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Field study of a modified chisel plow performance:

(A): the draft force requirement and the soil pulverization ability

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Abstract

A conventional chisel plow was modified by adding two rotors behind the chisels blades. The rotors were provided with harrowing blades to pulverize the soil clods created by plowing operation of the chisel blades. Both rotors rotate when the modified plow in operation. The rotors were fixed behind each other and their depth can be changed relative to the plowing depth.

The experiments were conducted on the modified and the conventional chisel plows to determine the advantages gained by the modification carried out on the plow using different operating depths, 15, 20 and 25cm and forward speeds 0.35, 0.5, 0.88 and 1.1m/sec.

The results showed that the draft force increased for the modified and conventional plows as the operating depth and forward speed. However the modified plow surpassed marginally the conventional plow in draft force requirement by only 1.5 to 2.5kN for one and rotors respectively. This small increase in the draft force of the modified chisel plow accomplished by great increase in soil pulverization expressed by Mean Weight Diameter (MWD), which decreased from 65cm for the conventional plow to 40 and 27cm when it was provided with one and tow rotors respectively.

The forward speed increased the draft force of the modified and conventional plows; however the draft force of the modified chisel plow was higher by 0.8 to 1.5kN and 1.4 to 1.17kN for the lower forward speed (0.3m/sec) and higher forward speed (1.1m/sec) respectively. The soil pulverization (MWD) of the modified chisel plow improved clearly, MWD decreased from 73 to 55 and 42cm and from 65 to 42 and 20cm for one and two rotors for forward speeds of 0.3 and 1.1m/sec respectively.

Keywords: Modified chisel plow, Conventional chisel plow, draft force, Mean Weight Diameter

1.0 Introduction

The chisel plow is widely used to cultivate the soil. But it has many drawbacks render the plow less popular than the other plows such as moldboard and disc plows [6]. Among those drawbacks are it leaves the soil surface rough and the soil pulverization is limited which is in possible sewing the seeds directly with out harrowing the soil. The soil harrowing can cause soil compaction and some time retains the soil bulk density to its value before the plowing operation when the soil clods requires more passes on the soil surface by the implement to break them up. The other drawbacks are the limited ability in mixing the plant residual with soil and it leaves the plants remains on the soil surface. To overcome or at least to reduce these drawbacks of the conventional chisel plow it was modified. The modification includes changing the forward angle of the chisel plow leg to reduce the draft force and providing the foot of the chisel plow by 8cm wide wings to increase the volume of the soil manipulated by each shank. Two rotors were added to the plow. Each rotor was provided with 10 groups of pulverizing blades. Each group contains three blades which fixed at

alternative position to neighboring groups and at alternative position with groups at the rear rotor. The depth of the two rotors can be changed relative to each other. The front rotor fixed at 35cm distance from the chisels plows while the rear rotor was fixed behind the front rotor by 40cm.

The conventional chisel plow draft force depends on the soil strength; it increases as the soil strength increases. It also depends on the soil type and the moisture content of the soil; it is higher in the heavy soil, solid and plastic soils than in the light and friable soils [1]. The chisel plow required higher draft force than moldboard plow [3,5] and it required draft force between 15 to 35kN in the heavy soils [3,7,8].

The draft force of the chisel plow increased as the operating depth increased, Davies at el [6] found that the draft force increased from 15kN to 30kN when the operating depth increased from 20 to 25cm, the same result was found by [7, 8], the draft force increased by 50% when the plowing depth increased from 15 to 25cm. Riethmiller [9] found that the draft force of the chisel plow increased linearly with operating depth. The increase in the draft force with operating depth was related to the increase in the volume of the soil manipulated by the plow and the moisture content [2].

The chisel plow draft force is considerably affected by the forward speed, it increased by 100% when the forward speed was increased from 0.2 to 0.9m/sec [10]. The same percentage of increase was found when the forward speed increased from 0.2 to 2.5m/sec [5] and it increased from 17.5 to 20.4kN when the forward speed increased from 0.26 to 0.67m/sec [3].

