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THE USE OF DIFFERENT TYPES OF PLOWS WITH DIFFERENT DEPTHS IN TWO TYPES OF SOILS AND THEIR EFFECT ON SOME PHYSICAL PROPERTIES OF THE SOIL AND THE PRODUCTIVITY OF THE POTATO PLANT (*SOLANUM TUBEROSUM* L.)

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Abstract:
A field experiment was conducted in two locations, the first in the research station of the College of Agriculture, University of Basrah, the Karmat Ali location in a loamy mixture soil, and the second location in the city of Al-Zubair in a sandy loam soil during the season 2021-2022.To study the effect of tillage type and depth on some physical soil properties (soil bulk density, soil penetration resistance) and potato yield (tons.ha^{-1}). The experiment was designed using a one-time split block method in three replicates. The type of plow occupied the main plots with three treatments: control treatment (without tillage NT), Moldboard plows (MP), and backhoe plow (CP). The tillage depth of the split plots was: D1 (0 - 15) cm, D2 (15 - 25) cm, D3 (25 - 35) cm. The results of the study showed a decrease in the bulk density and soil penetration resistance in the tillage treatments compared to the no-tillage treatment. The Moldboard plows treatment was significantly excelled in improving these traits in both locations and at the two measurement periods in the middle and end of the season on the two treatments of chisel plows and the no-tillage treatment.

Keywords: plows, soils, physical properties, potato plant, *Solanum tuberosum* L.

1.Introduction:-

The tillage process is one of the necessary operations in agricultural production, and it is one of the stressful and costly operations and one of the agricultural administrative practices that improve the physical and chemical properties of the soil and vitality, which is responsible for preparing the appropriate shrine for seed germination through dismantling and fragmenting the soil and mixing it with the remains of previous plants, eliminating weeds and providing the appropriate conditions for the plant (Collinestal etal, 2005). It directly affects the increase in crop growth and productivity as well as agricultural sustainability (Brenna etal, 2014) and (Zubeldia etal, 2018).The optimum selection of tillage equipment is of great importance in improving the qualitative traits of the soil and determining the quality of tillage .Despite the many benefits of tillage, the inappropriate and intensive use of tillage equipment may lead to negative effects on soil traits through damages caused by soil compaction, poor aeration, destruction of aggregates, increase in their apparent density and resistance to penetration, and deterioration of their other structural qualities, and this reduces their suitability for plant growth and it leads to reduced crop productivity (Licht and al-kaisa, 2005; Jabro etal, 2009.(Moldboard plows that loosen and break up soil are more commonly used when overturning and burying crop residues and organic matter (Kepner etal, 2005).Either Chisel plows other than tipping are used in dry and hard soils. Therefore, the plows differ in their

effect on the properties of the soil. The bulk density is one of the most affected physical traits in agricultural operations, especially the tillage process, which leads to the dismantling of the soil and then increasing its porosity, which results in a decrease in the weight of the soil relative to the unit volume (Jassim et al., 2017.(The bulk density of the soil can be adopted as a good predictor of both the structure of the soil and the ease of root growth and extension in the soil (Al-sharifi etal, 2021b)and to know the degree of soil compaction and to determine the depth of the deaf layers in agricultural fields (Al-sharifi etal, 2021a.(The type of plow affects the physical properties of the soil, as many studies indicated a significant decrease in the bulk density when using the inverter plow compared with the use of Chisel plows (Saqr et al., 2013.(This was confirmed by the results of Saeed (2004) to the significantly excelled of the Moldboard plows treatment over the Chisel plows treatment in reducing the bulk density and soil resistance to penetration and increasing the total porosity of the soil.On the effect of long-term tillage systems on the physical properties of the soil, the results of the study conducted by Noui etal (2018) showed a decrease in the value of the bulk density of the plowed treatments using the Chisel plows and Moldboard plows compared to the no-till system, and it reached its lowest value when treating the plow, which amounted to (1.45).) g/cm³.These results are in agreement with the results of several studies (Gelik etal; 2012; Abdllahi and Munkholom, 2014; Acar etal; 2018), which indicated an improvement in the physical properties of soil in tillage treatments compared with no-tillage treatments. The type and depth of tillage affect the physical properties of the soil and its suitability for plant growth. Deep tillage led to loosening the soil, increased the rate of water penetration into the soil body, and increased the efficiency of the plant's use of the added fertilizers compared to the treatment of surface tillage and medium depth tillage . (Alamouti and Navabzadeh, 2007; Strudley etal; 2008).In this regard, the results of Jabro etal (2010) showed. tillage at a depth of 0-20 cm reduced both the bulk density and the resistance of the soil to penetration compared to the surface tillage 0-10 cm. While the total pore size and the amount of water available for absorption increased compared to surface tillage. This was confirmed by the results of the study conducted by Ji etal (2013) that tillage clay soil at a depth of 30 cm led to a decrease in both bulk density, soil resistance to penetration and soil control compared to tillage at a depth of (20) cm. Al-Mohammadi (2013) found that by increasing the tillage depth from 15 to 30 cm, the bulk density values in a mixture of soils decreased from 1.49 to 1.38 Mg-m³. and (Gholami etal) (2014) obtained when it was used for three tillage systems (conventional, low and no-tillage) the excelled of the traditional tillage system on other tillage systems in giving the lowest apparent density of the soil amounting to 1.29, 1.36, 1.41 mcg m^{-3} for the tillage systems, respectively.Likewise, the traditional tillage continued on the other tillage systems in recording the highest total porosity of the soil as it reached 47.58, 50.58 and 52.45% for the three systems respectively. The results of Hassan et al, (2019) indicated that the tillage process had a significant effect on the values of the bulk density and the total porosity of the soil, where it was (1.38, 1.44, 1.48) Mg m^{-3} for the treatments without tillage, conventional tillage, deep tillage and porosity of the soil amounted to (47.80, 46.70, 44.30)% for the above treatments.This was confirmed by the results of Alwan (2014) by the significantly excelled on the treatments of the subsoil which were conducted using the inverted compound plow on the control

