Effect of some mechanical planting methods on potato tuber characteristics

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Abstract: The study aimed to identify the effect of planting machine on potato Burren variety characteristics under planting method by going and return and planting method by rotation oceanic at different distances and ranges of planting depths. Two types of potato planting methods (PMBGR and PMBRO) were tested under two planting distances (25 and 30 cm) and three levels of planting depths (8, 10 and 12 cm). The experiments were conducted in a factorial experiment under a randomized complete block design with three replications, The PMBGR was significantly better than PMBRO in all studied parameters. For PMBGR, the fuel consumption, machine productivity, machine efficiency, germination percentage, root density and distributed in soil for vegetative growth stage, root density and distributed in soil for tubers formation stage, tubers number and one plant productivity were 9.870 L ha^{-1}, 869.902 kg ha^{-1}, 82.636%; 89.374%; 0.46 Mg cm^{-3}; 0.80 Mg cm^{-3}, 7.59 tuber plant^{-1} and 1005.99 g plant^{-1} respectively. The planting distance 30 cm was significantly superior to the other level of 25 cm in all studied parameters, while the planting depth at range of 8 cm was significantly superior to the other ranges of 10 and 12 cm in all parameters.

Keywords: potato, tractor (type New Holland–TD80), planting distances machine (type Adwhit), mechanical properties, depth

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1 Introduction

Potato is one of the most important crops in the world, in Iraq potato crop is one of the important agricultural crops, as the Ministry of Agriculture seeks to increase the area planted with this crop to reflect positively on increasing productivity, according to the optimal use of the machines involved in production by scientific and engineering methods. Potato is an important industrial crop, as it enters in several industries, as bread (Aleawi et al., 2020). No two differed on the economic importance of the Potato crop on the nutritional level and therapeutic, in Iraq was called the crops king. (Al-Sharifi et al., 2019b), potatoes are used largely as a staple food, it is a financial source for a number of farmers in many countries of the world, including Iraq (Al-Sharifi et al., 2020b).

The methods of planting and planting depth, were large impact on some characteristics of the potato crop, whereas with planting depth, total yield was reduced and this proved that the increasing in the planting depth, is the lack of a suitable environment for root growth, and its spread in the soil (Al-Sharifi et al., 2019a). Confirmed in their studies that planting depth and distances, had a significant effect on all growth characteristics of the crop, and the best results were obtained at 4 cm planting depth and 8 cm seeding distance. This is as a result of providing the largest distance for roots to spread and

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obtaining the highest nutrients for the plant during the growth period. (Shtewy and Al-Sharifi, 2020). The planting and productivity of any agricultural crop is affected by mechanical treatments such as planting method, depth and distance planting. (Alaamer and Al-Sharifi, 2020).

That one plant productivity and the dry weight It is affected by the planting distance and soil physical properties Khallouf et al. (2019), through their studies, they mentioned improving the soil physical properties, increasing planting distances, positively reflected on the growth characteristics of the potato crop (Al-Sharifi and Ameen, 2018), planting spaces between plants was a great impact during the study which carried out by Bin (2016), on all studied characteristics (yield, tubers number / plant, one plant productivity) high moral results were obtained, as a result for less disease, during the growth period, also provides adequate nutrients for potato plant. they with their studies of effects of planting depth on the mechanical performance of two varieties of potato, that 15 cm planting depth was much better than 10 cm planting depth in terms of productivity and some growth properties in the light soil (Cheaibi et al., 2013). Study of Kumar et al. (2015) showed that, evaluate the effect of three planting depths (10, 15 and 20 cm) on planting of potato, in both the processing varieties, final plant emergence and growth traits (plant height, stem and leaf number/plant) decreased significantly at 10 cm planting depth, and concluded that there is a significant impact of the planting depth on all the crop properties (Al-Sharifi, 2009a). The planting date affects the growth characteristics of crop, through the large effects of the period of exposure of the plant to sunlight, as well as the influence environmental factors in the soil on the nutrients readiness, as well as the impact of the environment on physiological processes such as transpiration and respiration, which in turn affects growth rates and the amount of yield, etc. (Al-Abdaly and Al-Zobaay, 2016). whereas with planting depth, total yield was reduced and this proved that the increasing in the planting depth, is the lack of a suitable environment for root growth, and its spread in the soil (Al-Sharifi and Naim et al., 2020c).

The main goal of this research is to study the effect of some mechanical planting methods on potato characteristics.

