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ENGINEERING STUDY ON DEVELOPING A FURROW FORMING UNIT FOR PLANTER

Ibrahim, M. M.; H .N. Abd El-Mageed and T. H. Abd-Alla
Agric. Engin. Dept., Fac. of Agric., Mansoura Univ.

ABSTRACT

Geometrical and experimental studies to prevent collapsing soil phenomenon behind planter furrow openers were carried out. Three different furrow openers that consist of chisel shank provided with share (Hoof shovel type) followed by press wheel were developed and used later in the field experiments. Preliminary experiments were conducted to determine, the best dimensions for three press wheel types under study, and evaluate the effect of different vertical loads on the press wheels which had been used to prevent the collapsing of soil in the furrow, also to be sure that the weight of the planter is quite enough to apply the required load on the press wheel to prevent the collapsing soil phenomenon. Different soil textures were used to indicate whether this system is acceptable for all types of soil or not.

To study the effect of press wheel shape, three press wheel shapes were also constructed and tested in the field under two levels of forward speeds and four depths. The field experiments were carried out during planting of Zea-maize. To evaluate the influences of developed furrow openers on the opening furrow structure, four measurements were conducted as follows: -

1. Furrow cross sectional area (A) and furrow cross – section profile.
2. The height of the collapsed loose soil in the furrow bottom.
3. Plants lateral scattering around the row centerline.
4. Emergence ratio of plants.

The obtained results showed that, using the developed furrow opener with press wheel triangular type prevents loose soil collapsing phenomenon behind planter furrow opener, and encourages the seeds depth to be more adjusted providing more contact area between seeds and soil particles. Also press the furrow walls and bottom, which caused higher emergence ratio of plants.

INTRODUCTION

The sowing process is considered one of the most important agricultural operations. The art of placing seeds in the soil to obtain high germinations ratio and healthy plants is the most important objective to achive to the highest yield. Soil collapsed behind planter furrow opener cause not adjusting sowing depth, which have negative effect on emergence ratio.

To achieve the final aim of mechanization for improving the agricultural production,effective efforts had to be done to improve the planters performance A number of factors have influence on the germination of seeds and the emergence of seedling plants, such as either horizontal or vertical separation of seed and fertilizer or both horizontal and vertical separations together. However the most important one of these factors is the prevention of loose soil getting under the seed due to the soil collapsing phenomenon behind the furrow opener (*Smith, 1984*).

Erbach (1981), described, in an extensive review described the major planter requirements for conservation planting as a) more seeds contact with soil, b) consistently cut plant residue, c) uniformly penetrate the soil, d) uniform of seed depth and e) adequateley seed cover. Therefore, furrow openers are considered very important to control seed placement.

Stout *et al.* (1961) found that planters should be designed to apply higher pressures on soil at seed level, but should place relatively loose soil above the seed.

Ismail and Hemeda, (1991) carried out geometrical studies on soil slippage phenomenon behind the furrow opener of planters. They reported that the height of the loose soil in the furrow bottom (h) can be estimated by using the follwing equation:

$$h = 4y\,(y - y^{-}) / w \tan\theta$$

Where:

y = the height of turned soil aside of opener wing when the opener lies inside the furrow, cm.

y^{-} = the height of turned soil after removing furrow opener effect, cm.

w = the width of the opener wings set in parallel position, cm.

θ = the sitting angle of soil.

Posnekov and Kan (1968), reported that the soil layer previously turned aside begins to slide down into the open furrow at the natural slip angle when the retarding action of the wings is stopped. The furrow depth of the covering is almost always lesser than the depth greatly influenced by the opener. The germination of cotton seed is greatly influenced by the type of furrow opener used.

Bainer *et al.* (1955), Hunt (1977), and Culpin (1986), showed that, several types of furrow opener available to meet different seeding conditions. The most common ones are: single disk, double disk, runner, and hoe opener.

Wurr *et al.* (1985), indicated that, sowing depth had a considerable effect on percentage of seedling emergence and the spread of emergence time.

Ozomerzi (1986) found that of the shoe, hoe, single and double disk types coulters. He found that the evenness of the depth distributions for the double disk type coulters was the best, but the evenness of the seed depth distribution for the hoe type coulter was the worst.

Tessier *et al.* (1989) found that the hoe openers encouraged more soil disturbance than disc openers, but gave consistent furrow compaction with 45 mm. wide press wheels . Disk opener minimize soil disturbance, and generally maintained a moisten seed zone, but soil-seed contact may not alwys be enhanced by a 45 mm. wide press wheel which then caused lower wheat emergence.