treatment (using Moldboard plows and then working furrows at a depth of 25 cm).Increasing the furrows depths treatments led to a decrease in the values of bulk density and soil resistance to penetration and an increase in the total porosity of the soil. Barakat et al. (2019) found a significant decrease in the bulk density and an increase in the total porosity of the soil in the plowed treatments and significantly compared to the no-tillage treatment.The treatment of the inverted plow showed a significantly excelled on the treatment of Chisel plows in improving these traits. As it led to a decrease in the bulk density and an increase in the total porosity of the soil, during their study of the effect of the type and depth of tillage on some physical properties of the soil and some growth indicators of potato plants and their productivity in clay soil. Al-Mousa (2020) obtained a highly significant increase in the values of bulk density, offset by a highly significant decrease in the total porosity of the soil with an increase in the tillage depths when studying the effect of tillage regimes on the values of bulk density and total porosity of clay loam at a depth of (30) cm. Abdul Wahed (2021) found that the tillage depth 0-50 cm was significantly excelled on the depth of 0-25 cm in decreasing the value of the bulk density and increasing the total porosity of the soil in silt clay soil. The study coundected by Wang etal (2009) indicated that the soil resistance to penetration increased with increasing depth before and after tillage. However, the values in the first year after tillage were lower than in the second and third year. He also explained that the value of the soil's resistance to penetration suitable for root growth is less than 1500 kN m², and if the soil resistance to penetration is more than 1800 kN m², it will be difficult for the roots to penetrate and grow in it. RooZbeh etal (2010) obtained an increase in soil penetration resistance from 8.851 to 1603 kN m² by increasing the tillage depth from (0 - 21) cm to (25 - 50) cm using moldboard plows equipped with a leveling machine followed by two passes of double disc harrows. Al-Mohammadi (2013) found a decrease in the soil resistance to penetration from 2.50 to 1.90 and 1.50 kg cm^{-2} when the tillage depth was increased from 15 to 30 and 45 cm in a loam of soil.In a study conducted by Al-Raji and Al-Tai (2013) using Chisel plows in silt clay soil, they obtained higher values of soil resistance to penetration at the end of the plant growing season compared to the middle of the season.Al-Taie et al. (2015) found an increase in the soil resistance to penetration by 18.79% in the subsurface layers of the soil in comparison with the surface layers using three types of plows (vertical disc plow, Chisel plows and Moldboard plows) in silt clay soil. As well as the higher values of soil resistance to penetration at the end of the growing season compared to the middle of the season.The tillage process leads to an improvement in the physical properties of the soil, which is positively reflected on the production of agricultural crops, given the importance of the potato crop as one of the most important vegetable crops in the world. 2001.(It is one of the crops most affected by the physical environment of the soil because the economic part grows below the surface of the soil. It has a branched root system with fine root hairs that may be exposed to damage by compressed layers, so it needs loose, deep, non-compressed, weed-free soil with good porosity and high permeability to water and air, which is positively reflected in a good production of potatoes in quantity and quality (Ojeniyi etal, 2009.(In a study conducted by Plissey(2002) , he did not get significant differences when using different tillage systems on the production of American potato , and that the tillage using Chisel plows is not effective compared to the use of Moldboard plows

