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EFFECT OF TURNING PLOWS ON SOME SOIL PARAMETERS

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Abstract

Experiments were carried out at the research farm of the Rice Mechanization Center, Meet El-Dyba, Kafr El-Sheikh Governorate during the summer season of 1996/97. The present study showed the effect of three turning plows on the plowing and inversion degrees of soil and indicated the effect of K-ratio (share width/plowing depth) on inversion degree at four levels of soil moisture contents, plowing speeds and plowing depths under local prevailing conditions.

The results showed that the maximum degrees of soil plowing were 28.30, 24.73 and 30.2% for disc, modified moldboard and moldboard plows, respectively, at plowing depths of 25.31, 18.28 and 26.46cm and plowing speed of 5.37 km/h. The maximum values of soil inversion degrees were found to be 40.63, 43.75 and 68.75% for these plows, respectively, at plowing speed of 2.18km/h, plowing depth of 27.43, 19.81 and 28.32 cm, respectively and soil moisture content of 19.98%. Whilst the minimum values of 30.2, 28.9 and 45.2% were obtained with the same plows at plowing depth of 8.1, 8.4 and 7.5cm, respectively, and soil moisture content of 16.81% and plowing speed of 5.37km/h.

The k-ratios of 1.13, 1.21 and 1.42 gave the maximum inversion degrees with plowing depths of 27.31, 19.81 and 28.32cm, respectively, at plowing speed of 2.18 km/h and soil moisture content of 19.98% .

INTRODUCTION

Plowing is considered the major operation in seedbed preparation. The moldboard plow is considered to be one of the most important tillage tools used for primary tillage in seedbed preparation (Kepner *et al.*, 1982). It lessens and pulverizes the soil efficiently to the tilled depth and has the unique ability to completely invert the soil, burying surface residues, killing surface growth and bringing up a new layer of a better aggregated structure (Richey, 1969). Also the moldboard plow does not harm arthropod fauna which conserves the soil fertility (Helmy, *et al.*, 1994). Disc plow is now used increasingly for multi-purpose uses. A knowledge of

tilt angle and soil moisture content is essential for deciding the depth of penetration as the former parameters greatly influence the later (Panigrahi *et al.*, 1990). Plowing requires more traction energy than any other single crop production operation. It is most important to utilize this energy efficiently by selecting and using only the most suitable type of plow to existing conditions (Korayem and Hindey, 1974).

Helmy (1980), El-Banna *et al.* (1987) and Helmy *et al.* (1994) stated that the relative increase in soil volume after plowing may be expressed numerically as the increase in soil surface above the original soil surface after plowing divided by plowing depth plus the increase in soil surface above the original after plowing. They reported that the relative plowing degree ranged from 16.7 to 23.1%.

Bukhari *et al.* (1981) reported that the degrees of inversion were 51.4, 51.0, 51.7 and 51.6% for the mouldboard plow, mouldboard plow plus packer, mouldboard plow plus subsurface packer and mouldboard plow plus spring-tooth harrow respectively. The field speed ranged from 4.06 to 8.65 km/h and working depth ranged from 22.0 to 25.5 cm.

Hanna *et al.* (1993) reported that the soil mass movement towards the center of the ridge (soil shift and ridge height) increased as the speed increased from 5 to 7 km/h., while the change in surface height decreased. When speed was increased from 7 to 9 km/h., the soil mass movement did not change significantly, however, soil bulk density decreased as indicated by increased change in surface height.

Imara (1996) indicated that by increasing the implement forward speed the degree of soil inversion tends to decrease, while increasing the plowing depth the degree of soil inversion tends to increase. The maximum degree of soil inversion was 44.44% at an implement forward speed of 2.57 km/h, soil moisture content of 20.24% and plowing depth of 19 cm.

The main objective of the present work is to study the effect of three turning plows on some operational parameters (the degree of soil plowing and k-ratio) and the degree of soil inversion at four levels of soil moisture content, plowing depth and plowing speed under local prevailing conditions .

MATERIALS AND METHODS

The field experiments were carried out in the research farm of the Rice Mechanization Center at Meet El-Dyba, Kafr El-Sheikh Governorate.

A three bottom moldboard plow (general purpose moldboard) with cutting width of about 120cm. (b = 40 cm) and height of bottom is 80cm was used to be compared with a five bottoms of modified moldboard plow (area of modified moldboard = 1/3 general purpose moldboard) with cutting width of about 120 cm. (b = 24 cm), height of bottom is 90 cm, and a three bottom disc plow with cutting width of about 92 cm. (b = 31 cm), disc diameter is 61 cm, disc angle 45°, and tilt angle 22°. These plows were drawn using a two WD, Diesel engine tractor (Model Ford 6610), 75 hp (55.97 kw), 4 cylinders and water cooled. The experimental plowing speeds were 2.18, 3.26, 4.43 and 5.37 km/h.

The soil mechanical analysis and organic matter are presented in Table 1.

Table 1: Soil mechanical analysis.