Table 1 Tractor specifications(type New Holland –TD80)

Parameter		
Capacity	3908 cm^3	
Bore ×Stroke	104 mm ×115 mm	
Rated engine power ISOTR143%,2000/25/EC		58.8/80 kw/hp
Rated engine speed	2500 r/min	
Max. torque at 1500 r/min	298Nm	
Torque rise	25%	
Synchro command TM transmission -30hp -Number of gears		12×4 (F×R)
speed range	1.7- 30Kph	
Synchro shuttle TM transmission -30hp -Number of gears		12×12 (F×R)
Number of gears with creeper		20×12 (F×R)
Speed range with creeper	0.25-30 Kph	
Max. Number of remote valves		3
Max lift capacity at ball ends with arms horizontal		3565 kg
continuous lift capacity through the range 610 mm behind bar ends		2700 Kg
PTO 540 r/min	2200 r/min	
PTO 1000 r/min	2381 r/min	
PTO activation	Mechanical	
Dimensions		
Minimum width	1808 mm	
Height at center of rear axle to top of ROPS		1788 mm
Total height with ROPS 2488Wheel base 2WD/4WD		2248/2192
Front 2WD	1405-1905	
Front 4WD	1560-2000	
Weight	3080 Kg	
Max permissible weight on the front axle 2WD/4WD		2500/2800
Max permissible weight on the rear axle 2WD/4WD		4150

2 Materials and methods

This study was conducted at 2019 to evaluate the performance of the planting machine (type Adwhit). The experiments were done at two levels of planting methods by going and return (PMBGR) and planting method of rotation oceanic (PMBRO) The advantage of this method is to reduce the time and increase the productive efficiency of the planting machine and two planting distances at levels of 25 and 30 and three planting depth at levels of 8, 10 and 12 cm with three repetitions. The Adwhit type machine was adjusted on 30 cm planting distance and linear speed of 3.212 km hr^{-1} and depth of planting 12 cm then the samples of potato were placed in the machine.

This study used tractor (type New Holland –TD80) with moldboard plow to stir the soil and create a suitable place for seed growth. Using the Drip Irrigation System and planting on shoulders, one shoulder width 25 cm, the distance between one shoulder and another is 75 cm and distance between one plant and another is 25 and 30 cm for both two methods in this experiment.

Steps of the calibration for planting machine used in the experiment.

2.1 The field method

Steps of the calibration

(1) Fill the hopper with plants;

(2) Planting machine movement to 200 m distance inside the field. The width of the planting machine is 1.5 m. The distance travelled by the planting machine becomes:

200 ÷1.5 = 133.33m

(3) Open the plants tubes and place the nylon bags and the planting machine movement for the distance mentioned above (133.33 m); 4. The tubers are collected and beaten in a 25 to give the amount of tubers to be planted in a hectare. (Figure 1)

Table 2 Moldboard plow specifications

Parameter	
Working width	120 cm
Length	3010 mm
Height	1130 mm
Weight	320 kg
Weapon width	40 cm

Figure 1 The machine (type Adwhit) used for potato planting

Table 3 Planter specifications(type Adwhit)

Parameters	
Required power	50-90 hp
Rows	3
Weight of machine w/o seeds	540 kg
Hopper ccapacity	350-450 Kg
Power transmission system	Sprocket - Belt -Pulley
Speed	2.5-3.5 km hr^{-1}
Number of cups	3×50
Number of belt conveyors	2
Potato seed size	20-60 mm
Overall dimensions	180 cm ×160 cm ×105 cm(L× W × H)

Cup insertion for small seeds	Optional
Working depth (Adjustable)	5 cm -20cm
Seeding spacing	18 cm -35 cm
Row spacing	50 cm -100 cm
Working efficiency	0.6-1 mu h^{-1}
Fertilizer tank capacity	0.08*2 M^3

2.1 Planting method by going and return (PMBGR)

The planting done from the left toward the corresponding pillow than move to the right after lifting the planting unit and resume the planting process with back to the corresponding pillow, as in Figure **2**.

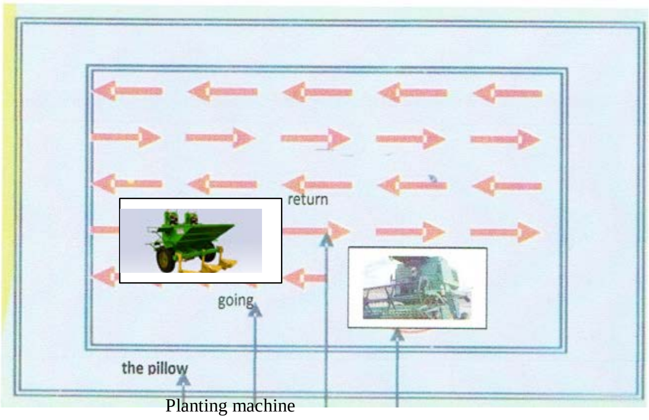

Figure 2 Planting method by going and return

2.2 Planting method by rotation oceanic (PMBRO)

In this method, the field is sown from outer borders and rotation to the right until the remaining spot which is planting in going and return as in the first method as in Figure 3.