The modified chisel plow and the conventional plow were tested in heavy soil to evaluate the field performance of the modified plow compared with

that of the conventional using the draft force and the Mean Weight Diameter (MWD) parameters for comparison. The modified plow was used with one rotor and two rotors. The two types of plows were tested at three operating depth (15, 20 and 25cm) and four forward speeds (0.3, 0.5, 0.88, 1.1m/sec).

2.0 Materials and methods

2.1 The modified chisel plow

The modified chisel plow was developed and manufactured in mechanization department, Agriculture College, Basra University (Fig.1a). The modified chisel plow consists of a frame 189cm long and 196cm wide. The frame is made of angled iron bars of 10x10cm with thickness of 0.5cm. Five tines were fixed on the frame in two rows. The tines on the two rows were fixed alternatively to disturb the soil cross the width of the plow. The lateral distance between the tines on each row was 80cm while between them on both rows was 40cm. The forward angle of the tine leg was 60^{o}. The tines were provided with winged foots. The width of the wings was 10cm. The attack angle of the front of the foot was 30^{o}. The modified chisel plow was provided with two rotors. Each rotor consists of a cylinder both ends were provided with a shaft to be fitted in a bearing to let the cylinder rotates freely during the plowing operation. Ten groups of blades were fixed on the cylinder. Each group consists three blades. The blades of the neighboring groups were fixed at alternative positions to ensure there are some blades working in the soil all the time when the plow is working the soil. The groups of the blades on both rotors are also fixed alternatively to ensure pulverizing all the soil across the plow width. The lateral distance between the groups on the same rotor was 18cm. The blade

length, width and thickness were 10, 7 and 0.8cm respectively. The distance between the two rotors was 54cm.

2.2 The conventional chisel plow

The conventional plow used to conduct the field experiments was the chisel part of the modified chisel plow after dismantles both rotors and leaving the five shanks. Using another chisel plow would cause difficult comparison between the results of the modified plow and the conventional plow. The working width of the plow was 1.96m.

2.3 Soil properties

The soil properties such as the soil texture, moisture content, penetration resistance, cohesion and angle of internal friction were measured. The soil texture was measured by the pipette method. The moisture content was measured across the field of the experiments for depths of 0-10, 10-20, 20-30cm using the core sample method and the measurements were repeated three times for each depth. The soil penetration resistance was measured by a hydraulic penetrometer for the same previous depths. The soil cohesion and angle of internal friction were measured by annuls ring. The results are shown in table (1).

Table (1): soil mechanical and physical properties

Depth (cm)	Moisture content %	Bulk density (ton/m^3)	Cohesion (kN/m^2)	Angle of internal friction (Φ)	Cone Index Cn (kN/m^2)	Adhesion c_α (kN/m^2)	Angle of friction between soil and metal δ
0-15	12.61	1.18	8.25	34.12	1951.62	0.65	28.44
0-20	12.28	1.27	12.50	33.62	2243.20		
0-20	17.62	1.30	16.70	29.10	3326.50		

3.0 Results and discussions

3.1 Draft force

3.1.1 The effect of the operating depth on the draft force

The draft force of the conventional and modified plows increased as the operating depth increased (Fig. 2). It increased by 10, 8.0, 9.5cm for CP+2R, CP+R, CP respectively when the operating depth increased from 15 to 25cm. This increase can be related to the greater volume of soil manipulated by both plows as the operating depth increased as well as the increase in soil strength due to higher moisture content. Also the grater volume of the soil manipulated by the plows changed the soil movement of the disturbed soil from upward to the soil surface to forward movement causing higher resistance on the disturbed soil from the undisturbed soil existed in the plow path of movement. This acting resulted in accumulation of grater volume of soil in front of the plow which required greater draft from the plow to this

volume of soil. However, adding one rotor or two rotors increased the draft force by only 2.0kN which it is not grater enough to give the conventional plow any advantages on the modified plow. This additional draft was due to the requirement of the blades which working in the soil for pulverization.