Sand, %	Silt, %	Clay, %	Organic matter, %	Soil textural class
29.12	17.45	53.43	1.82	Clay

The experiments were carried out at four levels of soil moisture content of 16.81, 19.98, 23.54 and 26.43% on dry basis. Profile-meter was used for measuring plowing depth as shown in Figure 1.

Degree of soil plowing:

Degree of soil plowing being the percentage of soil increase in soil height h, divided by plowing depth a, was calculated by using the following equations:

$$Pd = (h/a)\ 100 \quad \ldots\ldots (1)$$

Where Pd = degree of soil plowing, %,

h = average increase in height above soil surface after plowing, cm and

a = plowing depth, cm.

The net-work of wooden blocks:

Three rows of marked small wooden blocks (1x1x1cm) were placed in a vertical plant perpendicular to the direction of plow travel to form a network of blocks according to the procedure mentioned by Korayem and Hindey, (1974) and Helmy, (1995).

The three-dimensional frame meter:

Figure 2 shows the designed frame-meter parts. It meansures of the wooden

blocks in the plowed soil in three dimensions (X,Y and Z). It consists of a wooden farme which is supported on four pins of iron and rests on the unplowed soil. So, both X and Y directions are divided into millimeters and centimeters. The vertical distance (Z) was measured by using a plumb line connected with a movable scale (vertically up and down) from the beginning of surface of the movable scale till the measured block position.

The degree of soil inversion:

The top and bottom rows of blocks should exchange positions. In an attempt to evaluate this quality, the cross-section of the turned slice was divided into three layers of equal thickness on top of each other. The layer thickness was equal to one third of the maximum profile height. A block belonging originally to the top row when moved to the bottom layer was given 2 points and when moved downwords to the middle layer was given only the point. The same was done for blocks of the bottom row considering their upward movement. In this manner, for an ideal inversion (the soil slice rotates a half rotation around x-direction) a score of 32 points must be obtained (each of bottom and top rows had 8 blocks).

The K-ratio:

$$K = b/a \quad \ldots\ldots (2)$$

Where :

K = furrow width to plowing depth ratio, dimensionless;

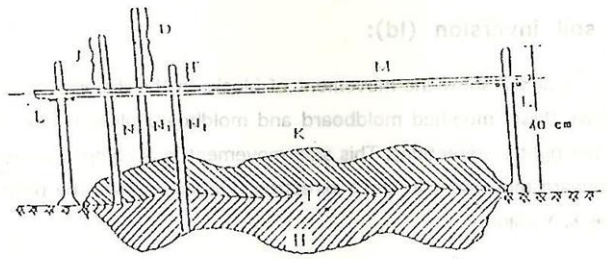
a = plowing depth, cm

b = furrow bottom or share cut width, cm.

RESULTS AND DISCUSSION

Degree of soil plowing (Pd):

Figures 3 and 4 show the effect of three turning plows, plowing speed (Sp), soil moisture content (Mc) and plowing depths (a) on the degree of soil plowing (Pd). It may be seen that plowing degree increased by increasing plowing speed (Sp) and plowing depth (a). Plowing degree at soil moisture content (Mc) of 19.98% (d.b) was higher than that at soil moisture content of 16.81, 23.54 and 26.43% for all treatments and turning plows. The maximum of plowing degree (Pd) was 28.30, 24.73 and 30.20% respectively at plowing speed (Sp) of 5.37 Km/h, soil moisture content (Mc) of 19.98% and plowing depth of 25.31, 18.28 and 26.46 cm. The minimum val-



I= Soil surface before plowing; II= Furrow bottom;
K= Soil surface after plowing; L= Profile-meter stands;
M=Horizontal bar; N, N_1, N_2 = Height mensuring bars;
J-F= Plowing depth, cm; D-J= Increasing soil surface after plowing, cm.

Fig. 1: Soil profile-meter.

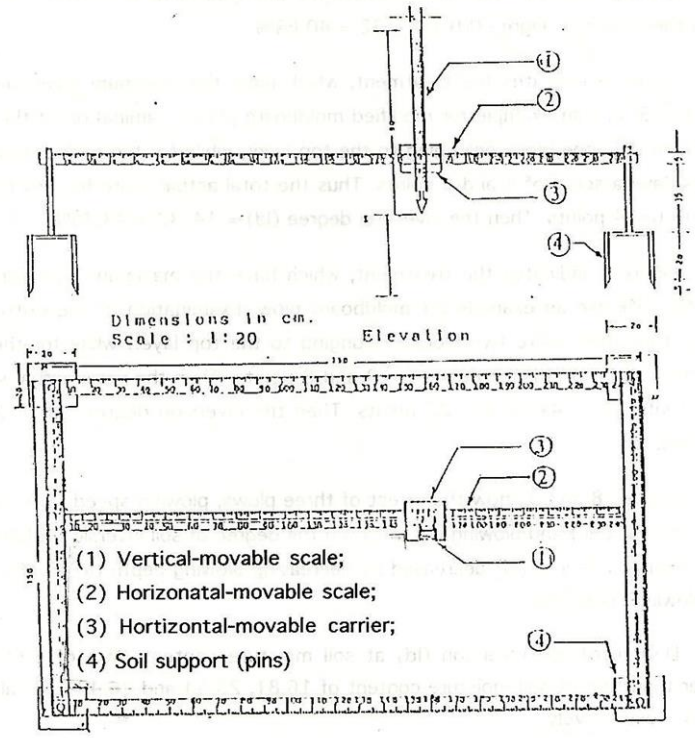


Fig. 2: Three dimensional frame-meter.

ue was 23.40, 21.71 and 23.95% at plowing depth of 9.0, 9.3 and 6.8 cm, respectively, soil moisture content (Mc) of 16.81% and plowing speed (Sp) of 2.18 Km/h.