Essam (1997) developed a planting furrow opener mechanism consists of press-wheel and new covering device. His results consists of press-wheel and new covering device. His results showed that, using a press wheel behind the machine furrow opener encouraged the seeds to be more distributed and hence an accurate seed depth.

Abd-Alla (1999) carried out geometrical and experimental studies on soil slip phenomenon behind the furrow opener of planters as a fundamental bases for manufacturing furrow opener . The obtained results showed that, using a press wheel triangular type, to be formed sowing furrow by planter encourage the seeds depth to be more adjusted, and providing more contact between seeds and soil particles due to press soil in asides and bottom of the obtained furrow, which caused more germination ratio.

The present work aim to develop a furrow opener to minimize soil collapsing phenomenon behind the furrow opener of planters, and on the other side press the furrow bottom for improve the contact between seeds and soil particles.

MATERIALS AND METHODS

The experiments were conducted in a clay loam soil. The physical and chemical properties of the experimental soil are summarized in Table (1)

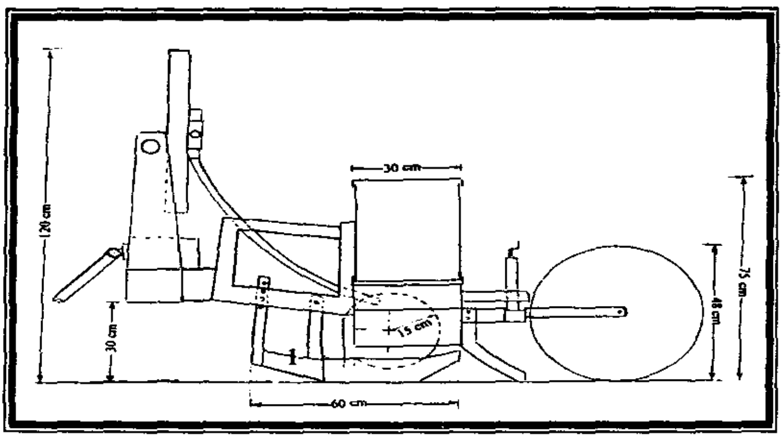
Table (1): The mechanical and chemical analysis of the experimental soil.

Particle size distribution (%)				Soil Texture	pH	$CaCO_3$ %	Soil Bulk density gm/cm^3
Clay	Silt	Fine sand	Coarse sand				
42.85	40.95	14.72	1.48	Clay loam	7.83	3.1	1.46

Average soil moisture content was 13.72 % w.b.

*** The tractor and planter:**

A 44.78 W (60 HP) Nasr tractor was provided with a four unit pneumatic planter (Gamma Model) produced by Italy company "SFOGGIA" used to evaluate the developed opener. The planter is provided with suction fan powered by the tractor (P.T.O). Every planter unit was provided with furrow opener (shoe type) and two covering rood followed by press wheel as shown in Figure (1).



1- The furrow opener (shoe type).

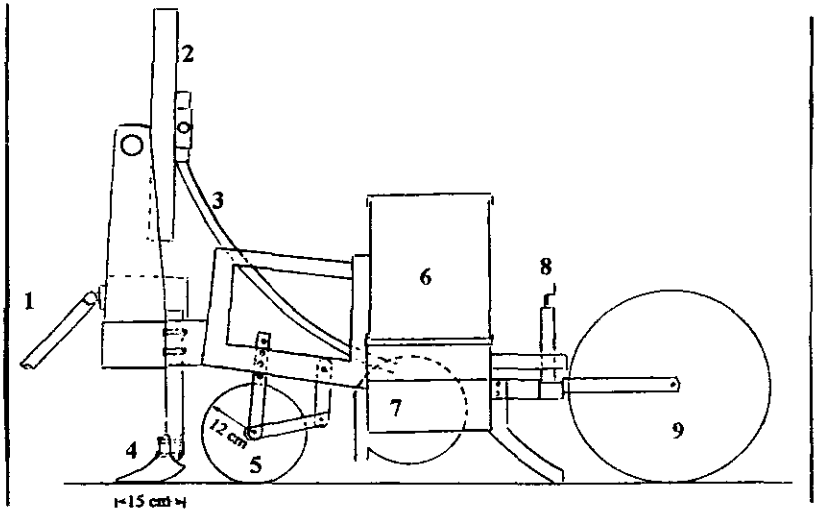
Figure **(1). Side view of the planter before modefication.**

Experimental Equipment

The developed furrow opener was produced at the Department of Agricultural Engineering, Faculty of Agriculture, Mansoura Univ. as shown in Figurs (2). It consists of the following parts:

1- Chisel shank: A chisel shank of (600 m.m. length) provided with share (Hoof shovel type) of 150 m.m. length and 110 m.m. width was fixed on the chisel frame. The depth of chisel shank was 25 mm.