The results showed that using two rotors required only 0.53kN higher than one rotor and this increase is small compared with gain in soil pulverization when two rotors were used. The reason of the low draft requirement of the second rotor was due to that the first rotor (front rotor) breaking the big soil

colds to smaller sizes while the second rotor (rear rotor) required less effort to complete the soil clods breaking up.

The results also showed that the depth required greater draft force than the rotors of the modified plow. When the operating depth increased from 15 to 25cm the draft force of CP, CP+R, CP+2R, increased from 26, 27.5 and 28kN to 36, 37.8 and 38.5kN respectively. However, the draft force requirement of one rotor and two rotors is 1.5 and 2.0kN at operating depth of 15cm and 1.8 and 2.5kN at operating depth of 25cm. The reason of the low draft force requirement of the rotors was because they were working in disturbed soil and at shallow depth.

3.1.2 The effect of the forward speed on the draft force

The draft force of the modified and the conventional plows increased as the forward speed increased (Fig. 3). For the three plow combinations (CP, CP+R, CP+2R), the draft force increased by 6.8, 7.2 and 7.2kN when the forward speed increased from 0.3 to 1.1m/sec respectively. The higher forward speed increased the soil clods acceleration and the collision between soil clods resulted in greater draft force. However, the draft force

requirement of the rotors is marginally increased with the forward speed of the plow; it was 0.8 and 1.5kN at forward speed of 0.3m/sec and 1.4 and 1.7kN at forward speed of 1.1m/sec for one and two rotors respectively.

The results showed that the draft force requirement of the conventional plow (CP) required greater draft force at higher forward speed than the modified plow (CP+R, CP+2R) at lower forward speed. At forward speed of 1.1m/sec, CP required greater draft force than CP+R by 3.7, 4.7 and 5.7 and than CP+2R by 4.7, 5.6 and 6.5 for forward speeds of 0.3, 0.5 and 0.88m/sec respectively. The plow required greater draft force to cut and to move the soil at higher forward speed due to the high soil strength at depth and the throwing of the soil away from the plow.

3.2 The Mean Weight Diameter

The Mean Weight Diameter (MWD) (Soil Pulverization Index) is regarded the best parameter to evaluate the field performance of the modified chisel

plow because the addition of the rotors to the conventional chisel plow were to increase its soil pulverization ability. MWD is the distribution of the different volumes of soil clods.

The effect of the plow operation depth and the forward speed on the MWD will be discussed as follows:

3.2.1 The effect of the operating depth on MWD

The ability of the modified chisel plow in pulverizing the soil improved considerably when one or two rotors were added to the conventional chisel plow (Fig. 4). MWD decreased from 60mm (for CP) to 38 and 31mm for

CP+R and C+2R respectively. The last value of soil pulverization made the soil soft enough for seeds sowing with out needing for further pulverization.

The operating depth increased MWD for CP, CP+R andCP+2R by 13, 11 and 7mm respectively and that was because the collusion between the soil clods reduced due to the reduction in the movement of the soil because the greater volume of the soil manipulated by the plow. Also at deeper operating depth the action of the rotors limited to the surface layer.

3.2.2 The effect of the forward speed on MWD

The plow forward speed had considerable effect on the MWD for chisel plow combinations CP, CP+R, CP+2R it decreased as the forward speed increased (Fig. 5). The reduction in MWD was due to the self breaking up of the soil colds during plowing operation. The clods collide with each other causing self pulverization to the soil. For example, increasing the forward speed from 0.5 to 1.1m/sec, MWD decreased by 14, 22 and 25mm for CP, CP+R and CP+2R respectively. This means using one rotor and two rotors decreased MWD to 29 and 20mm which can drill the seeds directly in the soil.

Conclusions

The following conclusions can be drawn from this work:

(1) The draft force of the modified chisel plow increased slightly compared with that of the conventional chisel plow (unmodified), only by 1.5 to 2kN for operating depths of 10, 15 and 25cm.

(2) The weight diameter (soil pulverization index) decreased from 65mm for the conventional chisel plow to 40 and 27mm for the modified chisel plow provided with one and two rotors respectively.