Degree of soil inversion (Id):

Figures 5, 6 and 7 show the movement of blocks in the dimensions X, Y and Z for turning plows (Disc, modified moldboard and moldboard plows). The soil slices are turned to the right (X direction). This side movement is accompanied by a nearly proportional forward movement in the Y direction. The line shows the proportionality drawn in the X, Y plane.

Figure 5 indicates the treatment, which have the maximum inversion degree (Id) 40.63% as a typical example for disc plow. Examination of the bottom layer shows that there was three blocks belonging to the bottom layer and one block belonging to the the top layer, while for the middle and the top layers have a score of 7 and points. Thus the total actual score for this treatment is 2+7+4 = 13 points. Then the inversion degree (Id) = 13/32 = 40.63%.

Figure 6 indicates the treatment, which have the maximum inversion degree (Id) 43.75% as an example for modified moldboard plow. Examination of the bottom layer and only one block belonging to the top layer, while for the middle and the top layers have a score of 6 and 6 points. Thus the total actual score for this treatment is 2+6+6=14 points. Then the inversion degree (Id) = 14/32 = 43.75%.

Figure 7 indicates the treatment, which have the maximum inversion degree (Id) 68.75% ase an example for moldboard plow. Examination of the bottom layer shows that there were two blocks belonging to the top layer, while for the middle and the top layers have a score of 10 and 8 points. Thus the total actual score for this treatment is 4+10+8 = 22 points. Then the inversion degree (Id) = 22/32 = 68.75%.

Figures 8 and 9 show the effect of three plows, plowing speed (Sp), soil moisture content (Mc) and plowing depth (a) on the degree of soil inversion (Id). It is seen that inversion degree (Id) decreased by decreasing plowing depth (a) and by increasing plowing speed (Sp).

Degree of soil inversion (Id) at soil moisture content (Mc) of 19.98% was higher than that at soil moisture content of 16.81, 23.54 and 26.43% for all turning plows, respectively.

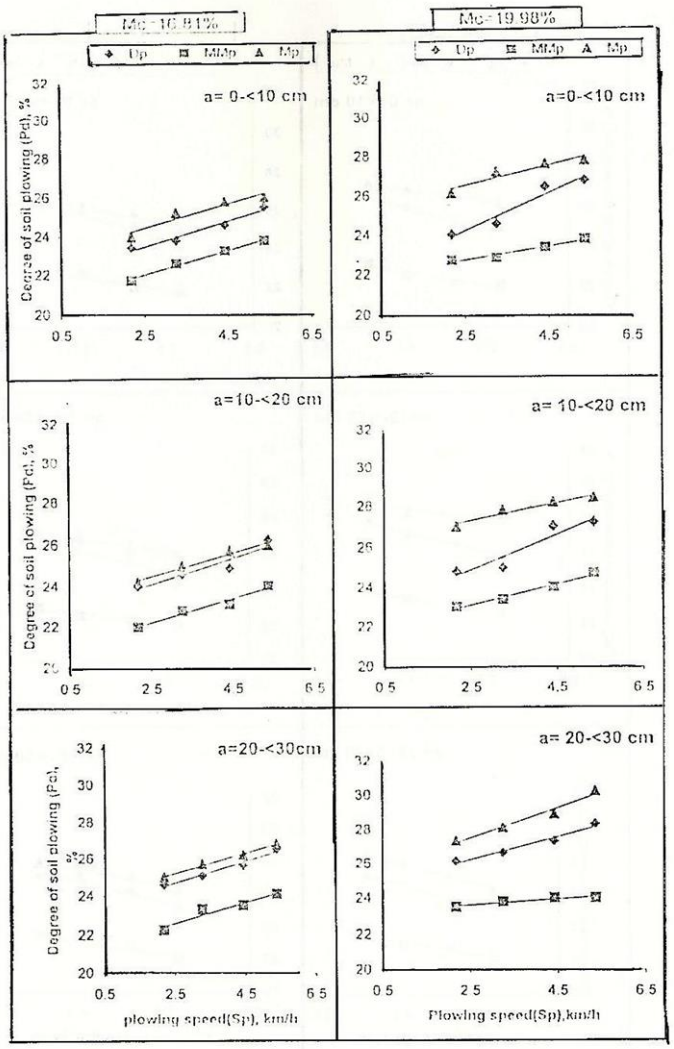


Fig.3 : Effect of plowing speed (Sp), plowing depth (a) three turning plows on degree of soil plowing at soil moisture contents (Mc) of 16.81 and 19.98%.