2- Press wheel: *As previously mentioned, preliminary tests were carried out* to determine the best dimensions for the press wheel, which was made of aluminum. It was found that the suitable wheel wide was 80 m.m. and its proper diameter was 240 m.m. . To study the effect of press wheel features, three press wheel figures were manfactured (Convex type P_1 & Flat type P_2 & Triangular edged type P_3) as showen in Figure (3)



1- Uneversal joint (the power take off). **2- The blower.**
3- The suction pipe. **4- The chisel chase.**
5- Furrow opener (press wheel). **6- The seed hopper.**
7- The seed metering. **8- Leveler for depth control.**
9- Machine press wheel.

Figure (2). Side view of the planter with developed furrow opener

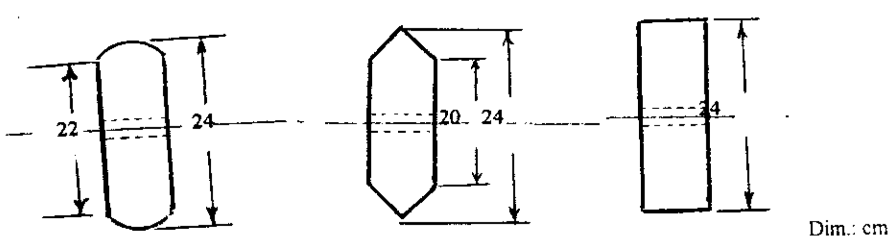


Figure (3). Types of press wheels used for experimental work

To control the press wheel depth, it was provided with a mounted system with five hitching holes to connect the planter at various levels. The press wheel runs inside the furrow opened by the shovel.

Experimental procedure:

The experiments were carried out during planting corn seeds, and seed-bed was prepared by using chisel twice followed by disk harrow and the mounted scraper was used after the disk harrowing To smooth and level the field area.

The experiments were run at two forward speeds (**V1**= 2.8 and **V2**= 5.9 km/h) , four press wheel depths (**d1**= 25, **d2** = 35, **d3** = 45 and **d4** = 55 mm.), three press wheel shapes (Convex type **P1** & Flat type **P2** & Triangular edged type **P3**)

- To evaluate the developed opener, a comparative study between conventional planter furrow opener (shoe type) and the developed furrow opener was carried out.

Experimental measurements:

To evaluate the performance of the developed furrow opener, four measurements were calculated as follows:

1- Furrow cross sectional areas (A) and profiles: The furrow cross sectional area was measured directly after each pass using a profile – meter where the following equation was applied according to Abo – Habaga (1990)

$$A = \frac{\Delta L}{2}(a + 2b) \qquad \text{...............(1)}$$

Where:

A = Total cross – sectional area. mm^2

ΔL = Constant horizontal distance. mm

a = Sum. of first and last ordinates.

b = Sum. of all ordinates excluding the first and last ones. mm

The ordinates and furrow cross – section profile were measured and drawed by using the profile-meter shown in Figure (4).

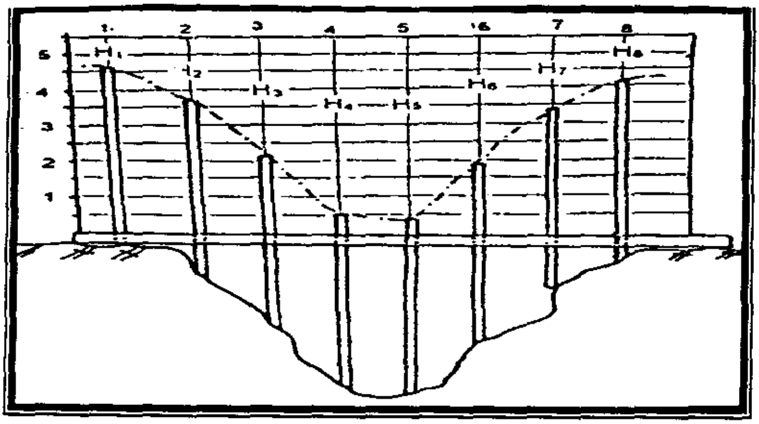


Figure (4): The profile-meter used for determing the furrow cross-section profile and the ordinates length.