that mix organic matter with the soil.He also explained that the tillage pattern and its time play an important role in potato production and that soil texture, irrigation and cultivar play an important role in preparing the soil for planting tubers. Ogbodo (2005) found that the plowed soil excelled on the non-plowed soil in the growth and productivity of the potato plant, and the tillage depth of 40 cm exceeded the tillage depths of (30, 20, 10) cm in giving the highest productivity of potato tubers amounted to (14.5 tons / ha (.(Ghazavi etal2010, found that agricultural machinery and equipment that have a direct impact on the depth of tillage are among the main factors affecting the production and quality of potato tubers. Al-Hamed etal (2016) obtained the highest potato yield by using Moldboard plows (37.19 tons ha^{-1}), significantly excelled on Chisel plows. Which gave (32.95 tons ha^{-1}) and these results are in agreement with the results of (Ati etal, 2015.(The results of Barakat et al. (2019) indicated the excelled of moldboard plows treatment and tillage depth (15-25) cm by giving it the highest productivity per unit area of potato tubers (53.8 tons ha^{-1}) in clay soil.In view of the growth of the fruiting part of the potato plant under the soil surface and because it is one of the crops that is very sensitive to what happens in the physical properties of the soil, its growth and productivity are affected by the changes that occur in the physical medium of the soil, which in turn are affected by the type and depth of the tillage machine. On some physical and mechanical properties of two types of soils to be planted with potatoes and determining the best types of soils for potato growth and productivity.

2. Materials and methods :

1.2. Soil sample preparation.

Two locations were chosen to implement the field experiment, the first at the research station of the College of Agriculture / University of Basrah / Karmat Ali location at the latitude and longitude of the location (N 30.33.17) and (E47.44.53) respectively and in clay loam soil.The second location is located in the city of Al-Zubair, southwest of Basrah provaince, 23 km from Basrah provaince, and within the coordinates (N 30.22.28) and (E 47.40.29), respectively, in loam sandy soil. complication samples were collected from the soil of the two locations for each depth of the study (0-15), (15-25), (25-35) cm, mixed well, dried air, then sieved and passed through a sieve with a diameter of 2 mm and kept in plastic boxes to estimate the initial characteristics. shown in Table (1).

2.2. Estimation of the chemical and physical properties of the study soil:

The degree of soil interaction was measured in the saturated soil paste suspension according to what was mentioned in (1958) Jackson. The electrical conductivity (Decismens M-1) was measured in the saturated soil paste filter (Ece) using the Ec-meter type wtw. The available nitrogen was estimated after its extraction from the soil with a solution of (2M) potassium chloride as in Bremner and Keeney (1966) using a steam distillation device, and the phosphorus was estimated after its extraction from the soil with a 0.5N sodium bicarbonate solution using the blue color method using a spectro photometer type PD - 303 - UV - APEL, at a wavelength of (700) nm,The available potassium was estimated after extraction from the soil with a 1N ammonium acetate solution using a flame photometer type (PFP7) as in (Page et al, 1982).Soil texture was

determined by calculating the percentage of soil particle sizes after estimating them using the pipette method, as described in Etal, Black (1965).

Table (1) Some of the chemical, physical and mechanical properties of the study soil

Alkarma location					
analysis		units	)cm(depth		
			analysis	25-15	15-0
soil separates	sand	gm kg^{-1}	289.3	292.7	294.5
	silt		310.7	311.4	317.3
	clay		399.3	394.8	390
soil texture			Clay loam	Clay loam	Clay loam
bulk density		Mgm^{-3}	1.38	1.32	1.27
total porosity		%	47.92	50.19	52.08
soil penetration resistance		KNm^{-2}	2070	1850	1620
		Dsm^{-1}	7.32	7.51	7.95
		pH	7.51	7.62	7.69
organic matter		%	0.27	0.67	0.71
available Potassium		ppm	23.2	35.2	57.5
available nitrogen		ppm	245	300	370
available phosphorous		ppm	60.18	60.97	79.16

Al-Zubair location					
analysis		units	)cm(depth		
			35-25	25-15	15-0
soil separates	sand	gm kg^{-1}	740.7	749.4	760
	silt		99.1	110.3	119.0
	clay		160.2	1403	121.5
soil texture			Clay loam	Clay loam	Clay loam
bulk density		Mgm^{-3}	1.34	1.30	1.21
total porosity		%	49.43	50.94	54.34
soil penetration resistance		KNm^{-2}	1580	1420	1270

	Dsm^{-1}	10.68	11.7	14.52
	pH	7.96	8.02	8.08
organic matter	%	0.32	0.51	0.64
available Potassium	ppm	40.0	44.7	54.3
available nitrogen	ppm	186.68	214.68	233.67
available phosphorous	ppm	15.6	15.7	25.3

The studied traits:
1. NT control treatment (no-tillage).
2. MpD1 tillage with Moldboard plows at a depth of 0-15 cm
3. MpD2 tillage with Moldboard plows at a depth of 15-25 cm
4. MpD3 tillage with Moldboard plows at a depth of 25-35 cm
5. CpD1 Tillage with Chisel plows at a depth of 0-15 cm
6. CpD2 Tillage with Chisel plows at a depth of 15-25 cm
7. CpD3 Tillage with Chisel plows at a depth of 25-35 cm

Experiment design:

The experiment was designed using a split plot design under a randomized complete block design. The research included a study of two factors (the type and depth of the plow), and the experiment was carried out in two locations with three replications for one treatment.The types of plows occupied the main plots, as the two plows were used, Moldboard plows (MP) and Chisel plows (CP).