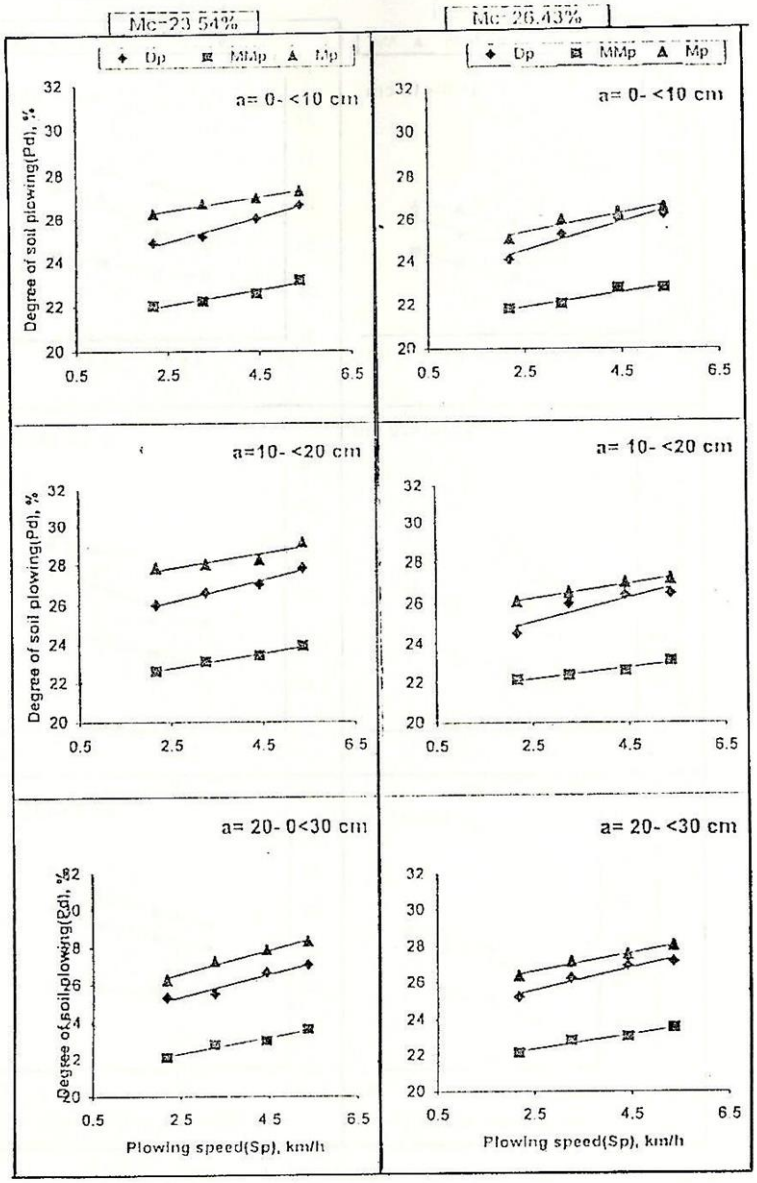


Fig.4 : Effect of plowing speed (Sp), plowing depth (a) three turning plows on degree of soil plowing at soil moisture contents (Mc) of 23.54 and 26.43%.

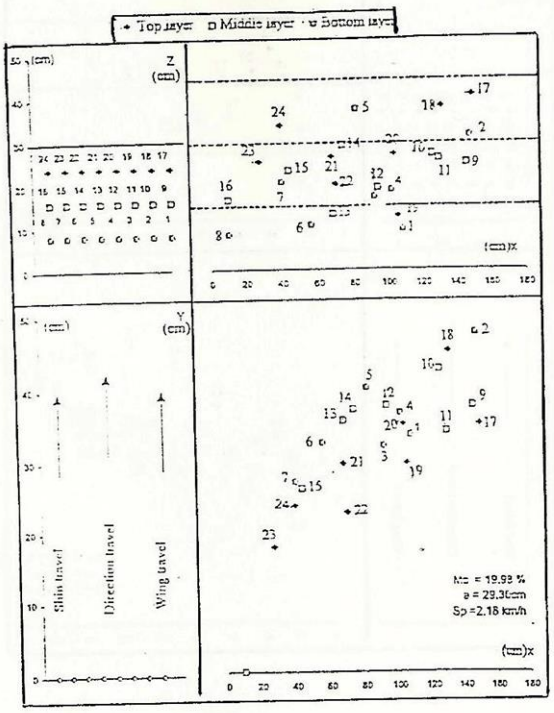


Fig. 5. Position of marked blocks before and after tillage operation by using disc plow.