2- The height of collapsed soil in the furrow bottom (H): To determine the height of the collapsed soil in the furrow bottom (H), the actual furrow depth after soil slipage (H_2) was measured, where (H_1) is the press wheel depth mm. and (H %) value was estimated by using the equation compatible by Abd-Alla (1999)

H = $H_1 - H_2$ mm ....(2)

H% = $H / H_1 \times 100$.................(3)

Where :

H% = Height of turned soil as a percentage from press wheel depth.

To determine the height of turned soil in the furrow bottom (H) for the traditional opener (shoe type), the opener depth was fixed at 4 cm (H1). The actual furrow depth (H2) was measured and (H) value was estimated using the previous equation.

3- Plants lateral distribution around the row centerline: To determine the cross scattering of seeds around the rows, the distribution for the plants around the row centerline was determined 15 days after planting and first irrigation. The distribution was estimated by relating the number of plants at different lateral distances from the row center to the total number of plants at ten meters along of the row. The frequency distribution curves were employed for expressing this relationship for each experiment.

4- The emergence ratio of plants (G): The emergence ratio of plants was calculated after 15 days from sowing and irrigation, the emergence ratio was estimated according to the following formula (Abd-Alla, 1999),

$$G = \frac{N}{S} \times 100 \qquad \text{....................(4)}$$

Where :

N = Number of plants per ten meters along the sowing row.

S = Number of delivered seeds per ten meters along the row. The value of (S) was calculated during the field calibration of the planter.

RESULTS AND DISCUSSION

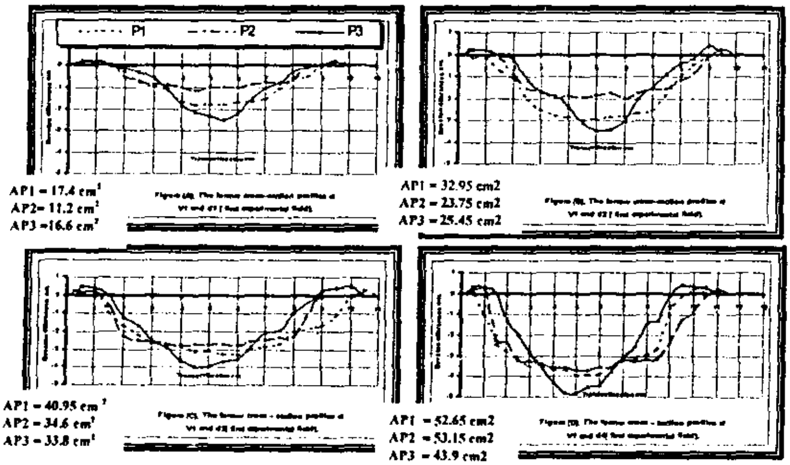
1) Furrow section area and furrow cross-section profile:

The furrow cross sectional area (A) and the profile of the obtained furrow were calculated after the passing of furrow opener and before seed covering. To estimate the furrow cross section shape, all ordinate measurements were replicated ten times and the average values were calculated. The results demonstrated in Figures (5 and 6) show that all furrow openers gave furrow profile correspondent to its press wheel shape, but the traditional furrow opener (shoe type) caused non-organized symetrical profile on the traverse direction of furrow as shown in Figure (7).

On the other hand, the increment in forward speed caused a decrease in furrow depth and increase in furrow width. and increasing press wheel depth encourage regularly the furrow depth, and in general the press wheel (Triangular type) caused the best furrow cross section profile

2) Height of collapsed soil in the furrow bottom:

The height of collapsed soil in the furrow bottom is considered as one of the most important measurements to evaluate the performance of planter furrow opener. Therefor, a comparative study between three types of developed furrow openers and conventional opener (shoe type) were run. The results are illustrated in table (1) show that, The increment of planting speed caused an increase in collapsed soil height (little furrow depth). This trend was expected due to the fact that, the high planting speed causes a high crashing effect to the side walls of the furrow which fall down in the furrow bottom. On the other hand, the press wheel (triangular type P_3) gave the lowest value of collapsed soil in the furrow bottom, while the press wheel (flat type P_2) caused the highest collapsing, which could be explained due to the slope of the side walls.



Where: A = Cross section area cm².
P = Type of press wheel under study.

Figue 5(a,b,c and d) :The furrow cross – section area and profile at (V_1) and four different press wheel depths (d).