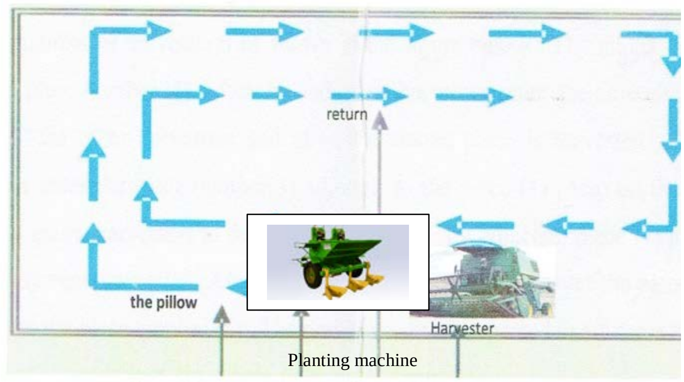

Figure 3 Planting method by rotation oceanic

2.3 Measurements

2.3.1 Planter fuel consumption

Planter fuel consumption is measured by the fuel consumption device in mL for treatment length 50 m. (Al-Sharifi, 2009a and Al-Sharifi et al., 2020a).

$$Q_F = \frac{Q_D \times 10000}{W_P \times D \times 1000} \quad (1)$$

Where: $Q_{F:}$ planter fuel consumed amount L ha^{-1}, $Q_{D:}$ planter fuel consumed amount for treatment length (50 m), $W_{P:}$ machine width (m), D: treatment length (50 m).

2.3.2 Planter productivity

The production process calculated according to the field method used before (Al-Sharifi, 2018), the planting tank is filled with tubers and weighed to grow one hectare, depends on machine capacity as well as the size tubers.

$$M_{P=W_{tf}-W_{tr}} \quad (2)$$

Where: M_P is machine productivity kg ha^{-1}, W_{tf} is weight of tubers after filling (kg)machine tank, W_{tr} is weight of tubers remaining in the machine tank (kg).

2.3.3 Planter field efficiency

Planter efficiency is the ratio of effective machine capacity to theoretical machine capacity, and it can be affected by time lost in the field and the full width of the machine**.**

2.3.3.1 Theoretical machine capacity

Theoretical machine capacity is the rate of work when the implement uses its full width and time and it was calculated as follow:

$$T_{FC} = \frac{S \times W}{C} \quad (3)$$

Where T_{FC}: theoretical machine capacity (ha h^{-1}), S working speed (Km hr^{-1}), W: operating width of implement (M), and C: Conversion factor (10)

2.3.3.2 Effective field capacity

Effective machine capacity is the actual rate of work and it was calculated as follow:

$$E_{FC} = \frac{A}{T} \quad (4)$$

Where E_{FC}: effective machine capacity (ha h^{-1})' A: distance (m), T: time (h)

Equation 5 was used for calculation of machine efficiency (Oduma et al., 2015)

$$F_E = \frac{E_{FC}}{T_{FC}} \times 100 \quad (5)$$

2.4 Soil characteristics

Physical properties of soil samples for six sites were taken randomly from the field and for three tillage depths determined in the experiment. These tillage depths (6, 8 and 10 cm) by the hydraulic device for a tractor according to the method used by (Langston, 2014) were taken of the soil samples for different depths when obtaining 12%-14% soil moisture. And then, the first part was executed from the experiment. Samples were taken to measure soil moisture in the surface layer, 6, 8 and 10 cm. Soil samples were weighted and drying in the oven with 105˚C. The moisture content of soil samples (Al-Sharifi, 2009b).

$$W = \frac{W_W}{W_S}\times 100 \quad (6)$$

Where: W is soil moisture percentage (%), W_w is mass wet soil(kg), W_s is mass dry soil.**(**kg**)**

2.4.1 Soil bulk density

For measuring bulk density, three soil samples from different parts of the land were collected using the pipette method. The collected samples were immediately put in plastic bags to conserve moisture during transferring to the laboratory and weighed it, then dried at 105˚C for 48 h. Mass of dried soils was weighted. Soil bulk density was determined by (Al-Sharifi and Ameen, 2018).

$$P_b = \frac{M_S}{V_T} \quad (7)$$

Where: P_b: Dry bulk density (mg m^{-3}), M_S: the weight of the dried soil sample (mg), V_T: total volume of the soil sample (m^3).

2.4.2 Total of soil porosity

The total porosity of soil samples collected for each treatment was calculated using the following equation, an assumed particle density of 2.65 mg m^{-3} (Jacobs et al., 2010)

$$T_{SP} = \left(1-\frac{P_b}{P_S}\right)\times 100 \quad (8)$$

Where: T_{SP}: total of soil porosity (%), P_b: dry of bulk density (mg m^{-3}), P_S : partial density (mg m^{-3}) as shown in the table.

