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DEVELOPMENT OF A DEVICE TO COVER THE SHANK OF FURROW OPENERS OF ZERO-TILLAGE PLANTERS

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Abstract

Assist farmers with the selection of the most appropriate the best performance system. The location of experiment was in Gardarash station in Erbil/Iraq and conducted in 2017. College of agriculture University of Salahaddin (N 36° 06' 48.9'' – E 044° 00' 45.0'' and at mean altitude of 412 m amsl). A new modification of zero-tillage planter was used for cleaning seeding row from crop residues. By adding a half-cylindrical plate to cover the stem of furrow opener to allow the previous crop residues to pass between the furrow openers of zero-tillage planter. Two Modifications were (7 and 9) cm and the high of that modification was 15 cm and compared that with non-modification. The second factor was three Speeds (8, 9, and 11 km.hr^{-1}). The third factor was two depths (4, and 6 cm) and the experimental design split-split plot with RCBD. The results showed that the narrow plate cover the shank of the furrow opener had better performance than the wide plate and non-modification. The narrow modification increased the effective field capacity with increasing the speed while decreased the E.F.C with depth increases. The traction power increased with speed or depth increases as like as the slippage power losses. The third interaction had a significantly affect with number of plant in one meter, number of spike per meter, and the number of grain in one spike. In addition cleaning the residue from the row seeder improves with narrow modification than the other treatments. Finally, the biological yield transporting between the treatments but the highest value was in narrow modification than wide and non-modification.

Keywords: Covering shank, furrow opener, seeding depth, seeding speed, zero tillage

Introduction

No-tillage is defined as planting crops over previous crop residue by making narrow slot or trench with small width and depth in the soil without pre-soil preparation (Avci, 2011) The no-tillage technique has many advantages over the traditional tillage such as erosion control (water and wind) by leaving residue over the field surface, increase organic matter, prevent to burn stubble, and reduce production cost. These residues may build up in front of the drill and disrupt seed placement. Time being there are no drills that have a good performance in high residue condition and base obstacle to be used in reduced tillage systems. The performance evaluation of the available drills in no-till system is very critical for farmers to adopt no-till system. In addition, many farmers prefer to use their own drills after adding to them some pieces for cutting or removing the residue from the planting rows rather than buying new machines.

Narrow-row planting implement are used to drill seeds directly to the soil through crop residues. No-till drill with hoe openers and air seeders mounted on field cultivators have also been used to seed small grains into the soil with existing residues. Coulters are used on many drills to help cut through residue in front of the seed delivery units.

Residue removing may be sacrificed in some drills. Other models offset every other row to improve plant residue movement through the drill assembly. However, a proper seed placement remains a major challenge in no-till of small grain production, especially in high levels of plant residue. Grain drills designed for no-till seeding are designed to cut through crop residues to ensure proper seed placement. Residue management, planting speed, soil moisture, soil density, drill weight, and row spacing are all factors that affect in seed placement. Placing the seed at the proper depth of 3-4 cm below the surface of the soil, not the residue is critical for achieving good seed-soil contact and proper crown development. Narrower row spacing and heavy crop residues become more difficult to manage in a no-till situation. Increasing the row spacing to 25cm or wider helps the flow of residue, but they also could result in a less yield. A row spacing of 20cm seems to be a good compromise for maintaining high yields while allowing the residue to flow through the drill. The suggested range for planting speed is 6.5-11.0 km/hr depending on the type of drill. Planting speeds above that range will tend to raise the grain drill and reduce the planting depth. However, planting at lower speeds will results in low field machine capacity (Grove *et al*., 2000)

Rui *et al*. (2016) noted a suitable depth control mechanism for existing no-till maize planters, to obtain consistent planting depth, uniform emergence, anti-blocking ability, and improve the performance of no-till precision maize planter on residue covered field was outlined.