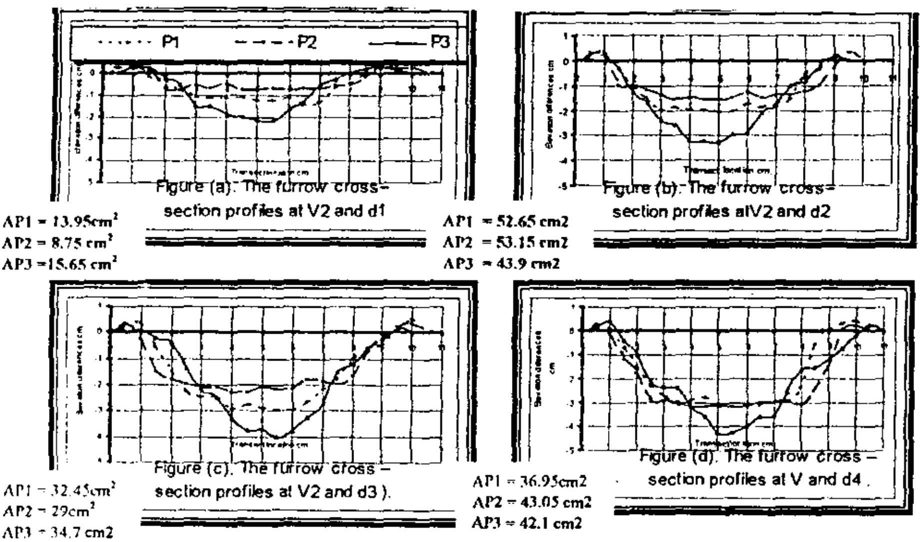
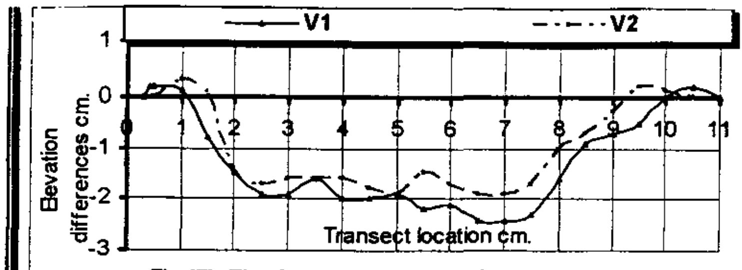


Figure 6: (a,b,c and d).The furrow cross – section area and profile at (V_4) and for different press wheel depths (d).



AV1 = 28.05 cm2
AV2 = 21.5 cm2

Fig (7). The furrow cross section profile for traditional opener

It could be realized that as the walls of furrow are formed vertically, the walls are getting more liable to collapsing. Consequently, one can say that as the slope of furrow walls decreases, the furrow could maintain its depth. The press wheel (triangular type) formed furrow with sides inclined 45° on vertical prevented soil collapsing behind the furrow opener.

3) The lateral scattering of seeds (L.S)

The obtained data show that, increasing the planting speed causes an increse in the lateral scattering of seeds (L.S), this is due to the increase in planter vibration at high forward speed.

Increasing the press wheel depth lead to decrease in seed scattering around the row centerline. Because the increase in the press wheel depth improves the furrow structure and causes more compaction to the furrow bottom and gives a good seedbed.

The type of press wheel recorded the highest factor affecting the lateral scattering of seeds (L.S) around the row centerline. As the press wheel produce furrows of shapes correspondent to their wheel edges. So, the triangular type wheel is considered the best because it forms the deepest furrow with a collecting triangular shape. On the other hands, the furrows produced from the flat type press wheel recorded the highest seeds lateral scattering, while the convex type recorded a moderate seed lateral scattering between the triangular type and flat type. From figure (8-a,b,c,d and9-a,b,c,d), it can be seen that the heighest forward speed under study (V2 = 5.9 km/h) and the lowest press wheel depth (d1 = 25 mm) showed the highest lateral scattering of seeds (L.S).

Table (1): Height of collapsed soil in the furrow bottom

d	V	Type of press wheel (P)						Traditional opener	
		Convex type (P_1)		Flat type (P_2)		Triangular type (P_3) F_1			
		Hcm	H %	Hcm	H %	Hcm	H %	Hcm	H%
d_1	V_1	0.7	28	1.3	52	0	0	1.5	37.5
d_2		0.5	25.7	1.5	42.9	0	0		
d_3		1.2	26.7	1.7	37.8	0.5	11.1		
d_4		1.5	27.3	1.8	32.7	0.7	12.7		
d_1	V_2	0.8	32	1.5	60	0	0	1.8	45
d_2		1.1	31.4	1.5	42.9	0.1	2.9		
d_3		1.3	28.9	1.9	42.2	0	0		
d_4		1.8	32.7	2.1	38.2	0.8	14.5		
d_1	V_3	1	40	1.7	68	0	0	1.8	45
d_2		1.1	31.4	1.8	51.4	0	0		
d_3		1.5	33.3	2.1	46.7	0.3	6.7		
d_4		2	36.4	2.3	41.8	1	18.2		
d_1	V_4	1.2	48	1.7	68	0.1	4	2.1	52.5
d_2		1.4	40	1.9	54.3	0.2	8		
d_3		1.5	33.3	2.2	48.9	0.5	14.3		
d_4		2.3	41.8	2.3	41.8	1.2	21.8		