Table 4 Soil mechanical analysis of the field experiment

Soil moisture %	planting depth, cm	distances of planting, cm	Silt(g kg^{-1})	Clay(g kg^{-1})	sand(g kg^{-1})	Soil texture
	8	25	480	360	160	
12-14%		30	470	360	170	
Av			476.67	363.33	160	Silt Clay loam
12-14%	10	25	480	370	150	
		30	480	350	170	
Av			480	360	160	Silt Clay loam
12-14%	12	25	460	390	150	
		30	480	360	160	
Av			470	376.67	153.33	Silt Clay loam

2.3 The crop and its components

2.3.1 Germination percentage

Germination percentage was calculated for a number of randomly selected plants, each experimental unit,in nine replications (Al-Sharifi and Naim et al., 2020c)

2.3.2 Root mass density roots distribution

Root samples were taken with a cylindrical drill, 5 cm diameter and 5 cm in length, inserted into the area near the plant in soil at different depths (6, 8 and 10 cm). After that the roots are separated from the soil by washing, the initial moisture content of roots was determined by oven drying methods at 75°C for 72 h. For vegetative growth stage and tubers formation, also five randomly selected plants at the season end, each experimental unit (Al-Sharifi, 2009a and Kumar et al., 2015). β is a function of root distribution at the root density value (Nr). Root weight density (RWD, Mg cm^{-3}):

$$Nr_{(Z.t)} = \frac{\beta[Z.t]}{\beta_t} \quad (9)$$

$$\beta t = \int_0^z \beta\lfloor Z.t\rfloor\, dz \quad (10)$$

$$Nr(Z.t) = \frac{\beta(z.t)}{\int_0^z \beta\lfloor Z.t\rfloor dz} \quad (11)$$

Where: $\beta(z.t)$ is the roots standard at depth (Z) and time (t), Kg m^{-3}; βt is the total root standard kg m^{-2}.

2.3.3 Tubers number

Tubers number calculated were five plants randomly selected, in three replications for each experimental unit (Al-Sharifi et al., 2019a and Mangani et al., 2016)

2.3.4 One plant productivity

Productivity of one plant and it was calculated as follow: (Othman, 2014).

$$Po_p = \frac{P_p}{T_p} \tag{12}$$

Where: Po_p is productivity of von plant (g), P_p is plants productivity (g), T_p total of plants (10 plants each experimental unit) (g).

The results were analyzed statistically by using the randomized complete block design RCBD. According to SPSS program and the difference among treatments for each factor was tested according to the least significant difference L.S.D test (Oehlent, 2010).

3 Results and discussion

3.1 Potato planter performance

3.1.1 Potato planter fuel consumption

Table 5 shown influence of planting method, planting distance and planting depth on the planter fuel consumption. The planting distance of 30 cm recorded the lower fuel consumption of 9.839 L ha^{-1} while, 25 cm planting distance recorded 10.526 L ha^{-1}. Table 5 indicated that the planter fuel consumption of PMBGR and PMBRO were 9.870 and 10.495 L ha^{-1}, respectively under the same operating conditions, for PMBRO. This is due to the efficiency and engineering design of the planting method and finishing the work, with less time. These results are consistent with the results of Al-Sharifi and Ameen (2018). The planter fuel consumption is proportional to the planting depth. The planting depth of 8cm recorded lower planter fuel consumption of 9.368 L ha^{-1}. While, 12cm planting depth recorded the higher planter fuel consumption of 10.961 L ha^{-1}at different planting depths. The increase in depth leads to the increase of the planter fuel consumption and negatively affected all studied conditions during the planting process by using a Adwhit type machine. This is also consistent with the study of Al-Sharifi et al. (2019a). The interaction among parameters of PMBGR, depth 8cm and the distances of planting 30 cm caused the best results (8.833L ha^{-1}).

Table5 Effect of potato planting method, planting distance and planting depth on potato planter fuel consumption L ha^{-1}

Methods	Distances, cm	Depth, cm.			The overlap between methods and planting distance
		8	10	12	
PMBGR	25	9.525	10.098	11.002	10.208
	30	8.833	9.576	10.185	9.531
PMBRO	25	10.009	10.981	11.540	10.843
	30	9.105	10.222	11.115	10.147
L.S.D=0.05		0.244			0.631
Average of planting depth		9.368	10.219	10.961	
L.S.D=0.05			0.318		
Methods	The overlap between methods and depth(cm)				Average of methods
PMBGR	9.179	9.837	10.594		9.870
PMBRO	9.557	10.602	11.327		10.495
L.S.D=0.05		0.711			1.201
Distances	The overlap between distances and depth				Average of distance
25	9.767	10.539	11.271		10.526
30	8.969	9.899	10.650		9.839
L.S.D=0.05		0.601			0.412

3.1.2 Potato planter productivity

The influence of planting methods, planting speeds, and planting depth on the planter productivity Kg ha^{-1}.The planting distances of 30 cm gave higher results, which required of 844.941 Kg ha^{-1} as compared with planting distances of 25 cm, which required of 927.009 Kg ha^{-1}. From Table 6, it is indicated that the PMBGR was significantly better than the PMBRO, for planter productivity 869.902 and 907.048 Kg ha^{-1}respectively, under the same operating conditions for PMBRO. The planting mechanical is the best way to complete the planting process in the least time, in addition to the regularity of planting methods for CMBRG. These results are consistent with the results of Al-Sharifi

(2018) study. The increasing of the planting depth led to the decrease of the machine planting were the planting depth 8 cm give best of results which required 821.602 Kg ha^{-1}, planting depth 12 cm required 949.642 Kg ha^{-1}respectively at different planting depths. Lead to obstruction of the transplant due to overload on a Adwhit type machine with increase in depth of planting. The interaction among parameters of PMBGR, depth 8cm and the distances of planting 30 cm caused the best results (777.765 Kg ha^{-1}).

