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DESIGNING AND TESTING OF TRIPLE COMBINATION TILLAGE IMPLEMENT

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Abstract

The aim of the research is to design and manufacture a triple combination soil preparation implement, which can complete soil preparation in one passage for the tractor in the field, this triple combination tillage consisted of three equipment collected in one implement : a moldboard plow, rigid tines and leveling board, the number of soil tillage operations applied were optionally with three levels: single tillage (plowing), dual combination tillage (plowing + harrowing) and triple combination tillage (plowing + harrowing + leveling), the second factor was plowing depth(20 and 25 cm), a factorial experiment with RCBD used to conduct the research. The results showed that: The triple combination tillage was significantly superior to the dual and the single tillage, as the bulk density, random roughness RR, clod greater than 10 cm and clod 5-10 cm decreased significantly, while the slippage increased significantly . Depth increasing was causing a significant increase in the RR, clod greater than 10 cm, the clod 5-10 cm and the wheel slippage, while bulk density decreased significantly. The field experiment demonstrated high efficiency of the triple combination tillage in achieving a complete soil preparation in one passage , and this proves the success of the triple combination tillage work and the possibility of using it, taking into consideration the use of a tractor with sufficient capacity to pull it.

Key word: tillage, combination, triple, RR.

Introduction

Developing the work of agricultural machinery as a main objective to increase the net return, one of the most important ways of this development is the use of combination mechanization to carry out several agricultural operations during one tractor passage in the field, which leads to reduce costs of production and the harmful effect of repeated traffic, on the other hand increases the productivity and quality of these operations, for example, soil preparation processes such as harrowing and leveling are more efficient when carried out directly after plowing when suitable conditions of soil moisture. In addition, the use of combination mechanization increases the efficiency of using tractor capacity and increases its loading coefficient. Combined tillage implements is one of the solutions that farmers use to decrease production costs and time, it can be defined as two or more equipment that working simultaneously performing different processes for soil preparation (Sahu and Raheman 2006; Prem *et al.,* 2016).

Use of combination tillage were expanded widely and many reputed companies which are manufacturing agricultural implements have developed new machines and technologies in order to seedbed preparation and sowing, using two passes or a one pass of the machine across the field (Craciun *et al.,* 2004).

Alkhafaji *et al.,* (2018) was found that combining the locally manufactured ripper implement to mold board plow resulted in a significant increase in the number of soil clod with the desired diameter (5-10 cm), versus to very low numbers of soil clod with a bigger diameter.

Use of combination tillage implements was reduced clod size, rised aeration, increased moisture holding capacity, medium uniformity of soil and finer pulverization modulus, also high soil loosening as reflected by the low soil bulk density (Kailappan 2001).

The random roughness index (RR), represents one of the most important soil surface parameters, which is related to irrigation efficiency, especially the storage capacity of water etc. this coefficient represents the standard deviation of soil surface elevations (Thomsen *et al.,* 2015; Abd Elbasit *et al*., 2019).

Labiadh (2015) used the pin meter method to measure

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the roughness of the surface to compare two types of plows and stated that despite its simplicity, it is an appropriate method to measure regardless of the type of surface.

Vidal Vazquez *et al.,* (2007) said that the different soil preparation equipment produces different forms of soil surface because it reformed a large layer of soil and turns large clods into smaller and producing mounds, rips 1 for designing, fabricating and testing the performance of combination tillage that can operate as a single , two or three tillage equipment in one tractor pass.

Materials and Methods

The research was conducted to design and fabricate a triple combination tillage equipment, that can operate as a single, dual or triple tillage combination (Fig. 1 and 2). This equipment consisted f moldboard plow as a main equipment with four shares. A rigid tines for harrowung and leveling board for leveling as addition parts, were attached to the mainframe of the moldboard plow . The frames of the rigid tines and leveling board had allowed to use or not of these tools with the moldboard plow.

Experimental process:

The experiment was conducted as a split plot design with RCBD, two factors was studied, the main factor was the number of tillage operation times with three levels:

a - single tillage (four shares moldboard plow),

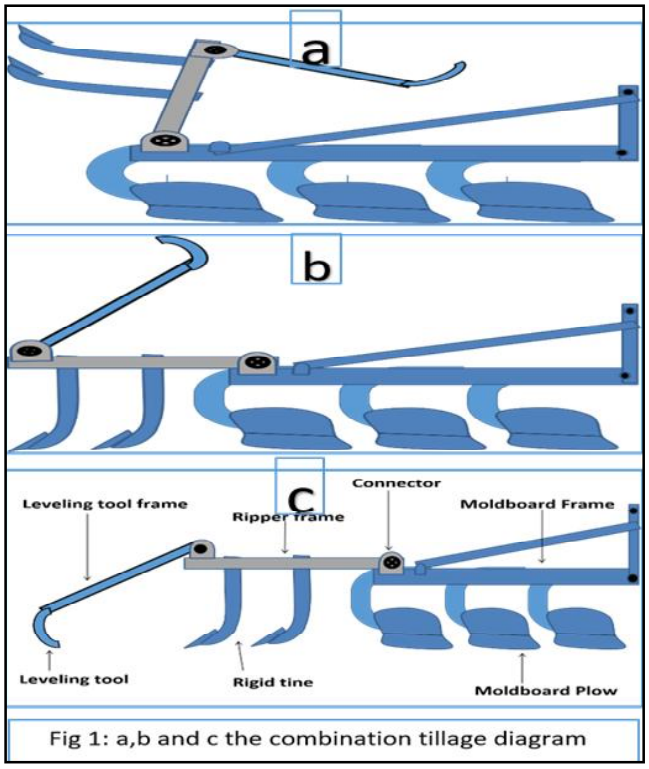

Fig 1: a,b and c the combination tillage diagram

Fig 2: d and e machine photos .

b - dual combination tillage (plowing + harrowing with rigid tines tool),

c - triple combination tillage (plowing + harrowing + leveling with leveling board).

The second factor was the plowing depth with two levels 20 and 25cm, that's represented the sub plots, three replications for each treatment was used., experimental plots (3 × 30) m was used for each treatment sub plots. Research data was analyzed by a Genstat V12 program, field soil was clay soil (5% sand, 85 % clay and 10% silty), it was not planted in past seasons.

Measurements: after applying all treatments the data were gathered and the bellow characteristics were measured immediately: Bulk density (bp) was calculated by a core sample method as a follow:

$$bp = \frac{WS - DS}{VC} \quad \text{..... } (\text{gm.cm}^{-3}) \qquad (1)$$

where WS: weight of wet soil (gm), DW: weight of dry soil (gm).

Random Roughness index (RR): the heights of soil surface were measured by the method of pin board for 33mm for 1 m (Thomsen *et al.,* 2014) , as a follow:

$$RRindex = \sqrt{\frac{\sum_{i=0}^{n}\left(Y_i - \bar{y}\right)^2}{n}} \quad \text{..... (mm)} \qquad (2)$$

Where yi soil height mm , $\bar{y}$ mean of all height reads mm, n: number of reads .

Clod size: wood square sieve with (0.5 × 0.5) m and (5 × 5) cm orifice were used for clods diameter (5-10) cm, while the same sieve but with (10 × 10) cm orifice used for clod diameter more than 10cm.

Slippage: it was fined from:

$$S\% = \frac{VT - VP}{VT} \times 100 \text{ .....(\%)} \quad (3)$$

Where VT, VP: theoretical and practical velocity of tractor (km.hr^{-1}) respectively.

Table 1: soil bulk density (gm.cm^{-3}).

	Plowing depth cm		mean
	20	25	
Single till	1.537	1.150	1.344
Dual till	1.307	1.157	1.232
Triple till	1.213	1.070	1.142
mean	1.352	1.126	
LSD depth =0.0289	LSD interaction = 0.0425		LSD tillage =0.0345

Table 2: Clod size more than 10cm at different tillage combination equipment types.

	Plowing depth cm		mean
	20	25	
Single till	12.67	18.33	15.50
Dual till	9.00	8.33	8.67
Triple till	1.00	1.67	1.33
mean	7.56	9.44	

Table 3: Clod size (5-10)cm at different tillage combination equipment types.

	Plowing depth cm		mean
	20	25	
Single till	40.33	62.33	51.33
Dual till	70.33	79.67	75.00
Triple till	9.33	16.00	12.67
mean	40.00	52.67	

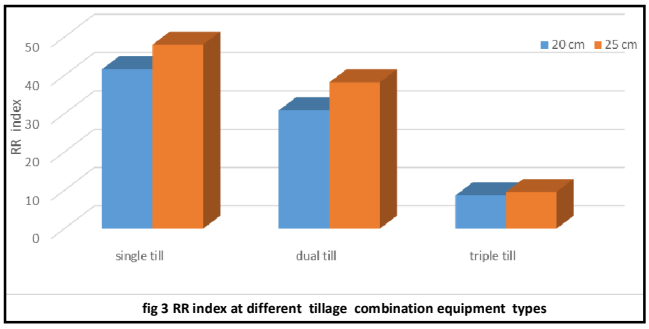

fig 3 RR index at different tillage combination equipment types

Result and Discussion

Bulk density: the results in table 1 explained that increased implements number in the combination tillage equipment led to reduce the bulk density significantly. It is clear that triple combination tillage has achieved the lowest value of bulk density, perhaps directly harrowing was leading to easily breaking the plowed soil, that's resulted in decreased clod size and increased in the number of air pores in the soil, in addition conducting the leveling operation directly after plowing was assisted in shattering clod to smaller size and decreasing bulk density, especially when plowing operations done at the appropriate conditions of soil moisture.