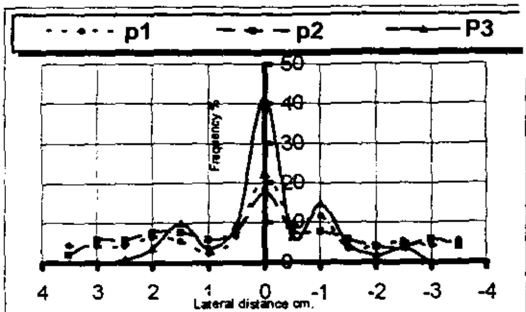


Figure (8-a). Plant distribution around the row center line at V1 and d1.

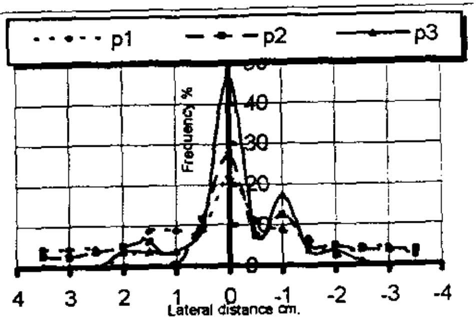


Figure (8-b). Plant distribution around the row center line at V1 and d2.

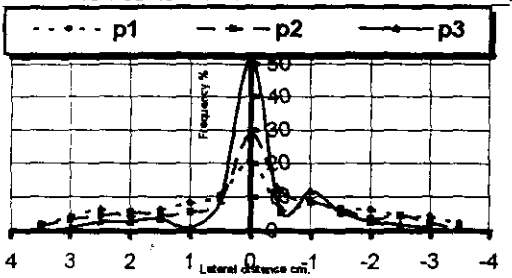


Figure (8-c). Plant distribution around the row center line at V1 and d3.

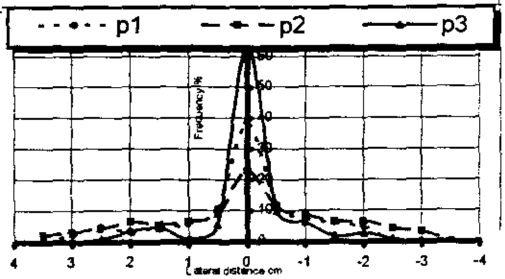


Figure (8-d). Plant distribution around the row center line at V1 and d4.

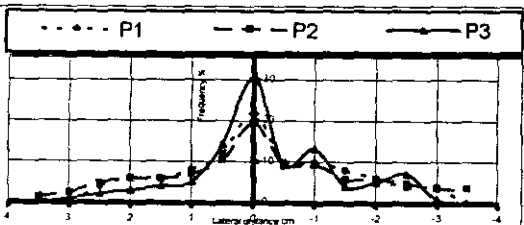


Figure (9-a). Plant distribution around the row center line at V4 and d1.

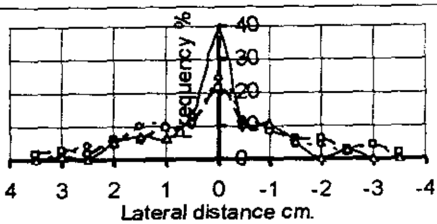


Fig (9-b). Plant distribution around the row center line for V2 and d2

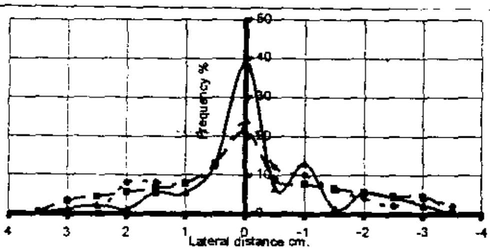


Figure (9-c). Plant distribution around the row center line at V2 and d3.