3.1.3 Potato planter efficiency

Table 7, it is indicated that the planter efficiency of the PMBGR is significantly better than PMBRO, the results were 82.636% and 80.705 % respectively. This due to lack of coherence between tractor wheels and soil when soil moisture increased hence field efficiency decreased, these results are consistent with the results of Al-Sharifi and Ameen (2018). The influence of planting depth on the machine efficiency %. At planting depth of 8 cm has the highest planter efficiency of 83.286%, and planting depth of 12 cm has the lowest planter efficiency of 80.360%. This is due to slippage percentage increase with increased planting depth. These results are consistent with the results of Al-Sharifi et al (2019). The planting distances of 30 cm give best of results, which required of, 82.283% as compared with planting distances of 25 cm, which required of 81.057%. The interaction among parameters of PMBGR, depth 6cm and the planting distance 30 cm caused the best results (85.562%).

3.2 Soil characteristics

The influence of planting methods, planting depth and speeds on soil bulk density and total of soil porosity was shown in Table 8. All the interactions are significantly different and the best results (1.33 mg m^{-3} and 49.18%) have come from the overlap among planting methods, 8 cm planting depth and 30cm distances of planting for PMBGR.. This is due to decreased pressure from the machine on the soil with increasing planting distances While gives the interactions among planting methods, 12cm depth, and 25 cm distances of planting,were the low results (1.45 mg m^{-3} and 45.28%) for PMBRO.

Table 6 Effect of potato planting method, planting distance and planting depth on potatoplanter productivity Kg ha^{-1}

Methods	Distances, cm.	Depth, cm.			The overlap between methods and planting distance
		8	10	12	
PMBGR	25	821.615	911.201	993.011	908.609
	30	777.765	820.009	895.813	831.195
	25	886.021	950.515	999.691	945.404
PMBRO	30	801.005	845.001	910.055	868.687
L.S.D=0.05		4.654			3.811
Average of planting depth		821.602	894.181	949.642	
L.S.D=0.05			2.654		
Methods	The overlap between methods and depth				Average of methods
PMBGR	799.690	865.605		944.412	869.902
PMBRO	843.513	922.758		954.873	907.048
L.S.D=0.05		4.091			3.563
Distances	The overlap between distances and depth				Average of distance (cm)
25	853.818	930.858		996.351	927.004
30	789.385	857.505		902.934	844.941
L.S.D=0.05		3.055			2.432

Table 7 Effect of potato planting method, planting distance and planting depth on potato planter efficiency %

Methods	Distances, cm.	Depth, cm.			The overlap between methods and planting distance
		8	10	12	
PMBGR	25	83.918	81.559	80.065	81.847
	30	85.562	88.785	81.926	83.424
	25	81.255	80.099	79.448	80.267
PMBRO	30	82.409	81.015	80.001	81.141
L.S.D=0.05		0.988			0.765
Average of planting depth		83.286	81.365	80.360	
L.S.D=0.05			0.233		
Methods	The overlap between methods and depth				Average of methods
PMBGR	84.740	82.172		80.996	82.636

PMBRO	81.832	80.557	79.725	80.705
L.S.D=0.05		0.856		1.094
Distances	The overlap between distances and depth			Average of distance(cm)
25	82.586	80.829	79.757	81.057
30	83.985	81.900	80.964	82.283
L.S.D=0.05		0.633		0.442

Table 8 Soil characteristics of the field experiments

Planting methods	Planting depth cm	Planting distances cm	Soil bulk density Mg m^{-3}	Total soil porosity %
PMBGR	8	25	1.36	48.67
		30	1.33**	49.18**
	10	25	1.38	47.24
		30	1.34	49.94
	12	25	1.41	46.79
		30	1.36	48.68
PMBRO	8	25	1.38	47.24
		30	1.36**	48.67**
	10	25	1.42	46.41
		30	1.40	47.16
	12	25	1.45	45.28
		30	1.43	46.03

3.3 Potato tuber characteristics

3.3.1 Germination percentage

The planting distance of 30 cm has the highest germination percentage (89.438%) and planting distance 25 cm has the lowest (87.977%), because of the damage to the tubers when the planting with high speed and the narrowing of the planting distance. These results are consistent with the results of Al-Sharifi and Ameen (2018) study. The germination ratio of the PMBGR (89.374%) is significantly lower than PMBRO (88.041%). From Table 9, the increasing planting depth leads to decrease in percentage of germination and which was 90.323%, 88.778% and 87.021% respectively, this is due to the increased effort with depth increasing on tubers during the planting process. This is consistent with Kumar et al. (2015). The interaction among parameters of PMBGR, depth 8 cm and the distance of planting 30 cm caused the best results (91.709%).