While the tillage depths occupied the secondary split plots with three levels (0-15) cm D1, (15-25) cm 2D, (35-25) cm 3D.

Thus, the number of experimental units was (3 x 3 x 2) + 3 control= 21 units.

Executing the experiment:

No tillage was conducted for the control treatment replicates (treatment without tillage). As for the soil of the repetitions of the depths of tillage treatments, it was plowed at the specified depth for each treatment using a three-Moldboard plows with a working width of 105 cm.The plow was also used as a seven-armed Chisel plows , its working width is 175 cm, and the type of weapon is a bird's tongue. The tillage process was conducted after calibrating the plows at the specified depths for each treatment and making sure of the required depth.

Tuber cultivation:

After tillage the soil with the required plows and at the studied depths, a final smoothing and leveling process was conducted in the field of the experiment, after which the automated potato tuber planter (SABZ DASHT) of Iranian origin was used, and it is planted on two lines, the distance between them is (80 cm), and the distance between one tuber and another is 25 cm, and the planting depth was (10 cm).Al-Zubayr field was sown as an autumn season on 10/20/2021. As

for the date of planting the Karma Ali field, it was 10/23/2021. The cultivated cultivar (Burren) was of Dutch origin, and it is a medium-early cultivar. Drip irrigation system was used to irrigate the two locations.

Service operations:

The service operations were conducted including fertilization, irrigation and control according to the plant's need. Where phosphate and potassium fertilizers and the first batch of nitrogen fertilizers (half the amount of N) were added before planting and mixed well with the soil.As for the rest of the nitrogen fertilizer, it was added in two batches: the first batch after the plants appear at the next irrigation, and the second batch when the tubers start to form. The following fertilizer equation was used, according to the recommendation of (Ibrahim and Al-Taweel, 2011), which is (26, 26, 26) kg / dunum of (N in the form of urea 46%, P in the form of triple superphosphate 46%, K in the form of potassium sulfate 50%) Control operations were carried out using insecticides (Contact) to eliminate cutworms, and Ridomil to prevent early and late blight on leaves.

Tubers harvest :

The plants were extracted after their maturity, when the leaves of the plants began to turn yellow after (120 days) of cultivation. The average production per unit area (kg m-2) was calculated.

After the weight of the tubers of 10 plants from each replicate was estimated for each treatment, then the average production of one plant was calculated and the yield was multiplied by the plant density and converted to (1-ton hectare).

The studied soil properties:

Plowed samples were taken at the studied depths (0-15, 15-25, 25-35) cm. After the middle of the season (60 days) and at the end of the season (120 days), the following physical analyzes were conducted on them.

1. Bulk density: using the $Mg.g^{-3}$ cylinder method (Black et al., 1965).
2. soil penetration resistance:

Use an electronic soil penetration resistance measuring device (Pentrologger) manufactured in the Dutch company Eijke I kamp Agrisearch Equipment, which measures soil penetration resistance per 1 cm of soil depth. A cone with a penetration angle of 30° and a base area of 1 cm 2 was used to measure soil penetration resistance for all depths.

Results and discussion:

1.3. The effect of plow type and depth on the bulk density of two types of soils ($Mg.m^{-3}$)

The results in Table (2) showed that the soil treatment without tillage gave the highest values for the bulk density of the soil, significantly excelled on the treatments using plows. It gave as average depths (D1, D2, D3) 1,380 and 1,400 Mg. m^{-3} at the middle and end of the season, respectively, in Karma Ali field, while the above values were 1,292 and 1,351 Mg. m^{-3} at the middle and end of the season, respectively. in Al-Zubair field.The Moldboard plows showed significantly excelled on chisel plows and no-tillage treatment by giving it the lowest values for bulk density.It gave as an average depths D1, D2, D3 1.235 and 1.341 $Mg.m^{-3}$ at the middle and end of the season, respectively, in Karma Ali field, while the above values were 1.213, 1.288 $Mg.m^{-3}$ at the middle and end of the season, respectively, in Al- Zubair field. Chisel plows occupied the middle rank in

