Mechanization of Potato Production in the Libyan Jamahiriya

I. Effect of Planting and Harvesting Methods

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ABSTRACT

A field experiment was conducted at the Faculty of Agriculture Farm, University of Al-Fateh, Tripoli, Socialist People's Libyan Arab Jamahiriya, during the Spring of 1977. The effects of mechanical, semi-mechanical and manual potato production on theoretical field capacity, labor requirement, sprout emergence and yield were studied.

Mechanical potato production (planting and harvesting) increased timeliness, efficiency and economy. It had 6.6 and 14.3 times more efficiency, required 11.4% and 8.1% of man-hours/hectare, and 10% and 6.8% of man-hours/ton of tubers compared to semi-mechanical and manual methods, respectively.

Sprout emergence and tuber yield/hectare was positively affected by the planting methods and the cultivars. Mechanically planted tubers took significantly more days to sprout and produced higher yield than the manually planted tubers. The sprouts of Cv. Vittorini emerged later as compared to Mirka and Arran Banner. The yield of Cv. Arran Banner was significantly higher (15.66 tons/ha) than Mirka and Vittorini.

The studies clearly emphasized the values of mechanizing potato production in the Libyan Jamahiriya. The production costs can be reduced by efficient machine use, resultant higher yields and minimum dependence on expensive farm labor.

INTRODUCTION

The potato (*Solanum tuberosum* L.) is mostly grown in the coastal belt of the Jamahiriya. It is planted as the fall and the spring crop. The area under potatoes has increased from 2,000 hectares in 1971 to 8,000 hectares in 1979. The respective tuber yields were 15,000 and 90,000 tons (FAO, 1979a).

Libyan Jamahiriya has the requisite characteristics and potentialities for mechanizing her agriculture. The farm labor is limited, transient, expensive and uncertain. This affects the efficiency and timeliness of farming operations adversely, increases the costs and reduces the farmer's profits. Cultivatable land and capital is available.

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Technological inputs are needed to economically increase the agricultural production per unit area and to maximize the farmer's returns. Mechanization is one of the critical inputs of production. Mechanization can increase yields through improvement of water control, better soil preparation for planting, efficient weed and insect control and the proper harvesting and post-harvest handling of crops.

The number of tractors or agricultural machinery units operating in a country indicates her willingness to invest hard currency in mechanized agricultural technology. This factor is well pronounced in the Jamahiriya because the imports of agricultural machinery are increasing. This country had 25,161 tractor units in 1978 against 2,250 units in 1968 (FAO, 1979b).

Avoidance of potato tuber damage during mechanical harvesting was major concern of potato growers and agricultural machinery designers. Tuber damage has been minimized by cushioning the relevant metal parts of the potato harvesters, by reducing the distance of tuber fall, proper elevator speed to forward speed ratios and minimum agitation (9, 11, 15, 17). Rennie (13), Chaudhry and Henderson (2) and Chaudhry *et al.* (3) have emphasized that mechanization of potato harvesting is an efficient and economical proposition for labor scarcity areas. Tavernetti and Baghott (17) have observed that potato growers are mechanizing potato harvesting to reduce the costs, labor requirement and arduous nature of work. French (8) found that two-row elevator diggers were economical than four-row machines because the fixed and operating cost/hour was less for the former. Cashmore (1) observed minimum tuber damage while operating the digger at elevator speed to forward speed ratios of 0.7:1 and 1.0:1. Chaudhry *et al.* (3) studied the comparative performance of a one-row tractor-drawn elevator potato digger against manual harvesting under the Libyan conditions. They found the digger very efficient and economical. The elevator speed to forward speed ratios of 0.57:1 and 0.85:1 were more effective to give enhanced capacity, to reduce labor requirement and cost of harvesting. The digger operating at these speed ratios without agitation gave tuber damage similar to the manual method.

The effect of mechanical planting of potatoes on tuber yield has been studied by many workers. Evans (5) found that irregularity of seed tuber spacing within the row reduced the tuber yield upto 7 percent. Manual planting gives this spacing variation and leads to the loss of tuber yield. Jarvis (10) also made similar observations. The tuber yields tended to decrease as seed tuber spacing became more irregular. The decrease was 1.7 t/ha when coefficient of variation of seed tuber spacing was increased from 0 to 60 percent.

Crop production surveys have been reported by Culpin (4), Johnson *et al.* (11) and West (18). They have recorded complete mechanization of potato planting in the countries known for potato production. They also found a rapid change in potato harvesting methods from arduous manual method to elevator potato diggers and complete potato harvesters, depending upon the extent of labor shortage and cost. The farmers have shown more attraction for complete potato harvesters due to their efficiency, automation and low tuber damage design characteristics.

The present investigations were undertaken to compare the mechanical potato production (planting and harvesting) with the conventional semi-mechanical and manual methods. The methods were evaluated on the basis of their field capacity, labor requirement and effect on tuber yield to have an idea of their efficacy under the Libyan conditions.