3.3.2 Root density and distributed in soil for vegetative growth stage

The increase in the planting distances leads to increase the root density and distributed in soil for vegetative growth stage, and the results were 0.42 and 0. 46 Mg cm^{-3} respectively. This is due to decreased levels of soil apparent density, total porosity, and this reflected negatively on the root density of a tuber during the growth stage with decrease for planting distances. These results are consistent with the results of Bin (2016). From Table 10, The planting depth of 8 cm recorded that the highest root density and distributed in soil for vegetative growth stage of 0.53 Mg cm^{-3} against 0.37 Mg cm^{-3} at planting depth of 12 cm, obstructing root growth with increased planting depth, this is due to the decrease all soil physical properties. The root density and distributed in soil for vegetative growth stage of the PMBGR (0.46 Mg cm^{-3}) is significantly better than PMBRO (0.42 Mg cm^{-3}). The interaction among parameters of PMBGR, depth 8 cm and the distance of planting 30 cm caused the best results (0.56 Mg cm^{-3}).

3.3.3 Root density and distributed in soil for tubers formation stage

The increase in the planting distances leads to increase the root density and distributed in soil for tubers formation stage, and the results were 0.79 and 0.76 Mg cm^{-3} respectively. the root growth determination due to an increased soil hardness, result of the applied load on the root zones, with decreased planting distances. The planting depth of 8 cm indicated that the highest root density and distributed in soil for tubers formation stage of 0.83 Mg cm^{-3} against 0.73 Mg cm^{-3} at planting depth of 12cm, this is due to the decrease all soil physical properties, directly impact on tubers formation These results are consistent with the results of Cheaibi et al. (2013). From Table 11. The root density and distributed in soil for tubers formation stage of the PMBGR (0.80 Mg cm^{-3}) is significantly better than PMBRO (0.76 Mg cm^{-3}). The interaction among parameters of PMBGR, depth 8 cm and the distance of planting 30 cm caused the best results (0.86 Mg cm^{-3}).

3.3.4 Tubers number

Table 12 shows the increasing planting depth leads to decrease in tubers number and which was 8.29, 7.48 and 5.84 tuber $plant^{-1}$ respectively, because low soil physical properties reduces the spread of roots and this adversely affects the number of tubers. Khallouf et al. (2019). The distance of planting of 30 cm has the highest tubers number (7.79 tuber $plant^{-1}$) and planting distance 25 cm has the lowest (6.61 tuber $plant^{-1}$), reason for this when decreasing the distance is the inaccuracy in planting, when decreasing of the distance of planting led to decreased soil physical properties hence tubers number decreased, this is consistent with Mangani et al. (2016). The tubers number of the PMBGR (7.59 tuber $plant^{-1}$) is significantly lower than PMBRO (6.81 tuber $plant^{-1}$). The interaction among parameters of PMBGR, depth 8 cm and the distance of planting 30 cm caused the best results (9.51 tuber plant $^{-1}$).

3.3.5 One plant productivity

The increase in the planting distances leads to increase one plant productivity, and the results were 904.04 and 1003.61 g $plant^{-1}$ respectively. the root growth determination with decreased planting distances, also failure to provide sufficient nutrients for plant growth, and adversely affect one plant productivity From Table 13.The planting depth of 8 cm indicated that the highest one plant productivity of 1113.28 g $plant^{-1}$ against 834.23 g $plant^{-1}$ at planting depth of 12 cm, this is due to the decrease all soil physical properties, directly impact on tubers formation. These results are consistent with the results of Al-Abdaly and Al-Zobaay (2016), the one plant productivity of the PMBGR (1005.99 g $plant^{-1}$) is significantly better than PMBRO (901.66 g $plant^{-1}$),decreased compact the soil when using PMBGR, and improve soil properties, to suit the plants growth. The interaction among parameters of PMBGR, depth 8 cm and the distance of planting 30 cm caused the best results (1300.93 g $plant^{-1}$).