soil bulk density values between the Moldboard plows and the no-tillage treatment, as it gave as an average depth of D1, D2, D3 1.315 and 1.372 $Mg.m^{-3}$ at the middle and end of the season in the Karma Ali field, respectively. While the values were 1.245 and 1.326 $Mg.m^{-3}$ at the middle and end of the season in Al-Zubair field, respectively. The reason for the decrease in the value of the bulk density of the tillage treatments compared to the no-tillage treatment is due to the dismantling of the soil and the conversion of the regular soil body of the cohesive section into separate blocks of different sizes, so the interstitial spaces increase at the expense of the solid soil material of the same measured size, which causes a decrease in the soil mass per unit size, and this is consistent with what was indicated. Ileh (2007) Siri-prieto et al. The bulk density decreases after soil treatment with tillage .The Moldboard plows showed a significantly excelled by giving it the lowest values of bulk density compared to chisel plows. Whereas, the bulk density decreased when using the Moldboard plows by 0.08 and 0.031 µg m-3 at the middle and end of the season, respectively. In Al-Karma Ali field, the amount of decrease was 0.032 and 0.038 at the middle and end of the season, respectively, in Al-Zubair field. The reason for the Moldboard plows excelled in reducing the value of bulk density compared to chisel plows is that the Moldboard plows works to dismantle and break up the large dirt blocks in a larger way, which increases their area and volume and leads to a decrease in weight per unit size, which causes a decrease in bulk density more compared to chisel plows, which It dismantles the soil locally, taking out the roots and plant residues and leaving them on the surface of the soil without turning it over.This is consistent with the results of each of (2004, Eynard et al; Khosrow, 2005) who indicated a significant decrease in the bulk density of the Moldboard plows compared with the treatment of chisel plows. The results of Table (2) show that there is a significant increase in the bulk density values with increasing depth and for all study parameters. The high moisture with depth, in addition to the low content of the lower layers of organic matter, as well as the exposure of the surface layer to soil stirring operations in the previous agricultural soil preparation operations. The decrease in the bulk density values of the deep tillage treatments in the middle and end of the season compared to the bulk density values of the depths of the no-tillage treatment may be due to the result of the effect, growth and branching of the roots of potato plants, which helped to improve the soil characteristics by binding its particles, increasing its porosity, increasing the volume of the soil and then decreasing its apparent density, as well as the presence of microorganisms and the substances they secrete that help in improving soil structure, which was

Table (2) Effect of tillage type and depth on soil bulk density (Mg-3) in the middle and end of the season

Alkarma location			
Tillage type	**Tillage depth**	**Tillage type * Tillage depth**	
		Bulk density in the middle of the growing season	**Bulk density in the end of the growing season**
NT	**0-15**	**1.290**	**1.320**
	15-25	**1.410**	**1.420**

	25-35	1.440			1.460		
Mean		1.380			1.400		
MP	0-15	1.169			1.290		
	15-25	1.243			1.332		
	25-35	1.294			1.400		
Mean		1.235			1.341		
CP	0-15	1.267			1.320		
	15-25	1.290			1.356		
	25-35	1.387			1.438		
Mean		1.315			1.372		
Mean of Tillage depth		D1	D2	D3	D1	D2	D3
		1.242c	1.315b	1.373a	c1.310	b1.369	a1.433
$RLSD_{0.05}$		T	D	T*D	T	D	T*D
		**0.015	**0.015	**0.025	0.004**	0.004**	0.008**

Al-Zubair location							
Tillage type	Tillage depth	Tillage type * Tillage depth					
		Bulk density in the middle of the growing season			Bulk density in the end of the growing season		
NT	0-15	1.212			1.285		
	15-25	1.322			1.370		
	25-35	1.342			1.399		
Mean		1.292			1.351		
MP	0-15	1.116			1.229		
	15-25	1.230			1.292		
	25-35	1.294			1.342		
Mean		1.213			1.288		
CP	0-15	1.184			1.276		
	15-25	1.241			1.324		
	25-35	1.309			1.379		
Mean		1.245			1.326		
Mean of Tillage depth		D1	D2	D3	D1	D2	D3
		1.171	1.264	1.315	1.263	1.329	1.373
$RLSD_{0.05}$		T	D	T*D	T	D	T*D
		0.020**	0.008**	0.020**	0.009**	0.004**	0.009**