Jajo (2016) Mentioned the superior effect of the cultivation system and the speeds of field practices on many machine performance characteristics such as slippage percentage, traction forces, and fuel consumption. For example, increasing the travel speed will reduce the fuel consumption (l.ha^{-1}) but the slippage percentage and traction force will increase.

The results of (Hussain Th. TAHIR, Nazat H JEEJO, & Tariq H KARIM, 2018) showed the superiority of zero-tillage system to achieve the best values for the seed emergence rate, number of grains per spike, 1000-grain weight, and grain yield. On the other hand, conventional tillage with reduced tillage system achieved the best value for the practical productivity and draft power recording 1.035 ha.h^{-1} and 5.898 kW, respectively. In addition, speed factor significantly affected the draft power and the practical productivity. Finally, that research showed the superiority of zero-till system to achieve the highest net profit.

The objectives of the study are:

1. Attach a device to the furrow opener shank of the conventional no-tillage drill to allow the residue to pass through the drill.
2. Remove surface residue from the row area in front of the furrow opener.
3. Move the accumulated residue in the seed line behind the seeding tube.

Materials and Methods

An experiment was conducted at Gardarash Research Station, College of Agriculture, Salahaddin University - Erbil (N 36° 06' 48.9" – E 44° 00' 45.0" and at mean altitude of 412 m amsl) in 2016-2017 to examine some modifications made to the zero-tillage drill (ZT drill). Field soil texture is silt clay loam (370 of clay, 525 of silt, and 105 of sand g.kg^{-1}) and pH= 7.60. Studied the effect of the modifications, travel speeds, and planting depth on some machine and plant indicators were tested. Machine performance indicators included the effective field capacity (ha.h^{-1}), Drawbar power (hp), and loss power in slippage (hp). Plant indicators were number of plant in one meter, plant height (cm), number of spikes in one-meter length, number of grains in one spike, weight of residue in unit of length (meter), and biological yield (kg.ha^{-1}). Some indicators were calculated using the equations listed below (Hunt, 2007).

1-Effective field capacity (E.F.C.) (ha/h).

$$\text{Effective field capacity}\left(\frac{ha}{h}\right)=\frac{\text{actual speed}\left(\frac{km}{h}\right)\times\text{work width}(m)\times\text{efficience}}{\text{unit area}(\text{hectare})} \quad ...(1)$$

2-Drawbar power (D.P) measuring by hp.

$$\text{Drawbar power (D.P)} = \text{draft force}(kg)\times\text{speed}\left(\frac{km}{h}\right)/270 \ldots (2)$$

3-Loss power in slippage (Sp).

$$Sp=\frac{Pf\left(V_t-V_p\right)}{270} \ldots (3)$$

Sp: loss power in slippage percentage

Pf: draft forces (kg).

Vt: theoretical speed (km.h^{-1}).

Vp: practical speed (km.h^{-1}).

2.1 Seeder modifications:

The seeder used in the experiment was modified at two levels of row and seed row cleaner: narrow modification and wide modification. The modifications were made by adding a plate or shell into the front of the shank of furrow opener. The plate has two sizes, the first size is 7 cm (narrow) and the second size is 9 cm (wide). The height of that modification is 15 cm. The modifications are designed to move and push most of the surface residue to the sides of the row, allowing ZT-drill to be achieved in a band with a clean surface. They were fixed immediately to the front of the furrow opener fig (1) and compared with original stem, which has no-modification (Aikins, Antille, Jensen, & Blackwell, 2017) (Duiker, Hoover, & Myers, 2013; Li *et al.*, 2015).

Fig. 1 : Shows the details of modification.