MATERIALS AND METHODS

A field experiment was conducted on sandy loam soil of Faculty of Agriculture Farm, University of Al-Fateh, Tripoli, S.P.L.A.J. The field had been a fallow since May, 1976 after growing alfalfa for three years. Planting was done on January 25, 1977. A split plot design with four replications was used. The main plots were assigned to three potato cultivars Viz: Arran Banner, Mirka and Vittorini, of similar source and physiological age. The subplots were assigned to three potato production (planting and harvesting) methods:

1. Manual
Making ridges with a spade locally called 'Misha', planting the seed tubers by hand, digging the mature tubers by spade and picking by hand.

2. Semi-mechanical
Making ridges with a tractor-drawn ridger and completing other stages of planting and harvesting according to the manual method.

3. Mechanical
Planting by a tractor-drawn and drive wheel-driven two-row potato planter, digging with a one-row power-take off-driven elevator digger and picking by hand. The elevator speed was adjusted to forward speed ratio of 0.6:1.

Phosphorus as single superphosphate (20% P_2O_5) at the rate of 60 kg P_2O_5/ha was broadcasted in the field before cultivation. Nitrogen was also applied at the rate of 125 kg N/ha as ammonium sulphate (21% N). This amount was divided into three doses: 45 kg N before cultivation, 40 kg N side-dressed after complete emergence of sprouts and 40 kg N before the last earthing up i.e. about 50 days after planting. Each subplot was 120 m^2 and consisted of two ridges 80 m long and 75 cm wide. Imported seed tubers of size 35–45 mm were used for planting. Manually planted tubers were spaced at about 30 cm in the ridges at a depth of 6 to 8 cm. Tractor-drawn potato planter was adjusted to plant tubers 30 cm apart and 10–12 cm deep in the ridges. Chemical pest control and manual weeding were practised. The crop was sprinkler irrigated at 6 to 10 days intervals depending upon the crop condition and amount of rainfall.

The theoretical field capacity (TFC) in hectars per hour and labor requirement in man-hours were determined from the time taken for making a 50-meters long ridge, planting seed tubers in it, digging and picking mature tubers from it. The formulae applied were:

1. $$\text{Theoretical field capacity (hectars/hour)} = 0.0001 \times \frac{\text{Area covered } (m^2)}{\text{Time taken (hours)}}$$

2. Labor requirement:

(a) $$\text{Man-hours/ha.} = \frac{\text{Number of workers}}{\text{Theoretical field capacity}}$$

(b) $$\text{Man-hours/ton} = \frac{\text{Man-hours per hectare}}{\text{Yield per hectare (tons)}}$$

The date of sprout emergence was recorded when more than 50 percent of sprouts had emerged. Harvesting was done after about 100 days from planting. Mature tubers were lifted from an area of $50 \times 1.5\,m^2$ of each subplot and weighed to determine the yield per hectare.

RESULTS AND DISCUSSION

I. Theoretical field capacity (TFC)

Mechanical potato production (planting and harvesting) method had the highest theoretical field capacity and the lowest labor requirement (Table 1).

Table 1. Effect of planting and harvesting methods on theoretical field capacity (TFC) and labor requirement*.

Planting and harvesting methods		TFC hectares per hour	Man-hours per hectare	Total man-hours per hectare	Yield per hectare (tons)	Man-hours per ton
Manual	Planting	0.011	363.64	935.07	12.86	72.71
	Harvesting	0.007	571.43			
Semi-mechanical	Planting	0.032	93.75	665.18	13.37	49.75
	Harvesting	0.007	571.43			
Mechanical	Planting	0.212	9.44	76.11	15.36	4.96
	Harvesting	0.045	66.67			

* Number of workers

A. Planting
- Manual: 2 for ridging and 2 for planting
- Semi-mechanical: 1 tractor driver for ridging and 2 for planting
- Mechanical: 1 tractor driver and 1 for attending the planter

B. Harvesting
- Manual: 2 lifters and 2 pickers
- Semi-mechanical: 2 lifters and 2 pickers
- Mechanical: 1 tractor driver for lifting and 2 pickers.

Theoretical field capacity of two-row potato planter (0.212 hectars/hour) was about 19 times higher than the manual planting (0.011 hectares/hour). The capacity of semi-mechanical method of planting was 0.032 hectares/hour. It was about 3 times more than the manual planting but about one-seventh of mechanical planting. The order of theoretical field capacities for planting was: mechanical > semi-mechanical > manual.

The harvesting of manually and semi-mechanically planted potatoes was done by hand tools. This resulted in the similar and very low theoretical field capacity (0.007 hectares/hour) for both of these methods. The harvesting capacity of one-row potato elevator digger was 0.045 hectares/hour. It was 6.5 times greater than harvesting by hand tools.

II. Labor requirement

Mechanical potato production was efficient and less laborious (Table 1). Its labor requirement (76.11 man-hours/hectare) was only 0.11 and 0.08 of semi-mechanical (665.18 man-hours/hectare) and manual method (935.07 man-hours/hectare) of potato production. The same trend of labor requirement was maintained when man-hours/ton of tubers were determined. Man-hours/ton of tubers were 4.96, 49.75 and 72.71 for mechanical, semi-mechanical and manual method, respectively.