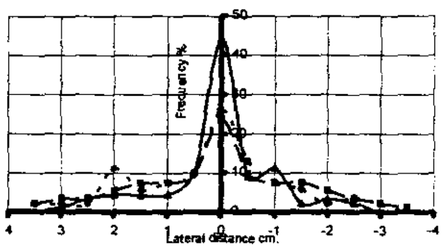


Figure (9-d). Plant distribution around the row center line at V2 and

4) The emergence ratio of plants (G):

Soil collapsing phenomenon behind the furrow opener of planter, causes high variation of sowing depth and has a negative effect on emergence of plants. It can be seen from table (2) that: Increasing the forward speed resulted in decreasing the emergence ratio of plants and more press wheel depth causes more stable furrow structure, and little collapsing to the soil on the furrow bottom, which causes regular sowing depth and higher emergence ratio,the conventional furrow opener (shoe type) showed the lowest emergence ratio.

Table (2). The emergence ratio of plants (G%)

d	V	Type of press wheel (P)			Traditional opener
		Convex type (P_1)	Even type (P_2)	Triangular type (P_3) F_1	Zea-maize
d_1	V_1	95	85.2	97	91
d_2		95.3	86	98.5	
d_3		96.1	86.8	98.5	
d_4		96.8	91	99	
d_1	V_2	95.1	85.9	97	91
d_2		95.1	85.7	97.8	
d_3		97.1	86.2	98.1	
d_4		97.3	89	98.3	
d_1	V_3	94.6	85.6	96.8	90.3
d_2		94.9	85.5	97.7	
d_3		95.1	85.5	97.1	
d_4		95	86.3	98.1	
d_1	V_4	93.9	85	96.5	90
d_2		94	85.1	97,5	
d_3		93.1	85.8	97	
d_4		93	86.1	97.9	

Conclusion

Soil slippage behind the planters furrow opener in the furrow bottom cause the seed depths more dissimilarity which caused unadjusted germination and reduce the germination ratio. To prevent this phenomenon, three planter furrow openers were developed, every one consists of chisel shank provided with share (hoof shovel type) followed by press wheel. Three shapes of press wheels were manufactured, there were (convex, even and triangular edged type). To control the press wheel depth, it provided with mounted system has five perforates to be connecting with planter frame at various depths.

To evaluate the developed furrow openers the field experiments were carried out during planting corn seeds. The field experiments carried out by using two levels of forward speeds (V_1 = 2.8 and V_2 = 5.9 km/h) and four press wheel depths (25, 35, 45 and 55 mm).

To evaluate the influence of developed furrow openers on the furrow property , there were four measurements carried out as follows:-

1-Furrow cross-sectional area (A) and furrow cross-section profile.

2-The height of the collapsed soil in the furrow bottom.

3- Plants lateral scattering around the row-center line.

4- The emergence ratio of plants.

The obtained results can be summarized as follows:

1- Increasing planting speed caused increasing in collapsed soil height, and on the other hand it caused increasing also in lateral scattering of seeds, and decreasing emergence ratio of plants.
2- The press wheel (Triangular type) showed the lowest value of the turned soil in the furrow bottom, while the press wheel (Flat type) caused the heighest turned soil in the furrow bottom. on the other hand, the best (lowest) seeds lateral scattering was recorded during using press wheel (triangular type), and the press wheel (flat type) recorded the highest seeds lateral scattering
3- Increasing the press wheel depth caused a decrease in the collapsed soil height in the furrow bottom, and in the same time, it lead to decreasing in seeds scattering around the row center line.
4- Increasing press wheel depth causes more fixed furrow structure, and little turned soil on the furrow bottom, which causes regular sowing depth and higher emergence ratio of plants.

REFERENCES

Abd-Alla, H. EL. (1999), "Performance evaluation of a developed planter furrow opener". Misr J. Ag. Eng., 16(2): 176 - 192.

Abo Habaga, M. M. (1990), " A comparative study on three chisel – blough share – forma." Misr J. Ag. Eng. , 7(4) : 378 – 383.

Bianer, R.Y. ; R. A. Kepner and L. E. Barger (1955), " Principles of farm machinery. The Ferguson Found, Agr. Eng. Series, John Willy and Inc. N.Y. :209 - 234.

Culpin, C. (1986), "Farm machinery. Crosby Lockwood," London U.K, 11th : 103 - 117.

Erbach, D. C. (1981), "Planting for crop production with conservation.", Proc. A.S.A.E pub, 7 – 81: 50 – 65, A.S.A.E, st. Joseph, MI 49085.

Essam, H. El. (1997), "Development and avaluation of the seed – drill furrow opener under Egyption conditions." Misr J. Ag. Eng. , 14(3): 336 - 352.

Hunt, D. (1977), "Farm power and machinery management." The low state Univ. press U.S.A. : 102 – 112.

Ismail, Z. E. and M. A. Hemeda (1991), "Geometrical studies on soil slippage phenomenon behind the furrow opener of planters." Misr J. Ag. Eng., 8(4) : 361 - 375.