2.2 Experimental Design:

The experiment was arrangement at a split-split plot in a Completely Randomized Block Design (RCBD) (CRBD). Three different modifications: seeder without modification (A_1), seeder with narrow modification (A_2), and seeder with wide modification (A_3) represented the main plots. Travel speeds (B_1=8, B_2= 9, and B_3=11km.hr^{-1}) and planting depths C_1=4, and C_2=6 (cm) represented the sub and sub-subplots, respectively. The experiment was repeated for three times, which resulted in an overall of 54 treatments (2 modifications and without modification×3 speeds×2 depths×3 replications). The data was analyzed by a Statistical Analysis System (SAS) and the significance between treatment means was tested by Duncan Multiply Range Test.

Results and Discussion

Table (1) shows the effects of two modifications and without modification in effective field capacity, draft or drawbar power, loss power in slippage, number of plants per meter, height of plant, number of spike per meter, number of grain in one spike, weight of residue, and biological yield.

According to table (1), the narrow modification (A_2) and without modification (A_1) had a superior value of effective field capacity (1.406 and 1.402) ha.h^{-1} respectively. The lower significant value (1.372) ha/h happened with wide modification (A_3).

The same table (1) also showed the significant effects between the treatments of drawbar power indicator. The best value (38.61, 38.96) hp recorded with narrow and wide modifications respectively. The highest value (39.8) hp recorded in the treatment of without modification.

Slippage power losses of the wide modification (A_3) recorded the highest value of 7.427 hp (table 1), which is significantly different with other two treatments. However, other modifications were not different between of them. While the lowest value achieved in narrow and without modification (6.08, 6.40) hp respectively.

The number of plants / meter of length (plant.m^{-1}) had a superior value of that indicator, the highest value achieved in without modified (52.94) plant per meter. The lower value (41) plant.m^{-1} of that indicator recorded with narrow modification according table (1).

Number of grain in spike was significantly affected by the treatments, and the highest value recorded in without modification 30.5 seed per spike. While the lower value, was (26.5) seeds per spike achieved in narrow modification, table

(1). That is agreement with the (Alrijabo, 2014) researcher encouraged to adopt ZT-planting.

From the same previous table the weight of residue (g.m^{-1}) was a significantly affect between modification treatments. The best or less value of that indicator achieved in narrow modification (20.05) g.m^{-1}. Therefore, the highest value of weight residue was in without modification (43.83) g.m^{-1}. Therefore, the weight of residue is the main indicators refer to clean the rows of no-till drill when it is working in the fields. That agreement with (Alrijabo, 2014) (Siemens, Wilkins, & Correa, 2004; Wang, Zhu, Li, Huang, & Jia, 2018) (Jin, Zhiqiang, Hongwen, & Qingjie, 2014) so they recommend to adopt new technology with ZT planter (Jin *et al*., 2014).

While there were non-significantly effect of treatments in other indicators: height of plant, number of spike per meter, and biological yield.

Table 1 : Explains the effects of the modifications on some mechanical and crop indicators.

Level of Modification	Effective field capacity (ha/hr) **	Drawbar Power (hp) *	slippage power loss (hp)*	No. of plants/m **	Height of plant (cm)	No. of spike/m	No. of grain in spike **	Weight of Residue (g/m) *	Biological Yield kg/ha **
A1	1.402 a	39.80 a	6.40 b	52.9 a	50.9	47.5	30.5 a	43.83 a	5760.5
A2	1.406 a	38.61 b	6.08 b	41.0 b	53.6	49.6	26.5 b	20.05 c	6101.8
A3	1.372 b	38.96 b	7.42 a	46.3 ab	52.0	43.4	30.0 ab	24.73 b	5224.8

*the lowest value is better **the highest value is better

Table (2) revealed the significantly effect of three speeds (8-9-11) km.h^{-1} in some indicators: effective field capacity, drawbar power, slippage power loss, biological yield, and weight of residue. While there were no significantly effect of speeds in other plant indicators: number of plants.m^{-1}, height of plant, number of spike.m^{-1}, number of grain per spike.