The studies conducted by Chaudhry and Henderson (2), Chaudhry *et al.* (3) and Rennie (13) have also stressed that mechanical potato harvesting was efficient, economical and required less labor compared to manual methods. The present findings strenghten their observations that mechanization of potato production is a necessity for farm labor scarcity regions like the Libyan Jamahiriya.

III. Sprout emergence

The number of days taken for sprout emergence, with different methods of planting are given in Table 2. The seed tubers took about the same period to sprout (27 days) for manual and semi-mechanical methods of planting, because seed tubers were planted by hand at 6 to 8 cm depth for both of these methods. The depth of seed tubers ranged from 10–12 cm for mechanical planting and the sprouts on average took 30.4 days to emerge. Mechanically planted tubers took significantly more days for sprout emergence than hand planted tubers. It was probably due to comparatively deeper placement of seed tubers in the ridge by the mechanical potato planter.

Potato cultivars were significantly different in sprout emergence. The maximum number of days (31.17) were taken to sprout by Cv. Vittorini and the minimum number of days (24.92) by Cv. Arran Banner. The order of sprout emergence was: Vittorini > Mirka > Arran Banner.

Table 2. Effect of planting methods and potato cultivars on the number of days taken for sprout emergence.

Potato cultivars	Planting methods			Mean[b]
	Manual	Semi-mechanical	Mechanical	
Arran Banner	23.50[c]	24.00	27.25	24.92
Mirka	27.25	27.25	31.00	28.50
Vittorini	30.25	30.25	33.00	31.17
Mean[a]	27.00	27.17	30.42	—

[a] Planting methods: L.S.D. (0.05) = 0.71 and (0.01) = 0.98 days.
[b] Cultivars: L.S.D. (0.05) = 1.37 and (0.01) = 2.08 days.
[c] Interaction: Non-significant.

IV. Tuber yield

The potato planting methods and the cultivars exhibited significant differences in yield of potato tubers (Table 3). The mechanical planting gave significantly higher yield (15.36 tons/ha) compared to semi-mechanical (13.37 tons/ha) and manual method (12.86 tons/ha). The semi-mechanical method produced significantly higher

Table 3. Effect of planting methods and potato cultivars on the yield of tubers (tons/ha.).

Potato cultivars	Planting methods			Mean[b]
	Manual	Semi-mechanical	Mechanical	
Arran Banner	14.80[c]	15.47	16.71	15.66
Mirka	11.95	12.60	15.23	13.26
Vittorini	11.83	12.03	14.14	12.67
Mean[a]	12.86	13.37	15.36	—

[a] Planting methods: L.S.D. (0.05) = 0.34 and (0.01) = 0.47 tons/ha.
[b] Cultivars: L.S.D. (0.05) = 0.89 and (0.01) = 1.35 tons/ha.
[c] Interaction: Non-significant.

yield of tubers than the manual method. The order of yields was: mechanical planting > semi-mechanical planting > manual planting. The size of the ridges had also the same order. The reason of the higher yield by mechanical method may be the deeper and regular placement of seed tubers in higher and bigger ridges. The ridges made by ridger for semi-mechanical planting and by spade for manual planting were comparatively smaller than those made by the mechanical planter. Hand planted tubers were also irregularly spaced in the ridges. The small size of the ridges and irregular placement of tubers therein adversely affected the yield. These results corroborate the findings of Evans (5) and Jarvis *et al.* (10).

Potato Cv. Arran Banner gave significantly higher yield (15.66 tons/ha) than Mirka (13.26 tons/ha) and Vittorini (12.67 tons/ha). The yields of the latter two were not significantly different.

The interaction between the methods of planting and the potato cultivars was not significant for sprout emergence and the tuber yield.

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ميكنة محصول البطاطس بالجماهيريـــة العربية الليبية الشعبية الإشتراكيـــة

١ — تأثير طرق الزراعة والحصـــاد (تقليع)

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المستخلـــص

أجريت التجربة بمحطة تجارب كلية الزراعة — جامعة الفاتح لمحصول البطاطس للعروة الربيعية ١٩٧٧ م ، لدراسة تأثير البذر الآلي ، النصف آلي ، واليدوي ، على السعة الحقلية النظرية ، إحتياجات العمالة ، الإنبات وإنتاج المحصول .

ميكنة محصول البطاطس (بذر — وتقليع) توفّر الوقت ، والجهد بكفاء إقتصادية وتمتاز بكفاءة أعلى ٦,٦ ، ١٤,٣ وتحتاج ١١,٤٪ و٨,١٪ منتج ساعة للهكتار و١٠٪ ، ٦,٨٪ منتج — ساعة للطن مقارنة بالميكنة النصف المتكاملة والطريقة اليدوية على التوالي .

والدراسة عملت لتأكيد أهمية ميكنة محصول البطاطس بالجماهيرية العربية الليبية الشعبية الإشتراكية . لتخفيض تكاليف الإنتاج ، باستعمال الآلة بكفاءة للحصول على إنتاجية عالية وتقليل العمالة اللازمة للعملية الزراعية الإنتاجية .