Table 9 Effect of potato planting method, planting distance and planting depth on germination percentage (%)

Methods	Distances, cm	Depth, cm			The overlap between methods and planting distance
		8	10	12	
PMBGR	25	90.011	88.526	86.413	88.316
	30	91.709	90.066	89.522	90.432
	25	89.569	88.101	85.241	87.637
PMBRO	30	90.003	88.420	86.911	88.445
L.S.D=0.05		0.621			0.395
Average of planting depth		90.323	88.778	87.021	
L.S.D=0.05			0.402		
Methods	The overlap between methods and depth				Average of methods
PMBGR	90.860	89.296	87.968		89.374
PMBRO	89.786	88.260	86.076		88.041
L.S.D=0.05		0.522			0.231
Distances	The overlap between distances and depth				Average of distance(cm)
25	89.790	88.314	85.827		87.977
30	90.856	89.243	88.216		89.438
L.S.D=0.05		0.437			0.344

Table 10 Effect of potato planting method, planting distance and planting depth on root density

Methods	Distances, cm	Depth, cm			The overlap between methods and planting distance
		8	10	12	
PMBGR	25	0.52	0.41	0.38	0.43
	30	0.56	0.49	0.40	0.48
	25	0.50	0.38	0.35	0.41
PMBRO	30	0.54	0.42	0.37	0.33
L.S.D=0.05		0.016			0.013
Average of planting depth		0.53	0.42	0.37	
L.S.D=0.05			0.010		
Methods	The overlap between methods and depth				Average of methods
PMBGR	0.54	0.45	0.39		0.46

PMBRO	0.52	0.40	0.36	0.42
L.S.D=0.05		0.011		0.012
Distances		The overlap between distances and depth		Average of distance(cm)
25	0.51	0.39	0.36	0.42
30	0.55	0.45	0.38	0.46
L.S.D=0.05		0.014		0.013

Table 11 Effect of potato planting method, planting distance and planting depth on root density

Methods	Distances, cm	Depth, cm			The overlap between methods and planting distance
		8	10	12	
PMBGR	25	0.85	0.78	0.72	0.78
	30	0.86	0.81	0.79	0.82
	25	0.81	0.75	0.70	0.75
PMBRO	30	0.82	0.78	0.73	0.77
L.S.D=0.05		0.011			0.008
Average of planting depth		0.83	0.78	0.73	
L.S.D=0.05			0.004		
Methods		The overlap between methods and depth			Average of methods
PMBGR		0.86	0.79	0.75	0.80
PMBRO		0.81	0.75	0.71	0.76
L.S.D=0.05			0.009		0.005
Distances		The overlap between distances and depth			Average of distance (cm)
25		0.83	0.76	0.71	0.76
30		0.84	0.79	0.76	0.79
L.S.D=0.05			0.008		0.007

Table 12 Effect of potato planting method, planting distance and planting depth on tubers number tuber plant^{-1}

Methods	Distances, cm	Depth, cm			The overlap between methods and planting distance
		8	10	12	
PMBGR	25	8.13	7.21	5.69	7.01
	30	9.51	8.30	6.71	8.17
	25	7.18	6.52	4.95	6.21
PMBRO	30	8.33	7.91	6.01	7.42
L.S.D=0.05		0.644			0.388
Average of planting depth		8.29	7.48	5.84	
L.S.D=0.05			0.543		
Methods		The overlap between methods and depth			Average of methods
PMBGR		8.82	7.75	6.200	7.59
PMBRO		7.76	7.21	5.48	6.81
L.S.D=0.05			0.428		0.615
Distances		The overlap between distances and depth			Average of distance (cm)
25		7.65	6.86	5.32	6.61
30		8.92	8.10	6.36	7.79
L.S.D=0.05			0.512		0.305

Table 13 Effect of potato planting method, planting distance and planting depth on one plant productivity

Methods	Distances, cm	Depth, cm			The overlap between methods and planting distance
		8	10	12	
PMBGR	25	1100.01	908.13	825.62	944.58
	30	1300.93	1000.08	901.20	1067.40
	25	996.33	803.10	791.11	863.51
PMBRO	30	1056.86	944.59	818.99	939.81
L.S.D=0.05		77.40			51.56
Average of planting depth		1113.28	913.98	834.23	
L.S.D=0.05			55.69		
Methods		The overlap between methods and depth			Average of methods
PMBGR		1200.47	954.10	863.41	1005.99
PMBRO		1026.09	873.84	805.05	901.66
L.S.D=0.05			57.17		57.89

Distances	The overlap between distances and depth			Average of distance (cm)
25	1048.17	855.61	808.36	904.04
30	1178.39	972.34	860.09	1003.61
L.S.D=0.05		49.93		13.96

4 Conclusion

The PMBGR is significantly better than the PMBRO. The depth of 8 cm was superior significantly to the other two levels (10 and 12 cm). Additionally, the distances of the planting of 30 cm was superior significantly to the other distance of planting 25 cm in all studied traits. The best results for potato yield were obtained from the interaction among PMBGR, 8 cm depth and 30 cm planting distance in all studied properties.

Recommendations

The present recommends to carry out future studies using other machinery types and other planting speeds or conduct other organizations on the machine and the planting depth to know their effect on the planting machine of potato.

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References

Al-Abdaly, M. M., and A. Al-Zobaay. 2016. The Effect of planting date on growth and yield of five potato varieties *Solanum tuberosum L. Anbar*. *Journal of Agricultural Sciences*, 14(2): 237-245.

Alaamer, S. A., and S. K. A. Al-Sharifi. 2020. Affecting mechanical on some growth characteristics for maize, SYN5018 variety. *Plant Archives*, 20(2): 1150-1155.