From table (2) the highest or best value (1.578) ha.h^{-1} of effective field capacity achieved with the third speed level (11) km.hr-^{1}. While the lower value (1.204) ha.h-^{1} was recorded with first speed (8) km.h-^{1}, due to the speed is one of the elements of effective field capacity equation and when the speed increase the E.F.C. increased too. Trend was similar to (Altuntas, Özgöz, & Taser, 2006) (Jajo, 2016) (Furlani, Canova, Bertonha, Cavichioli, & Silva, 2013; Hussain Th. TAHIR, Nazat H JEEJO *et al*., 2018).

The significantly effect of speeds in drawbar power explained in table (2), and the best value is the lower (25.72) hp that recorded with first speed (8) km.h-^{1}. While the high value was (52.63) hp recorded with third speed (11) km.h-^{1}. The reason is when the speed increased the traction in draw bar increases and the draft power increases too. Due to the soil resistance, and That situation agreement with (Jajo, 2016) and (Altuntas *et al*., 2006; Furlani *et al*., 2013) (Harrigan & Rotz, 1995) (Li *et al*., 2015).

The loss power in slippage was a superior effect with speeds level, and the low value of slippage power loss recorded with first speed (2.605) hp, while the highest value (11.16) hp achieved in third speed level. Due to increases the slippage percentage, that Agreed with (Jajo, 2016).

There were no significant effects of speeds on the number of plants per meter, height of plant, number of spikes per meter, and number of grains in spike.

The weight of residue (g.m-^{1}) was a significantly affect between the different speed levels, and the best value (23.99) g/m recorded in first speed while, the highest value achieved in second and third speeds (32.18, 32.44) g.m-^{1} respectively. That agreed with (Aikins *et al*., 2017) (Jin *et al*., 2014; Siemens *et al*., 2004; Wang *et al*., 2018).

The last indicator in table 2 shows the superior value of biological yield was recorded in third speed (6322.6) kg.ha-^{1} and the lower value achieved with second speed (5297.7) kg.ha-^{1}.

Table 2 : Showed the speed levels effect on mechanical and crop indicators.

Level of speed (km/h)	Effective field capacity (ha/hr) **	Drawbar Power (hp) *	slippage power loss (hp)*	No. of plants/m	Height of plant (cm)	No. of spike/m	No. of grain in spike	Weight of Residue (g/m) *	Biological Yield kg/ha **
B1(8)	1.204 c	25.72 c	2.60 c	47.9	50.34	49.5	30.7	23.99 b	5466.8 ab
B2(9)	1.398 b	39.01 b	6.14 b	44.8	52.35	44.1	28.5	32.18 a	5297.7 b
B3(11)	1.578 a	52.63 a	11.16 a	47.5	53.86	46.8	27.8	32.44 a	6322.6 a

*the lowest value is better ** the highest value is better

From table (3) that we note the significantly effect of depth factor (4, 6) cm in some indicators: effective field capacity, drawbar power, loss power in slippage percentage, biological yield, and non-significantly effect in other plant and crop components indicators: number of plant per meter, height of plant, number of spike per meter, number of grain in spike, and weight of residue.

The effective field capacity had a significantly affect between two depths. The higher or best value (1.418)ha.h-^{1} recorded with first depth (4 cm), while the lower value (1.369)ha.h-^{1} achieved with second depth (6 cm), due to the speed decreases by increases the soil rolling resistance, agree with(Aikins et al., 2017; Jajo, 2016).

Table (3) shows the significantly effect of depths (4, 6)cm on drawbar power (37.11, 41.13) hp that reveled if the depth increase the drawbar power increased too, because when the depth increased, the rolling resistance of soil against the implement (planter with tractor) increasing, that caused to increase drawbar power (Jajo, 2016) (Tahir, Matti, & Al-Tahan, 2018). They resulted near that trends and agreed with it (Hussain Th. Tahir, Nazat H. Jeejo, & Tariq H. Karim, 2018)

Slippage power Loss gives a significant effect with depths treatments according to table (3) the best or lower value (5.54) hp happened from the first depth (4) cm. While the higher value (7.73) hp registered with second depth (6) cm, because when the depth increase the power loss increased too, due to increases the slippage. That agreement with (Jajo, 2016; Jing, Wei, Baofa, & Yanfen, 2015).