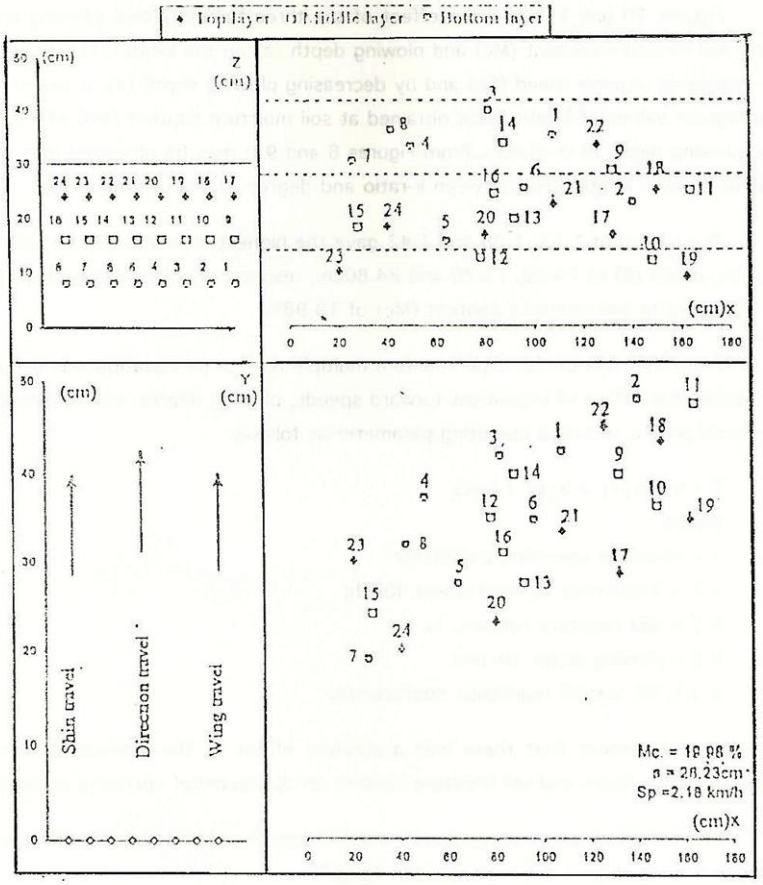


Fig. 7. Position of marked blocks before and after tillage operation by using the conventional moldboard plow.

4.3. K-Ratio:

Figures 10 and 11 show the effect of the three turning plows, plowing speed (Sp), soil moisture content (Mc) and plowing depth (a) on the k-ratio. This increased by increasing plowing speed (Sp) and by decreasing plowing depth (a). It seams that the highest values of k-ratio were obtained at soil moisture content (Mc) of 16.81% and plowing depth of 0-<10cm. From Figures 8 and 9 it may be observed that there was an inverse relationship between k-ratio and degree of soil inversion (Id).

The k-ratio of 1.13, 1.28 and 1.42 gave the highest inversion degree (Id) with plowing depth (a) of 24.20, 16.70 and 24.80cm, respectively, at plowing speed (Sp) of 2.18, km/hr soil moisture content (Mc) of 19.98%.

From the data of the experiments a multiple regression equation was deduced to explain the effect of implement forward speeds, plowing depths and soil moisture contents on the technical operating parameter as follows:

$$Y = b + b_1x_1 + b_2x_2 + b_3x_3$$

Where :

Y = technical operating parameter

X 1 = implement forward speed, Km/h;

X 2 = siol moisture content, %.

X 3 = plowing depth, cm and

b, b1, b2 and b3 regression coefficients.

It was evident that there was a positive effect of the implement forward speed, plowing depth and soil moisture content on the technical operating parameter.

The technical operating parameter coefficients (b, b1, b2 and b3) and the determination coefficient (R^2) are listed in Table 2.