Aleawi, A., S. K. A. Al-Sharifi, and J. H. Ibrahim. 2020. A study the effect of Sowing machine (type Adwhit) on potato specification, Bintje cultivar. *Plant Archives*, 20(2): 981-989.

Al-Sharifi, S. K. 2009a. Comparing effect of (disk and moldboard plow) with depths and speeds different for tractor in some soil physical properties and wheat yield for (2004 and 2005 seasons) *Journal of Babylon university*17(3);1083-1100.

Al-Sharifi, S. K. 2009b. Effect of two plows types, different depths and speeds on performance of mechanical unit and some soil physical properties. *Journal of Babylon University*, 17(1): 182-205.

Al-Sharifi, S. K. 2018. Affecting on threshing machine types, grain moisture content and cylinder speeds for maize, Cadiz variety. *CIGR Journal*, 20(3): 233-244.

Al-Sharifi, S. K., and S. H. Ameen. 2018. Study some performance indicators and soil physical properties for wheat Zagros variety. *Euphrates Journal of Agriculture Science*, 10(4): 23-35.

Al-Sharifi, S. K., A. Mousa, and A. T. Manhil. 2019a. Effect of two types of digger machines and speeds of tractor on the qualitative characteristics of potato. *Fayoum Journal, Agriculture, Research and Developed*, 33(1): 308-322.

Al-Sharifi, S. K., A. Mousa, and A. T. Manhil. 2019b. Effect of sheller rotational speed on some maize cultivars quality. *CIGR Journal*, 21(2): 196-203.

Al-Sharifi, M. Y. S., S. K. Al-Sharifi, and A. Maryam. 2020a. A study some rice growth properties under impact practical speed and tillage depth. *Euphrates Journal of Agriculture Science*, 12(1): 110-121.

Al-Sharifi, S. K., J. H. Ibrahim, and Y. Mohamed. 2020b. Study some performance indicators,soil physical properties and growth characteristics for wheat AlNOOR variety. *Fayoum Journal. Agriculture, Research and Developed*, 34(1): 448-463.

Al-Sharifi, S, K., S. Naim, and N. Thamer. 2020c. The effect of sowing methods on the growth characteristics of wheat in Alhashemia, Iraq. *Asia Life Sciences*, 10(4): 675-685.

Bin, S. S. M. 2016. Effect of planting spaces and cutting tuber on quality characteristics of potato plants (Solanum tuberosum L.) *Assiut Journal of Agricultural Sciences*, 47(4): 178-185.

Cheaibi, S., W. Wissem, and A. Khaoula. 2013. Effects of planting depth on agronomic performance of two potato varieties grown in the Sahel region of Tunisia. *Journal of Development and Agricultural Economics*, 5(7): 272-275.

Jacobs, A., M. Helfrich, S. Hanisch, U. Quendt, R. Rauber, and B. Ludwig. 2010. Effect of conventional and minimum tillage on physical and biochemical stabilization of soil organic matter. *Biology and Fertility of Soils*, 46(8): 671-680.

Kumar, P., S. Singh, R. Kumar, S. Rawal, and B. P. Singh. 2015. Effect of tuber planting depth on yield, quality and profitability of potato (Solanum tuberosum) processing varieties. *Indian Journal of Agronomy*, 60(1): 139-144.

Khallouf, A., J. Aree, K. Amera, K. Nabela, and W. Salwa. 2019.

Effect of biofertilizers on some fertility soil properties and some qualitative and production traits of potato. *Syrian Journal of Agricultural Research*, 6(1): 276-287.

Langston, A. S. 2014. Soil hydraulic and physical properties as affected by logging management. M.S. thesis, Faculty of the Graduate School, University of Missouri, 14-24.

Mangani, R., M. Upenyu, M. T. Abduel, and S. Admire. 2016. Effect of planting method on growth, yield and quality of three Irish potato (Solanum tuberosum) varieties Grown in zimbabwe. *Annual Research and Review in Biology*, 9(5): 1-7.

Oehlent, G. w. 2010 A First Course in Design and Analysis of Experiments. Design-Expert is a registered trademark of implements in Ebonyi State. *International Journal of Engineering and Technology*, 5(4): 199-204.

Oduma, O., J. E. Igwe, and D. I. Ntunde. 2015. Performance evaluation of field efficiencies of some tractor drawn Stat-Ease, Inc. Library of Congress Cataloging-in-Publication Data. University of Minnesota. 2010.Pp:85-189.

Othman, J. 2014. The effect of different ways of treatment with a feeding organ on the growth, yield, and quality of potato tubers (*Sulanum Tuberosum L*). *Tishreen University Journal for Research and Scientific Studies*, 36(2): 13-146.

Shtewy, N., J. H. Ibrahim, and K. A. Salih. 2020. Effect of mechanical properties on some growth characteristics for wheat crop. *Plant Archives*, 20(1): 3141-3148.