 c	13.671 c
Korrigane	367.01 a	16.310 a	703.63 a	31.269 a
Planting depth (20 cm)				
Ajex	152.65 bc	6.784 bc	435.25 b	19.342 b
Korrigane	229.83 b	10.214 b	744.86 a	33.067 a

Means with the same letter in each column are not significant at 0.05.

ally, the best interaction for tuber yield was Korrigane X 12 cm in spring and Korrigane X 12 or 20 cm in fall season.

The distribution of total yield into size grading is shown in Fig. 1. The yield of the marketable tuber sizes (size 1,2) in fall season was more than 75% of the total tuber yield, while it was 25% of total yield in spring. Fall crop was significantly higher than spring crop and it was higher for Korrigane than Ajax. Planting depth has no effect on marketable yield.

The postharvest measurements of tuber physical properties were taken in the laboratory. The average moisture content of tubers was 81.8 and 82.1% for Ajax and Korrigane, respectively in spring season, while it was 82.8 and 83.2% in fall. The average tuber density was 1.12 gm/cm^3 for Ajax and 1.11 gm/cm^3 for Korrigane.

The coefficient of static friction, sliding (Si) and rolling (Rol), was measured using different surfaces of different frictions. The results were recorded in degrees and listed in Tables 4 and 5. The sliding angles were always greater than rolling angles for both cultivars. For Ajax, there was no sliding angle for the grading size between 28 to 35 mm. That was mainly due to the spherical shape as well as the small size of tubers. It was also found that the marketable size had larger angles with all surfaces tested. The angle of any surface could be affected by the weight of tuber. Also, the angle increased by increasing the tuber weight. The coefficient of static friction; as shown in Tables 4 and 5, would depend entirely on the roughness of the surface and on the tuber shape and weight.

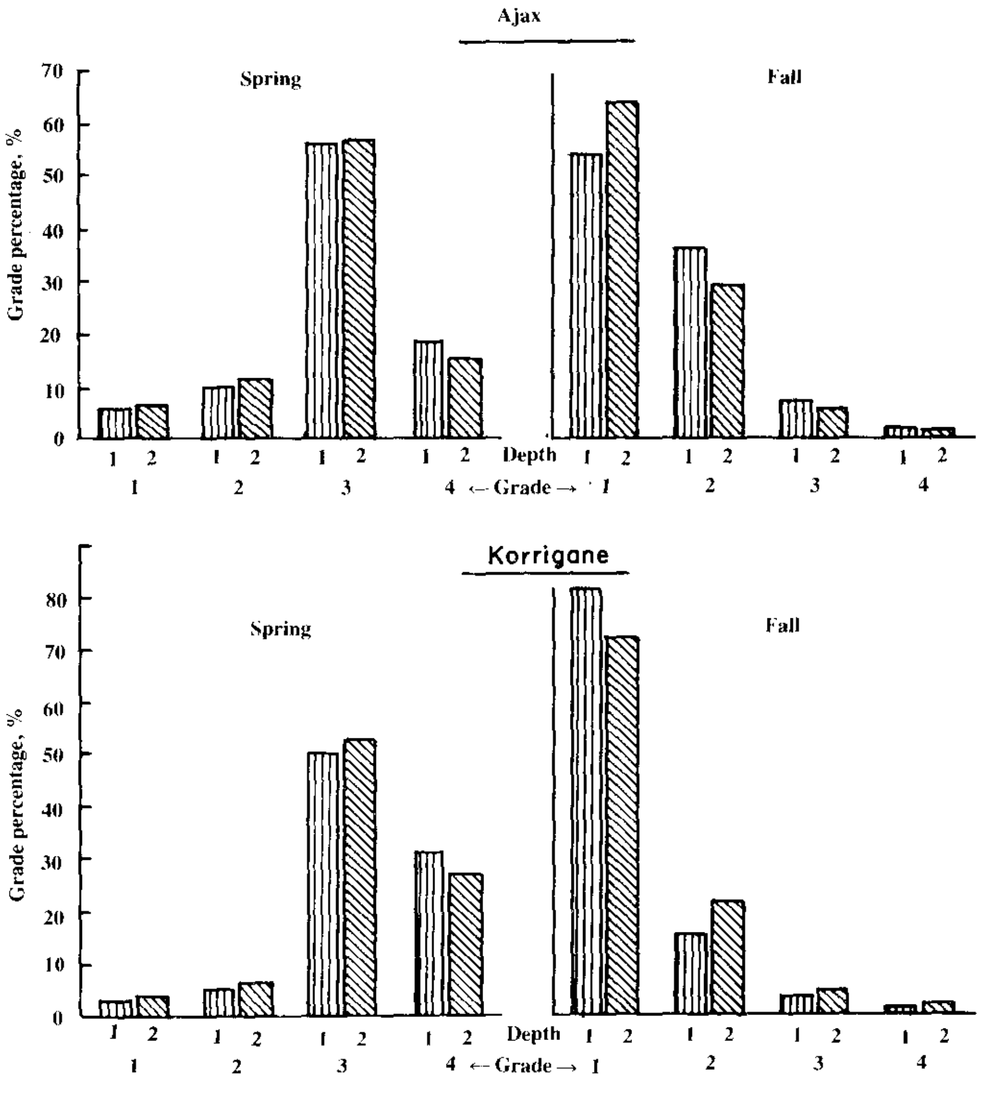

Fig. 1. Weight of each size as a percentage of total yield as affected by planting depth for Ajax and Korrigane in both growing seasons.