Increasing plowing depth was resulted in decreasing the bulk density significantly (Table 1), also the interaction between these two factors had a significant effect on the bulk density, triple tillage at 25 cm resulted in low bulk density (1.07 gm.cm^{-3})while highest value found in single tillage at 20cm (1.537 gm.cm^{-3}).

RR index : Statistical analysis showed a significant improvement in the soil surface leveling process when using more than one tillage tools in one pass in the field (Fig. 3), there was a decrease of 45 to 35 mm in the random roughness index for dual and triple tillage (respectively) compared to 9 mm with the single tillage. It is a natural result, because single plowing results in a few high and low plowing furrow (equivalent to the number of the plow shares), which causes a great variation in the height of the soil surface, thus increasing the RR index.

Fig. 3 RR index at different tillage combination equipment types

Applying of the harrowing after plowing directly caused that tine rigid tool were scattered the plowing lines and reshapes the soil surface, that is resulting in more lines with little differences in soil height, and this led to a significant decrease in the RR index. On the other hand, the leveling board tool will push the raised soil parts towards the low furrows, that produces more leveling in the soil surface, which led to a significant decrease in the variance iof the soil heights, as a result of which the RR index decreased significantly.

Clod size more than 10 cm: It is normal that the use of a moldboard plow produces a large number of clods with a large diameter that are not suitable for planting, therefore we found about 13 clod. m at the plowing depth 20cm, and it was increased to 18 clod. m at 25cm depth. This is due to the increase in the depth of cultivation, which leads to an increase in the area of the raised soil section, and consequently, the number and size of large clods increases.

The use of the tine rigid tool immediately after the moldboard plow reducing the number of large clods by breaking it to less than 9 clods.

Table 2 clod size more than 10 cm at different tillage combination equipment types when using the triple

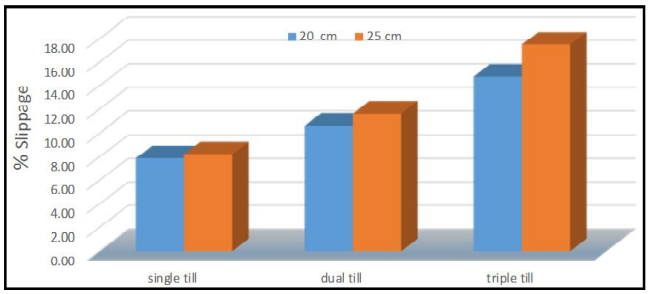

Fig. 4: slippage at different tillage combination equipment types.

combination tillage (plow, tine rigid and leveling board) the numbers of large clods decreased significantly to about 1 clods m, because the leveling board broke the large clods and reduced their number to the lowest possible level. Table 3 clod size (5-10)cm at different tillage combination equipment types clod size (5-10)cm: The results in table 3 showed that the number of medium clod (5-10 cm) increased from about 51 to 75 clod when using the dual tillage system instead of the single tillage system, this result was coming from the direct harrowing action after plowing that was breaking large clod to a big number of medium clod.

However using the triple tillage system, it was noted that the number of medium clod decreased to about 13 clod, because the leveling board caused the break-up of both large and medium clod to smaller clod, This is very desirable in agriculture, especially with the minimum number of large clod, that is mean soil will be ready for subsequent planting operation after use of a triple combination tillage. From all of the above, we think that the triple combination tillage succeeded in making a complete soil preparation with one tractor passage in the field.

Slippage: Fig. 4 shows that the increase in the number of operations performed with the combination tillage causes a significant increase in the percentage of wheel slippage, it was increased from 8% to 12% when adding harrowing to plowing operation, also slippage was increased significantly to a high percentage of about 17% when using the triple combination tillage (plowing, harrowing and leveling), the reason for this was the final result of the soil resistance forces against the combination tillage is equal to the sum of the individual resistances of the all shares of the equipment, this causes an increasing in tractor wheels slippage with the increasing number of tillage shares or tillage operations.

Therefore, the combination tillage need to use a high power tractor, while a medium-power tractor was used to carry out this research, which caused an increase in the slippage percentage.

Despite all of the above, the slippage levels achieved when using the triple combination tillage remained close to the permitted rates.

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