It has the greatest positive effect from the negative effect of the wetting and drying cycles and the effect of salinity on soil aggregates during the growing season. These results are consistent with the findings of (Saqr et al., 2013) who indicated that all tillage systems lead to a reduction of soil bulk density to the depth of tillage. When comparing the bulk density values for tillage depths treatments, we notice a higher soil bulk density value at the end of the season compared to its value at the middle of the growing season for both locations and for depths D1, D2, and D3. Where the percentage of height was (5.47, 4.10, 4.36)% for the above depths, respectively, in Al-Karmat Ali location, while the percentage of height was (7.85, 5.14, 4.41)% for the above depths, respectively, for Al-Zubair locations .The reason for the increase in the bulk density values at the end of the growing season compared to the middle of the season is due to the stability of soil structure with time. The operations of cultivation, irrigation and crop service play an important role in increasing soil compaction over time, and this is a result of the movement of some clay particles during irrigation operations and their sedimentation in the soil pores, which reduces the value of the total porosity of the plowed soil and increases its apparent density.This was confirmed by (Al-Salawi, 2000) that the decrease in bulk density resulting from tillage is a temporary decrease that decreases with successive irrigation and rainfall and ends almost at the end of the season.

3.3. Effect of plow type and depth on soil penetration resistance (kN-2) for two types of soils:-

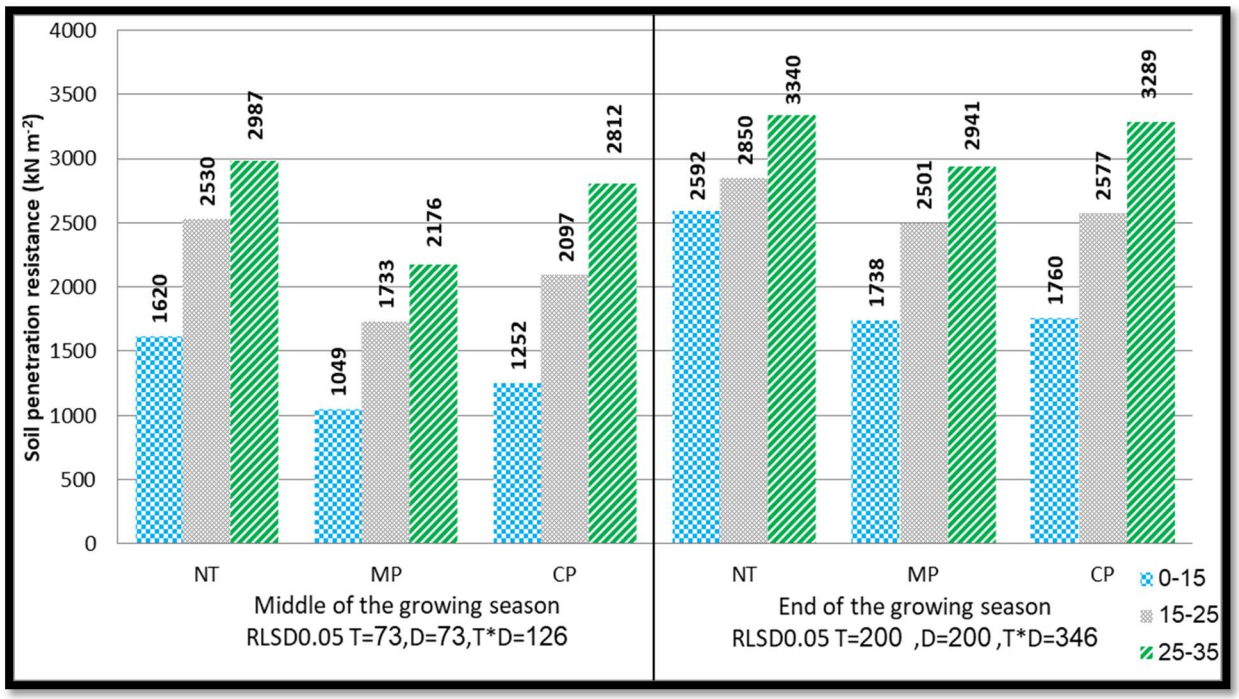
The results in Figure (1) showed that there was a significant decrease in soil penetration resistance values in the inverted plow and chisel plows treatments, compared with the no-tillage treatment after the middle and end of the season and in both locations. Where the percentage of decline was 30.51% and 13.66% in the two treatments of the inverter plow and chisel plows, respectively, compared with the no-tillage treatment at the middle of the season, while the percentage of decrease at the end of the season was 18.24% and 13.15% for the above treatments, respectively, Al-Karma Ali location.The Moldboard plows also recorded a significant decrease in soil penetration resistance compared with chisel plows, where soil penetration resistance decreased by 19.52% and 5.86% for the middle and end of the season, respectively, in Karma Ali location. As for Al-Zubair location, the percentage of decline was 24.77% and 9.90% for the plow and chisel plows treatments, respectively, compared with the no-tillage treatment at the middle of the season. As for the end of the season, the percentage of decrease was 20.52% and 7.24% for the above treatments, respectively.The inverter plow treatment continued to be significantly excelled in reducing soil penetration resistance compared with the chisel plows treatment by 16.49% and 14.31% for the middle and end of the season, respectively. The reason for the superiority of the Moldboard plows in reducing the values of soil penetration resistance is due to the same reasons that led to its excelled in reducing the values of the bulk density of the soil referred to previously because the relationship between them is direct.As for the effect of the depth of tillage on soil penetration resistance values, we note from Figure (2) that with increasing depth, soil penetration resistance increased significantly. Where the depth D1 recorded the lowest value of soil penetration resistance (1307 and 2030) kNm-2 at the middle and end of the season, respectively.It recorded a significant decrease at the depths D2 and D3, which recorded soil penetration resistance values of (2120 and 2658) kN-m-2 for the above depths, respectively, at the middle of the season,