(3) The draft force of the modified chisel plow was also higher than that for the conventional chisel but only by 1.3 and 1.5kN.

(4) The mean weight diameter of the conventional chisel plow of 73mm decreased to 55 and 42mm for the modified chisel plow provided with one and two rotors respectively for forward speed of 0.3m/sec.

(5) The weight diameter decreased from 65mm for conventional chisel plow to 42 and 20mm for the modified chisel plow provided with one and two rotors respectively for forward speed of 0.1.1m/sec.

Notation:

CP= Conventional Plow
CP+2R= Conventional Plow and two Rotors
CP+R= Conventional Plow and one Rotor
MWD= Mean Weight Diameter

References

(1) Aday, S.H. and K,A. Hameed (1993): Effect of soil moisture content on soil shear strength . Basrah J. Agric.Sci. 6 (1): 79-110

(2) Aday, S. H. and Y. Y. Hilal (2001): The effect of wings width on the field performance of the subsoiler in heavy soil. (part1): the draft force and the disturbed area. Basrah J. of agric. Sic. 14(1)

(3) Aday, S.H. and K,A. Hameed, R. F. Salman(2001): The energy requirement and energy utilization efficiency of two plows typy for pulverization of heavy soil.

(4) Aday, S.H. and A.A. Al-Edan (2004). Comparson between the field performance of a modified moldboard plow and a conventional moldboard plow in wet and friable silty caly soils. (A) Draft force and specific resistance. Basra J. agric. Sci. vol. (17) No. 1

(5) Collonelli, D.F. and G. Farina(1982): Subsoiler and chisel plows performance for primary tillage. Rivista-di-Engineering – agric. 13 (34) P. 211-214.

(6) Davies, D.B., J. Eagle and J. B. Finney(1979): soil management. 4th edition, farming press limited. London.

(7) Mckey, E. and F.L. Desir(1984): Prediction and field measurement of tillage draft force and efficiency in cohesive soil. Soil and tillage research J. 43: 195-204.
(8) Mckey, E (1985): Soil cutting and tillage. 1st ed. Elsevier Science publishers.

(9) Riethmiller, G.P. (1989): Draught requirement of tillage equipment in the western Australian wheat field. J. Agric. Eng. Australia 18(2): 17-22.
(10) Stafford, J.V. (1979): The performance of rigid tine in relation to soil properties and speed. J. Agric. Engng. Res. Vol (24). 41-58

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دراسة متطلبات المحراث الحفار المطور من قوة السحب والقابلية على تفتيت التربه

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الخلاصة

تم تحوير محراث حفار أعتيادي بأضافه منعمتين أحدهماخلف الاخرى ، تتكون المنعمة من أسطوانه تثبت عليها

قطع معدنية طولها 20سم وعرضها 5سم لتنعيم كتل التربه الناتجه من الحراثه 0تم أجراء التجارب على المحراث الاعتيادي والمحور لتحديد التحسن بالاداء الحقلي للمحراث نتيجه التحوير الذي جرى على المحراث الاعتيادي من خلال قوة السحب وقابلية تفتيت التربه بأستخدام ثلاثه أعماق حراثه (25,15,10 سم) وأربعه سرع أمامية 1.1,0.88,0.5,0.3م/ثا

أظهرت النتائج زياده قوة السحب مع زيادة عمق الحراثه لكلآ المحراثين ألا أن متطلبات المحراث المحور من قوة

السحب كانت أعلى ولكن بمقدار محدود حيث تراوحت الزياده بين 1,5 الى 2 كيلونيوتن فقط وهذة الزياده رافقها زياده واضحه بقابليه المحراث على تفتيت التربه حيث قلت من 65 ،27,40 ملم بأستخدام منعمه ومنعمتين على التوالي وهذا يعتبر تطور هام وهدف اساسي من تحوير المحراث 0كما زادت قوة السحب مع زياده السرعة الامامية