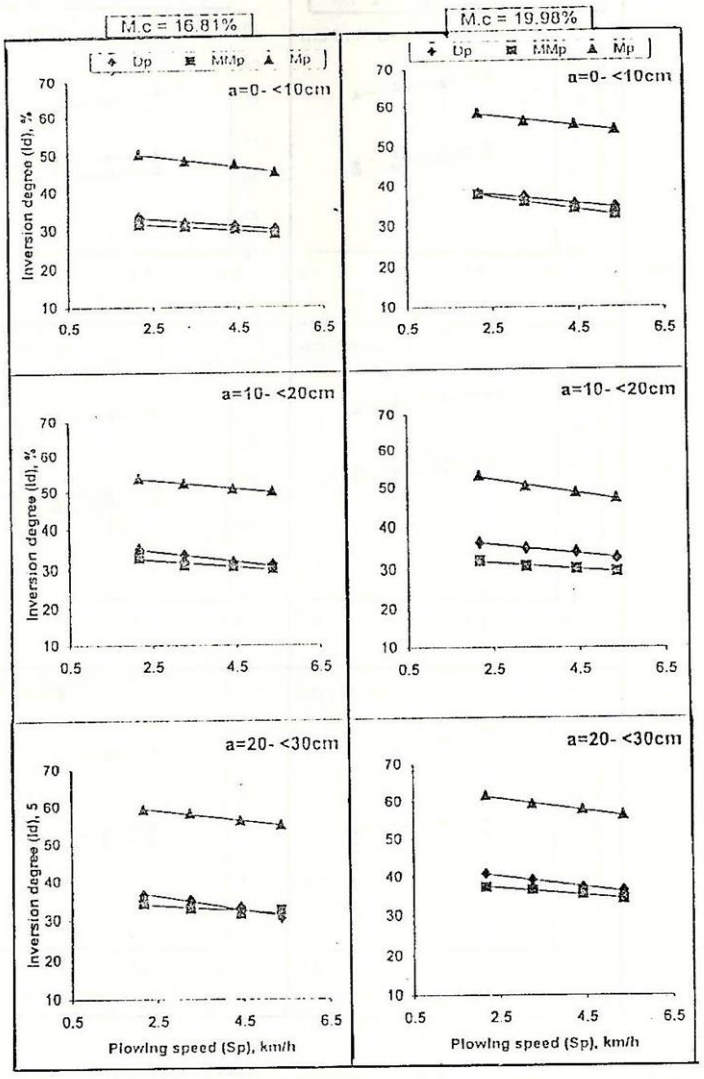


Fig. 8. Effect of plowing speed (Sp), plowing depth (a), three turning plows on inversion degree at soil moisture contents (Mc) of 16.81 and 19.98%.

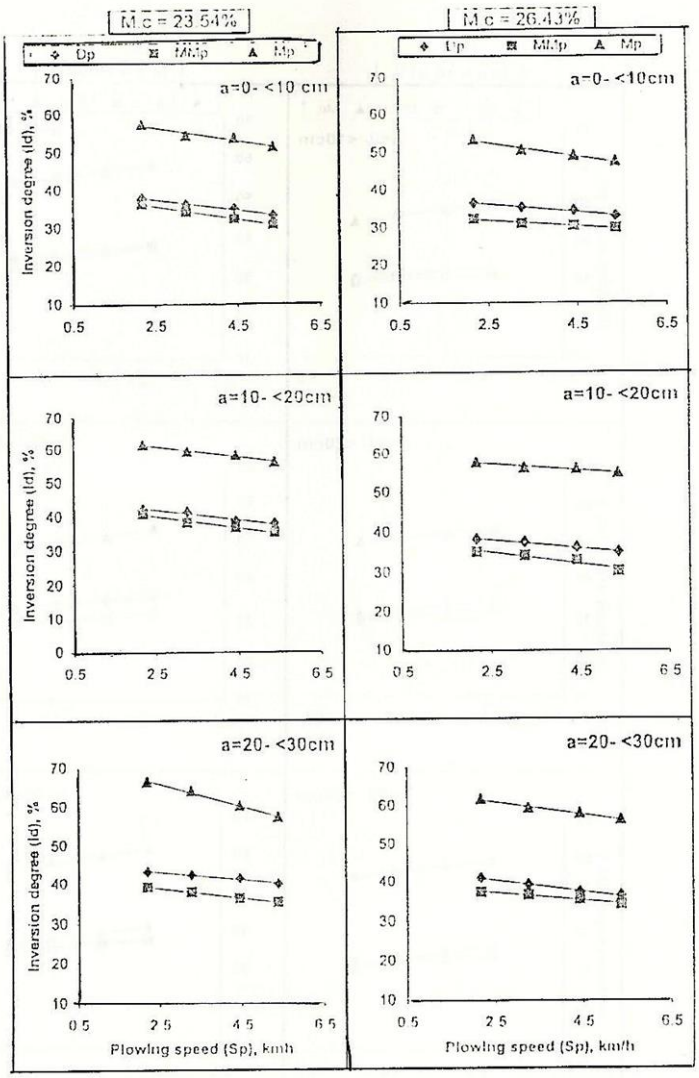


Fig. 9. Effect of plowing speed (Sp), plowing depth (a), three turning plows on inversion degree at soil moisture contents (Mc) of 23.54 and 26.43%.