Planting depth 1 = 12 cm 2 = 20 cm.
Grades 1 = size 1 > 50 mm 2 = size 2, 35-50 mm
3 = Size 3, 28-35 mm 4 = size 4 < 28 mm

Table 4. Static coefficient of friction, sliding (Si) and rolling (Rol), expressed in degrees on different surfaces for Ajax*.

Size	Wt	Smooth sur.		Plastic bag		Galv. sheet		Metal net	
	gram	Si	Rol	Si	Rol	Si	Rol	Si	Rol
28-35 mm	19.6	–**	14	–**	13.5	–**	14	–**	8
	19.7	–	19	–	11.5	–	7	–	8
	26.7	–	7	–	10	–	4	–	3.5
	27.5	–	13.5	–	17	–	12.5	–	14
	35.6	–	16.5	–	17	–	16	–	8
35-50 mm	38.7	19.5	5	26	11	16	11	18	9
	50.2	19	4	24	12	10.5	8	22	14
	60.9	17	11	15	9	15	12.5	28	7
	86.0	19	5	21	6	19.5	5	25	8
	78.1	20	14	26	18	21	5	26	15
> 50 mm	105.3	18	6	24	10	20	9	18	10
	112.6	16	8	24	15	20	15	22	9.5
	124.5	16.5	8.5	26.5	13	18.5	14	25	10
	145.6	15	8	23	10	20	9	22	8.5
	195	16	12	23	11	20	14	22	8

* The unmarketable grade (28 mm) was not listed.
** No measurement recorded

Table 5. Static coefficient of friction, sliding (Si) and rolling (Rol), expressed in degrees on different surfaces for Korrigane*.

Size	Wt	Smooth sur.		Plastic bag		Galv. sheet		Metal net	
	gram	Si	Rol	Si	Rol	Si	Rol	Si	Rol
28-35 mm	20.2	20	15	22	18	22	17	45	12
	23.1	14	4	18	10	18	9	30	8
	23.1	12	6	15	12	16	9	35	12
	23.6	18	5	21	12	20	8	45	5
	26.3	19	9	23	10	24	8	35	7
35-50 mm	29.8	10	5	15	10	14	10	29	9
	59.9	15	8	20	9	17	9	19	9
	67.8	18	7	28	10	20	9	28	7
	87.4	20	11	24	15	19	11	23	12
	94.8	15	9	23	11	17	10	29	14
> 50 mm	106.2	20	10	27	14	19	10	26	10
	158.2	20	8	30	13	19	9	28	9
	160.5	19	10	27	14	20	14	25	13
	199.2	27	12	24	14	19	10	30	12
	288.7	22	10	25	10	22	10	27	12

* The unmarketable grade (28 mm) was not listed.

The sliding static coefficient of friction was always greater than the rolling static coefficient, for both cultivars. However, there was no effect of planting depth on the coefficient of friction and other physical properties. The determination of coefficient of static friction could be of great help during the handling, transporting, and storage process of potato as well as for the design of mechanical harvesters.

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تأثير عمق الزراعة على المحصول والصفات الطبيعية لدرنات البطاطس

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ملخص البحث. تمت زراعة درنات صنفين من البطاطس وهما أجاكس وكوريجان لدراسة تأثير عمقي الزراعة ١٢سم و ٢٠سم على المحصول والصفات الطبيعية للدرنات. وقد كانت آلة الزراعة ذات كفاءة عالية في وضع الدرنات على العمق المناسب لكلٍّ من الصنفين، وكانت نسبة الفقد أقل من ٥٪. وكانت الزراعة على عمق ٢٠سم قد أثرت على نسبة الإنبات في الموسم الربيعي بدرجة أعلى مما في الموسم الخريفي، وكان الإنتاج عاليًا من صنف كوريجان في كلا الموسمين بالمقارنة مع صنف أجاكس. وقد كان أفضل تفاعل بالنسبة للمحصول هو لدى صنف كوريجان المزروع على عمق ١٢سم في الموسم الربيعي أو على عمق ١٢ أو ٢٠سم في الموسم الخريفي. كما تم قياس معامل الاحتكاك الاستاتيكي للدرنات. وقد وجد أن معامل الانزلاق كان أعلى من معامل التدحرج لكل من الصنفين. ولم يكن هناك تأثير لعمق الزراعة على الصفات الطبيعية لدرنات أي من الصنفين.