لكلاً المحراثين وكانت متطلبات المحراث المحور من قوه السحب أعلى وتراوحت الزياده بين 1.3 - 1.5 للسرعه البطيئه 0.3م /ثاوالعليا 1.1 م/ثا على التوالي كما أن هذة الزياده بقوة السحب صاحبها زياده واضحه بقابلية المحراث المحور على تفتيت التربه حيث كان الانخفاض بمعدل القطر الموزون وهودليل التفتيت من 73الى 42,55 ملم بأستخدام منعمه ومنعمتين للسرعة البطيئه 0.3 م/ثا وعلى التوالي ونخفض من 65 الى 20,42 ملم لمنعمه ومنعمتين للسرعه العليا 1.1 م/ثا وعلى التوالي.

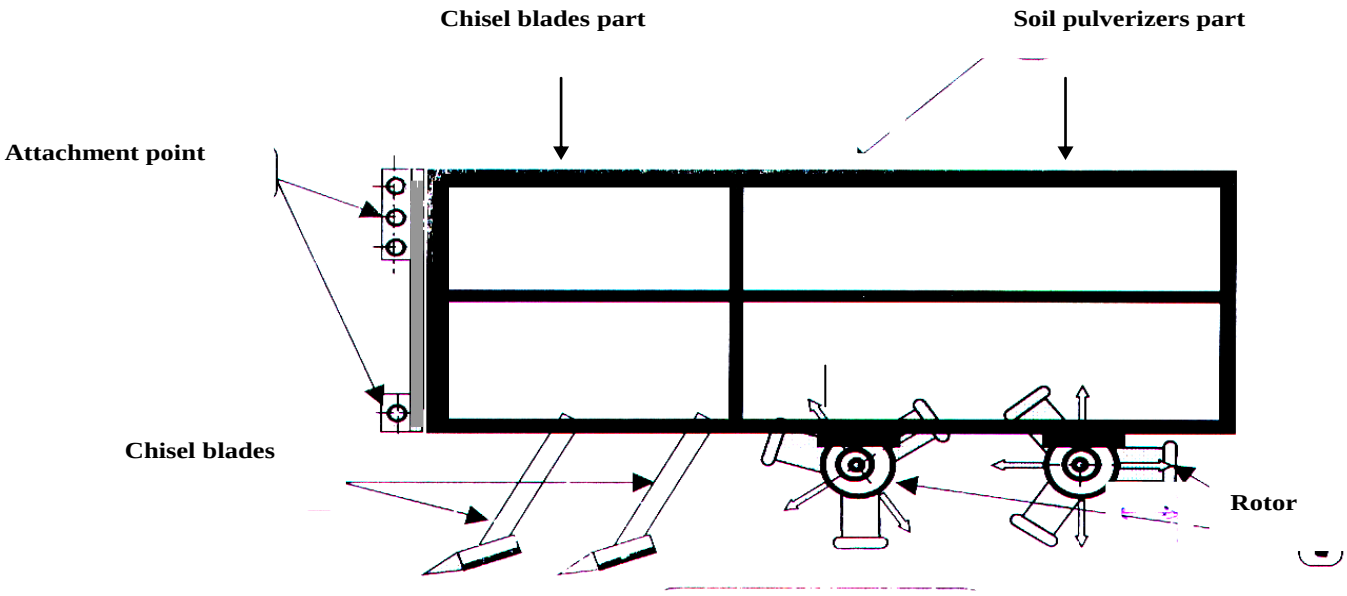

Figure (1A) : The modified chisel (side view)