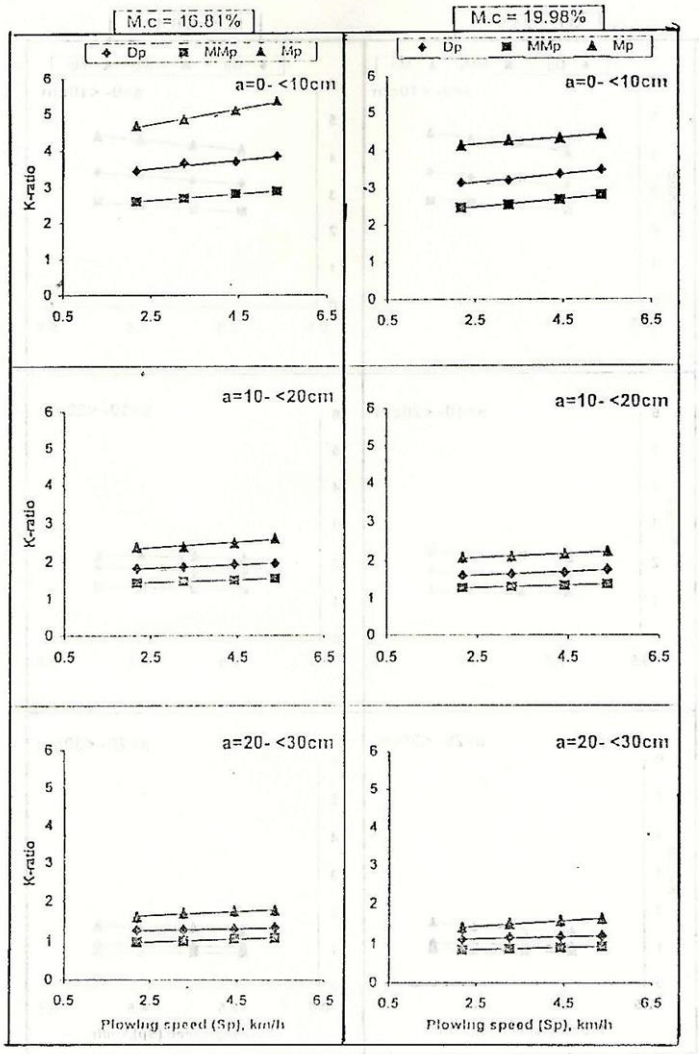


Fig. 10. Effect of plowing depths (a), three turning plows on K-ratio at soil moisture contents (Mc) of 16.81 and 19.98%.

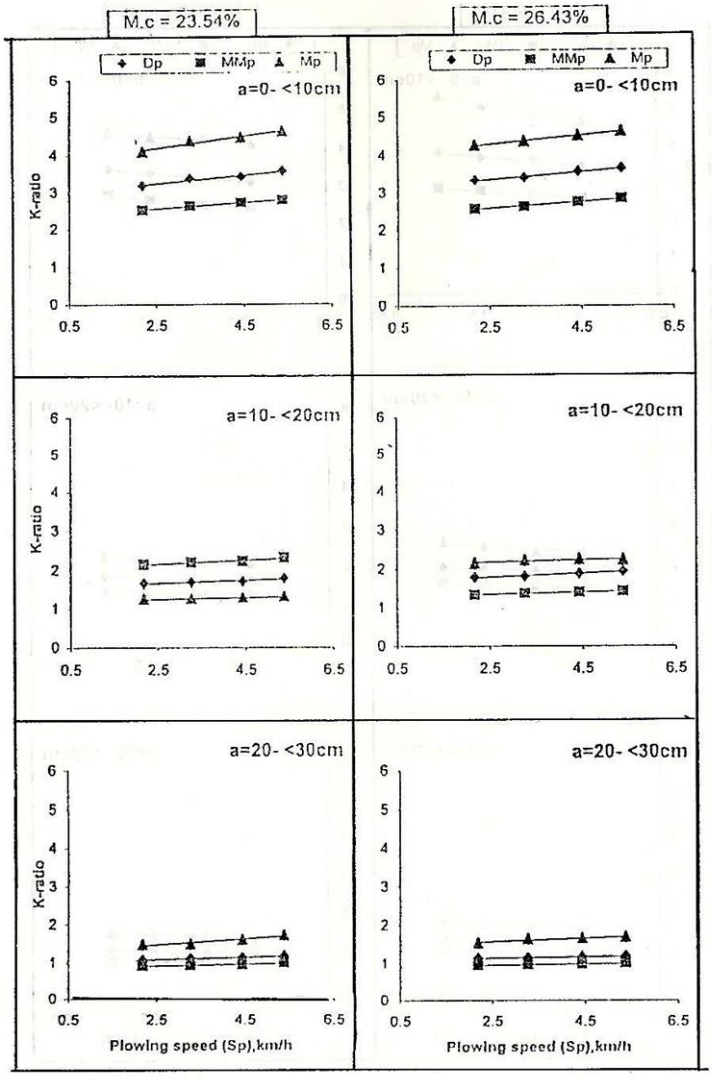


Fig. 11. Effect of plowing speeds (Sp), plowing depth (a), three turning plows on K-ratio at soil moisture contents (Mc) of 23.54 and 26.43%.

Table 2. Effect of implement forward speed, soil moisture content, plowing depth and turning plow types on regression coefficients b, b_1, b_2, and b_3 and the determination coefficients (R2) .

technical parameter	turning plow types	regression coefficients				R^2
		b	b_1	b_2	b_3	
Inversion	Dp	37.592	0.10	1.00	-0.30	50.00
dagree	MMp	39.079	0.20	0.40	-0.40	38.00
Plowing	Mp	57.328	0.40	1.00	-1.00	62.00
degree	Dp	18.620	0.10	0.30	0.20	79.00
K-ratio	MMp	18.153	0.050	0.01	0.20	46.00
	Mp	20.755	0.10	0.30	0.20	49.00
	Dp	4.396	-0.10	0.10	0.01	92.00
	MMp	3.096	-0.10	-0.02	0.02	90.00
	Mp	4.959	-0.10	-0.20	0.10	66.00

Dp = Disc plow MMp = Modified Moldboard plow Mp = Moldboard plow

CONCLUSIONS

The conclusions can be summarized as follows:

1. Degree of soil plowing increased by increasing plowing speed and plowing depth.
2. The maximum plowing degrees of 28.30, 24.73 and 30.20% were obtained at the plowing speed of 5.37 km/h, plowing depths of 27.31, 18.28 and 26.46 cm and soil moisture content of 19.98% for disc, modified mouldboarrd and mouldboard plows respectively.
3. The maximum degreess of soil inversion of 40.63,43.75 and 68.75% at plowing speed of 2.18 km/h. and plowing depths of 27.43, 19.81 and 28.32 cm and soil moisture content of 19.98% for the plows, respectively. The minimum values were 30.2,28.9 and 45.2% at plowing speed of 5.37 km/h, plowing depth level of 0-< 10 cm and soil moisture content of 16.81%, respectively.
4. K-ratio increased by increased plowing speed and decreased plowing depth.
5. In general, the inversion degree was found to be maximum at a soil moisture content of 19.98%.
6. The k-ratio of 1.13, 1.12 and 1.42 gave the highest inversion degrees with plow-

ing depths of 27.31, 19.81 and 28.32cm, respectively, at plowing speed of 2.18 km/h and soil moisture content of 19.98% for the plows under study.

Applied recommendations:

In clayey soil, the implement forward speed of 2.18 km/h could be used in case of much vegetative residuals or weeds on soil since this speed gave the highest inversion degree (40.63, 43.75 and 68.75% at plowing depths of 27.43, 19.81 and 28.32cm and soil moisture content of 19.98% for the plows, respectively.

In saline soil, the implement forward speed of 5.37km/h may be used to obtain the lowest inversion degree 30.2, 28.9 and 45.2% at soil moisture content of 19.98% and plowing depth level of 0-<10cm for the plows, respectively.

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تأثير المحاريث القلابه للتربه على بعض العوامل التشغيلية

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أجرى هذا البحث لدراسة تأثير أداء المحاريث القلابة (قلاب قرصى، قلاب مطرحى معدل، قلاب مطرحى تقليدى) على بعض العوامل التشغيلية ودرجة القلب وتم إجراء التجارب الحقلية بمساحة حوالى ٢ فدان بمزرعة مركز ميكنة الأرز بميت الديبه – كفر الشيخ.

وتم دراسة تأثير كل من السرعة الأمامية والمحتوى الرطوبى للتربه وعمق الحرث على أداء هذه المحاريث وكانت النتائج المتحصل عليها كما يلى:

- أقصى قيم لدرجات الحرث ٢٨,٣٠ ، ٢٤,٧٣ ، ٣٠,٢٠ ٪ للمحراث القلاب القرصى والقلاب المطرحى المعدل والقلاب المطرحى التقليدى على الترتيب عند أعماق حرث ٢٥,٣١ ، ١٨,٢٨ ، ٢٦,٤٦ سم وسرعة اماميه ٥,٣٧ كم/ساعة، ومحتوى رطوبى ١٩,٩٨٪.
- أقصى درجات قلب التربة كانت ٤٠,٦٣ ، ٤٣,٧٥ ، ٦٨,٧٥ ٪ عند سرعة امامية ٢,١٨ كم/ ساعة ، وعمق حرث ٢٧,٤٣ ، ١٩,٨١ ، ٢٨,٣٢ سم ، ومحتوى رطوبى ١٩,٩٨ ٪ للمحاريث الثلاثة على الترتيب. بينما كانت أقل القيم ٣٠,٢ ، ٢٨,٩ ، ٤٥,٢٪ عند عمق حراثة من صفر الى اقل من ١٠ سم ومحتوى رطوبى ١٦,٨١٪ ، وسرعة امامية ٥,٣٧ كم / ساعة.
- قيم K-ratio (عرض السلاح / عمق الحرث) تقل بزيادة عمق الحرث وتزيد بزيادة السرعة.
- أكبر درجات وسرعة أمامية ٢,١٨ كم/ساعة، عمق حرث ٢٧,٤٣ ، ١٩,٨١ ، ٢٨,٣٢ سم، ومحتوى رطوبى ١٩,٩٨٪.

التوصيات التطبيقية:-

- فى الأراضى الطينية : يفضل استخدام السرعة ٢,١٨ كم/ساعة عند وجود بقايا محاصيل وحشائش ويراد دفنها فى التربة حيث أنها تعطى أكبر درجة قلب (٤٠,٦٣ ، ٤٣,٧٥ ، ٦٨,٧٥ ٪) عند عمق حرث من ٢٠ – ٣٠ سم ومحتوى رطوبى ١٩,٩٨ ٪ لجميع المحاريث على الترتيب.
- فى الأراضى الملحية : يفضل استخدام السرعة ٥,٣٧ كم/ساعة حيث أنها تعطى اقل درجة قلب (٣٠,٢ ، ٢٨,٩ ، ٤٥,٢ ٪) عند عمق حرث من صفر – ١٠ سم ومحتوى رطوبى ١٦,٨١٪ لجميع المحاريث على الترتيب.