The depth had a significantly effect and increased with depth in biological yield. The values were (5317.5, 6073.9) kg.ha-¹, with planting depth (4, 6)cm respectively, this trends was similar to (Rui *et al.*, 2016) (Aikins *et al.*, 2017).

Table 3 : Explains the effect of depths level on some mechanical and crop indicators.

Depths level	Effective field capacity (ha/hr) **	Drawbar Power (hp) *	slippage power loss (hp)*	No. of plants/m **	Height of plant (cm)	No. of spike/m	No. of grain in spike **	Weight of Risdue (g/m) *	Biological Yield kg/ha
C1(4cm)	1.418 a	37.11 b	5.54 b	45.1	51.45	46.8	29.2	28.97	5317.5 b
C2(6cm)	1.369 b	41.13 a	7.73 a	48.4	52.91	46.8	28.8	30.10	6073.9 a

*the lowest value is better **the highest value is better

Table (4) explained the significant effect of interactions between three factors (depths, speeds and modified) in mechanical and crop indicators. The Effective field ha.h-¹, drawbar power (hp), slippage power loss (hp), number of plant in one meter, height of plant, number of spike in one meter, and number of grain in spike in addition, the weight of residue(g) and biological yield (kg.ha-¹).

Effective field capacity increases when speed increased, according the table (4). The best value of that indicator recorded in first depth with third speed in without modification, and narrow modification (1.625, 1.628) ha.h-¹ respectively. Due to the speed is one of the elements of equation of effective field capacity, when the depth increase the speed decreased and the effective field capacity decreases too. While the lowest value was recorded in second depth, first speed with all modifications.

The big different between all treats in drawbar power table (4) and the best value of this indicator recorded with narrow modification, first speed and first depth (21.75) hp. That refers to the narrow modification give a best value for drawbar power. While the highest value of drawbar achieved in second depth, third speed, with (narrow modification and without modifications) (56.15, 54.91) hp, respectively.

The slippage power loss increased when the depth or speed increases, from table (4), the superior or best value achieved with first speed in first depth with all modifications; without, narrow, and wide modification (1.956, 1.576, 1.743)hp respectively. In contrast, the highest value obtained at second depth, third speed, with wide modification (13.963) hp.

Table 4 : Explained the effect of interaction between the modified, speed, and depth on mechanical and crop indicators.

Levels modified, speed, and depth	Effective field capacity (ha/hr) **	Drawbar Power (hp) *	slippage power loss (hp)*	No. of plants/m **	Height of plant (cm)*	No. of spike/m **	No. of grain in spike **	Weight of Residue (g/m) *	Biological Yield (kg/ha) **
A1b1c1	1.226 f	24.71 j	1.95 h	52.6 ab	49	33.0 cd	26.0 bc	30.3 c	3650.5 fg
A1b1c2	1.183 g	29.80 g	3.53 g	54.0 ab	51.6	40.9 bcd	38.3 a	19.4 ef	6865.0 abc
A1b2c1	1.430 d	37.84 f	4.93 f	45.6 abc	49.6	48.7 bcd	31.4 abc	48.5 b	6428.6 bcd
A1b2c2	1.390 d	40.27 e	6.58 d	48.3 ab	49.8	44.5 bcd	23.0 c	60.7 a	5952.4 bcde
A1b3c1	1.628 a	51.28 c	8.90 c	55.0 ab	51.6	75.6 a	35.1 ab	46.6 b	6468.3 bcd
A1b3c2	1.556 b	54.91 a	12.50 b	62.0 a	53.6	42.1 bcd	29.4 abc	57.2 a	5198.4 cdef
A2b1c1	1.233 f	21.75 l	1.57 h	51.3 ab	50.5	60.2 ab	30.6 abc	23.2 def	6190.5 bcde
A2b1c2	1.175 g	26.64 i	3.35 g	41.0 abc	52.9	54.0 b	28.9 abc	19.3 fe	6333.3 bcde
A2b2c1	1.420 d	37.58 f	5.19 ef	25.0 c	53.8	33.0 cd	28.1 abc	19.2 ef	3531.7 fg
A2b2c2	1.394 d	40.39 e	6.45 de	49.6 ab	52.5	53.0 b	24.2 bc	20.0 ef	4682.5 def
A2b3c1	1.625 a	49.13 d	8.64 c	45.3 abc	56	45.9 bcd	22.5 c	16.6 f	8254.0 a
A2b3c2	1.592 ab	56.15 a	11.26 b	33.6 bc	55.8	51.6 bcd	25.0 bc	21.8 ef	7619.1 ab
A3b1c1	1.231 f	23.25 k	1.74 h	44.3 abc	51	59.5 ab	34.3 ab	25.7 cde	5238.1 cdef
A3b1c2	1.178 g	28.20 h	3.46 g	44.3 abc	46.8	49.6 bcd	26.3 bc	25.9 cde	4523.5 ef