amounted (2642 and 3190) kN-m-2 for the above depths, respectively, at the end of the season in Al-Karma Ali location.

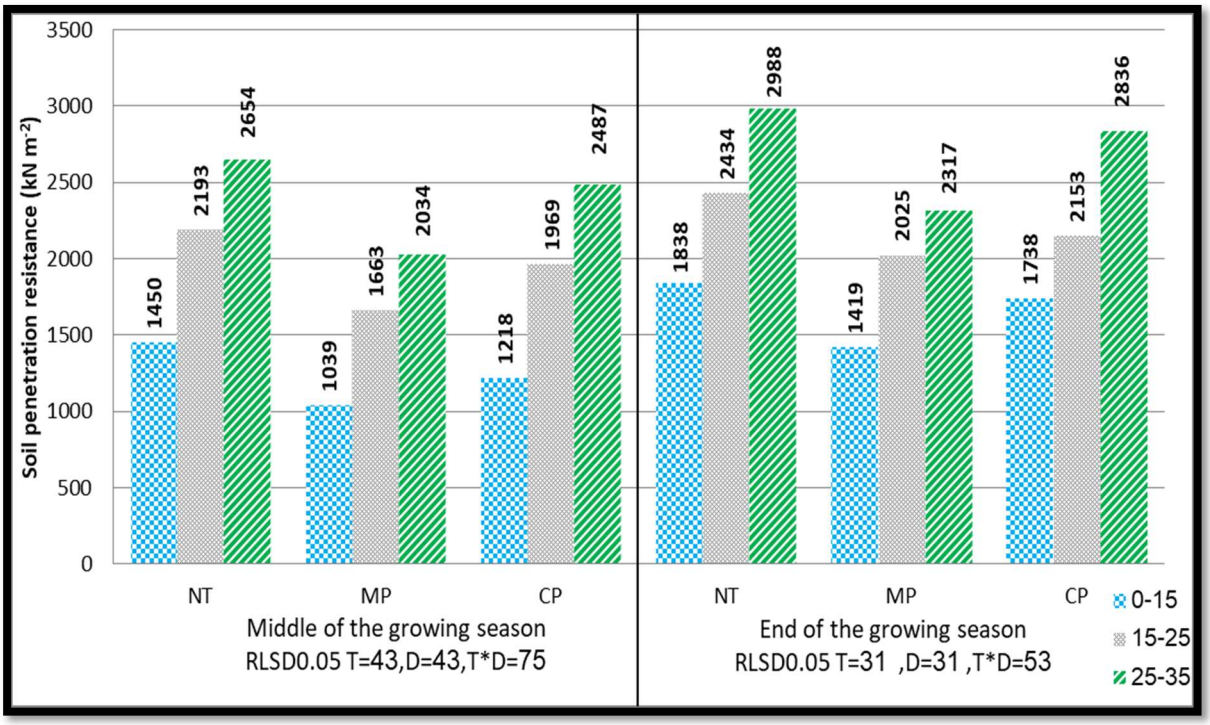
As for the Zubair location, the depth D1 recorded the lowest values of soil penetration resistance, which amounted to (1235 and 1665) kNm-2 at the middle and end of the season, respectively, recording a significant decrease at the depths D2 and D3, which gave soil penetration resistance values of (1941 and 2391) kN. m-2 for the above depths, respectively, at the middle of the season, and it rose to (2204 and 2713) kN-m-2 for the above depths, respectively, at the end of the season.The reason for the increase in soil resistance to penetration with increasing depth is attributed to the increase in the closeness of soil particles to each other with increasing depth as a result of the pressure obtained from the layers above it and then increasing the compaction of soil layers that lead to raising the bulk density. Since the relationship between bulk density and soil penetration resistance is a direct relationship, so all factors that raise the bulk density values lead to increased soil penetration resistance, as well as the rise in soil strength and moisture with depth, which increases its resistance to penetration. We also notice from Figure (1) a significant increase in soil penetration resistance values for the depths of tillage treatments at the end of the season compared to its value in the middle of the season. It increased by 55.31%, 24.62%, and 20.01% for depths D1, D2, and D3, respectively, Al- Karma Ali location.While the percentage of height was 34.81%, 13.54%, and 13.46% for the above depths, respectively, in Al-Zubair location, and this is due to the same reasons that led to the increase in the bulk density values at the end of the season that was mentioned earlier, because the relationship between them is direct.