Ozamerzi, A. (1986), "Seed distribution performance of the furrow opener used on drill machines." AMA 17(2) : 32 - 34.

Posnekov, N. M. and M. E. Kan (1968), "Bpotato planting mechines." Machinstroenee pub. Co., Moscow: 32 - 45.

Smith, A. E. (1984), "Farm machinery and equipment." 6 th. ed. Tata McGraw – Hill pub. Co Ltd., New Delhi, 110020.

Stout, B. A. ; WF. Buchel and F. W. Synder (1961), "Effect of soil compaction on seedling emergence under simulated field conditions." Agric. Eng. Feb. 1961 : 68 - 71.

Tessier, S. ; Hyde G. M. ; Papendick R. I. and Saxton K. E. (1991b). " No till seeders effects on seed zone properties and wheat emergence. Trans. of ASAE, 34(3), 733 – 739.

Wurr, D. C. ; Jane E. and R. Fellows (1985), "The influence of sowing depth and seed press wh eel weighting on seeding emergence of crisp lettuce." J. Agric. Sci. , camb. 104: 631 - 636.

دراسة هندسية على تطوير فجاج لآلة الزراعة فى خطوط

ماهر محمد إبراهيم ، هشام ناجى عبد المجيد و طارق حسنى الشبراوى
قسم الهندسة الزراعية – كلية الزراعة – جامعة المنصورة

إهتم هذا البحث بدراسة ومعالجة ظاهرة إنهيار التربة خلف فجاج آلة الزراعة فى جور – حيث تؤدى هذه الظاهرة إلى عدم إنتظام عمق الزراعة مما يؤثر بجدية على نسبة إنبات البذور وبالتالى على المحصول النهائى.
للسبب السابق ذكره تم تصنيع فجاج مطور يقوم بعمل أخدود منتظم الشكل مع علاج ظاهرة إنهيار التربة خلف هذا الفجاج – وقد تم التصنيع بورش كلية الزراعة جامعة المنصورة – وقد تم إختباره فى مركز بحوث الميكنة الزراعية بالجميزة – محافظة الغربية . والفجاج الجديد عبارة عن عجلة ضغط (وقد تم إختبار ثلاث أشكال مختلفة من عجلات الضغط) ونظام للتحكم فى عمق العجلة وقصبة مزودة بسلاح عريض.

- لتقييم أداء الفجاج الجديد تم إجراء التجارب الحقلية والتى شملت دراسة المعاملات التالية:

١- دراسة تأثير ثلاثة أشكال مختلفة الحافة من عجل الضغط (المحدب و المثلثى الحافة و المستوى)
٢- دراسة تأثير السرعة الأمامية لآلة الزراعة على شكل الأخدود الناتج ، ولهذا الغرض تم دراسة تأثير سرعتى تقدم للآلة وهى (٢,٨ ، ٥,٩ كم/س).
٣- دراسة تأثير عمق عجلة الضغط على شكل الأخدود الناتج وعلى ظاهرة إنهيالا التربة فيه، وقد تم دراسة أربعة أعماق من عجلة الضغط وهى: (٢٥ ، ٣٥ ، ٤٥ ، ٥٥ مم).

وقد تم إختبار الفجاج الجديد بتركيبه على آلة زراعة من النوع جاما ٩٠ إيطالية الصنع– أربع وحدات زراعة تستخدم سحب الهواء فى تلقيم البذور، وقد تم مقارنة الفجاج المطور مع الفجاج التقليدى للآلة وهو من النوع الحذائى

• وقد أخذت أربع قياسات هامة للحكم على أداء الفجاج محل الدراسة ،حيث يمكن إجمال هذه القياسات فيما يلى:

١- تعيين قطاع الفج بإستخدام جهاز قياس القطاع (profile meter) المصنع يدويا – وأيضا تم حساب مساحة المقطع الناشىء.
٢- تقدير إرتفاع التربة المنهارة (المرتدة) فى الفج وتم حسابها كنسبة مئوية من العمق الكلى للفج (H%).
٣- قياس التشتت العرضى للبذور حول مركز خط الزراعة (L.s).
٤- قياس نسبة النباتات(البادرات) النامية (G).

•وقد أظهرت النتائج المتحصل عليها على أن إستخدام الفجاج المطور المحتوى على عجلة الضغط المثلثة الحافة عند سرعة تقدم منخفضة (٢,٨ كم/س) وعند عمق للعجلة مقداره(٥,٥ سم) يحقق أفضل إنتظامية لشكل الفج وأعلى نسبة إنبات.