A3b2c1	1.419 d	37.54 f	5.23 ef	42.3 abc	52.6	33.3 cd	33.0 abc	20.7 ef	5318.2 cdef
A3b2c2	1.337 e	40.42 e	8.46 c	58.0 a	55.5	52.3 bc	31.6 abc	23.8 cde	5873.0 bcde
A3b3c1	1.553 bc	50.89 c	11.70 b	44.0 abc	48.6	32.3 d	22.0 c	29.6 cd	2777.8 g
A3b3c2	1.515 c	53.44 b	13.96 a	45.0 abc	57.3	33.3 cd	33.0 abc	22.5 ef	7618.4 ab

* the lowest value is better ** the highest value is better

The number of plant in one meter was a significantly effect by the interaction of three factors. The best value recorded in second depth, third speed, and without modification -(62) plant per meter, and (58) plant per meter achieved in second depth, second speed, with wide modification. While the lower number (25) plant meter achieved in narrow modification, with second speed, in first depth.

On other hand, there is no significantly effect of interactions in the height of plant.

Table (4) number of spike in one meter was superior effect with interactions and the highest value (75.6) spike.m-^{1} recorded in without modification, third speed, with first depth. While the lowest value (32.3) spike.m-^{1} achieved in wide modification, third speed, with first depth.

The highest number (38.3) of grain in one spike recorded in without modification, first speed, with second depth. While the lower value of that indicator achieved in many treats without modification, in second speed and depth (23.03) grain per spike also the same letter recorded in (narrow and wide) modification, third speed, with first depth (22.5, 22) respectively.

The superior effect of weight of residue recorded with interaction of three factors (modification, speed, and depth) and the best or less value (16.66 g) recorded with (narrow modification, third speed, and first depth). While the highest value (60.73 g) of weight residue achieved in (without modification, second speed, and second depth) and the same letter in (without modification, third speed, and second depth) was (57.26 g).

The last indicator was biological yield and the superior or best value (8254) kg.ha-^{1} achieved in narrow modification, third speed, and first depth. While the lowest value (2777.8) kg.ha-^{1} recorded in wide modification, third speed, first depth (Opoku, Vyn, & Swanton, 1997)

Conclusion

- The result showed that the narrow modified row and seed row cleaner is the best one.
- The first level of forward speed is the best one.
- The 4cm depth is the best one.
- The interaction between narrow row and seed row cleaner with the first speed 8km.h-^{1} and first depth 4cm is the best, one that recorded best value of indicators.
- The interaction between narrow row and seed row cleaner with third level of forward speed 11 km.h-^{1}, recorded a good values with most indicators.

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