Figure (1) Effect of type and depth of tillage on soil penetration resistance (kN-2) in the middle and end of the season

Alkarma location



Al-Zubair location



4.3. Effect of plow type and depth on potato yield (tons. ha^{-1}):

The results in Table (3) indicate that the two treatments of tillage with the Moldboard plows and chisel plows were excelled on the control treatment (without tillage) in productivity per area unit (ton.H-1). The Moldboard plows treatment was significantly excelled on the chisel plows treatment, with an increase of 9.33% in Karma Ali location. While its excelled was 17.00% in Al-Zubair location.This is due to the role played by the Moldboard plows in providing the appropriate environment for root growth and nutrient absorption, which reflects positively on vegetative growth, which leads to an increase in the leaf surface area, which eventually produces larger quantities of carbohydrates that are stored in potato tubers, which increases the weight of this potato. Tubers, which reflects positively in increasing production.These results agreed with (Ati etal, 2015; Alam etal, 2013) who confirmed that crop productivity increased in plowed treatments compared to uncultivated treatments as a result of improving the physical properties of the soil.

The results in table (3) also showed that the productivity per area of tubers increased significantly with the increase in the depth of tillage, as the depth of tillage D3 excelled by an increase of (39.32 and 15.02)% on the two depths D1 and D2, respectively, in Karma Ali location. The percentage of increase was (31.34, 18.72)% in Al-Zubair location at depths D1 and D2, respectively. This is due to the role played by deep tillage in increasing soil loosening and improving its physical properties, which ensures better growth of roots and improves metabolic processes, thus increasing the production of tubers. These results agreed with (Haider et al, 2012), which indicated that there is a significant correlation between the depth of tillage and the increase in the number of tubers and their size produced by the plant.When comparing the effect of the two locations on the productivity

of potatoes, we note that the productivity in the Al-Zubair location was significantly excelled on the productivity of the Karma Ali location (tons. ha^{-1}), which is the final outcome that the researchers seek in order to increase production if given the inverting plow treatment and the depth of tillage (25- 35) cm yield amounted to (55.96 tons.ha^{-1}) at Al-Zubair location, while the same treatment gave a yield of (41.08 tons.ha^{-1}) at Karma Ali location.This is due to the effect of the soil texture, which was more loose (mixed sandy) at Al-Zubair location, which reduced the mechanical resistance to the growth of tubers. Whereas, it was clayey mixture in Karma Ali location, in addition to the effect of environmental conditions in both locations, where the Zubair location is characterized by an increase in low temperatures at night in the winter season, which leads to encouraging the plant to store carbohydrates inside potato tubers.

Table (3) Effect of type and depth of tillage on potato yield (ton ha^{-1})

Alkarma location					
Tillage type	**Tillage Depth (cm)**				
	D0	D1	D2	D3	Mean of Tillage
NT	18.37				18.37
MP		27.66	33.88	41.08	34.219
CP		26.86	32.16	34.87	31.297
Mean of Depth	18.37	27.26	33.02	37.98	
$RLSD_{0.05}$	T		D	T X D	
	1.153**		0.200**	1.148**	
Al-Zubair location					
Tillage type	**Tillage Depth (cm)**				
	D0	D1	D2	D3	Mean of Tillage
NT	22.60				22.60
MP		43.73	45.24	55.96	48.31
CP		34.88	41.72	47.28	41.29
Mean of Depth	22.60	39.30	43.48	51.62	
$RLSD_{0.05}$	T		D	T X D	
	**1.171		**0.117	**1.168	

Conclusions and recommendations:

Conclusions:

1. The values of bulk density and soil penetration resistance were significantly decreased using the two types of plows until the depth of tillage, compared to the treatment without tillage.

2. The Moldboard plows treatment is superior to the chisel plows treatment in terms of affecting and improving the physical properties of the soil.
3. The increase in the depth of tillage led to an increase in the productivity of the unit area of tubers of the potato plant.
4. The Al-Zubair location, which has a sandy-loam texture, was superior in increasing the productivity of potato tubers per unit area, compared with the Karma Ali location.

Recommendations:

1. It is recommended to use Moldboard plows at a depth of (25-35) cm when preparing the soil for planting potatoes.
2. We suggest continuing the study on other physical properties related to the soil, using other types of plows, and conducting the study on different crops.

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