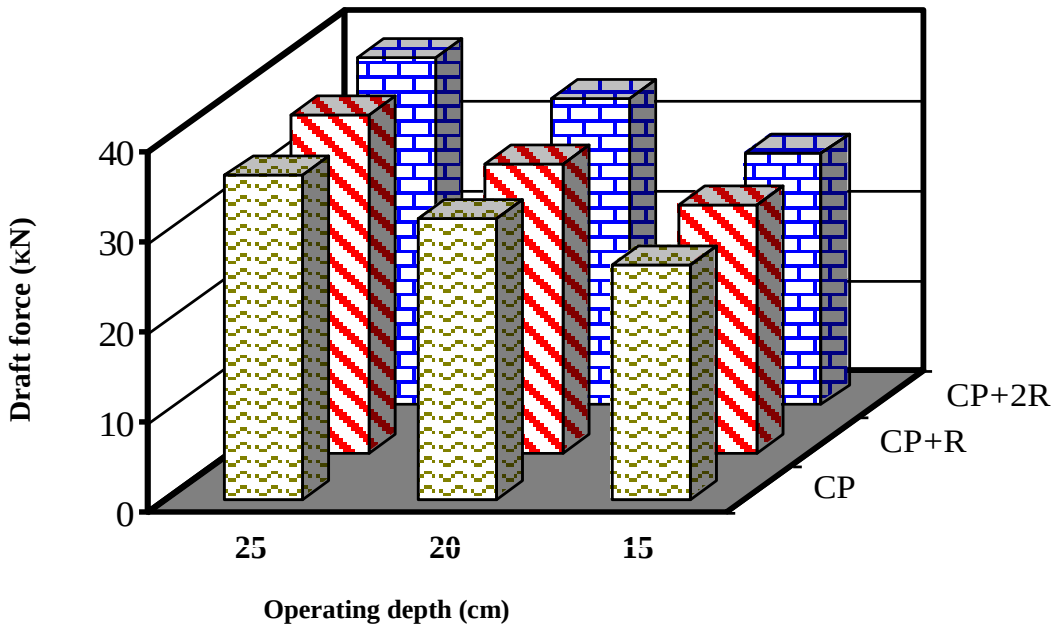

Figure (2): The draft force versus the operating depth for three chisel plow combinations

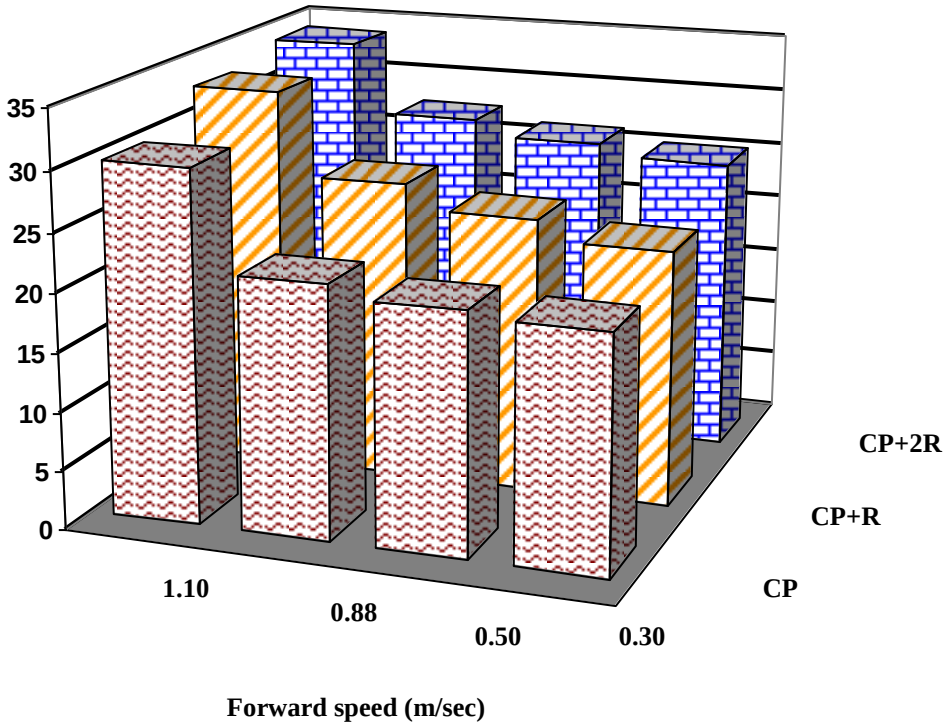

Figure (3) :Draft force versus forward speed for three plow combinations

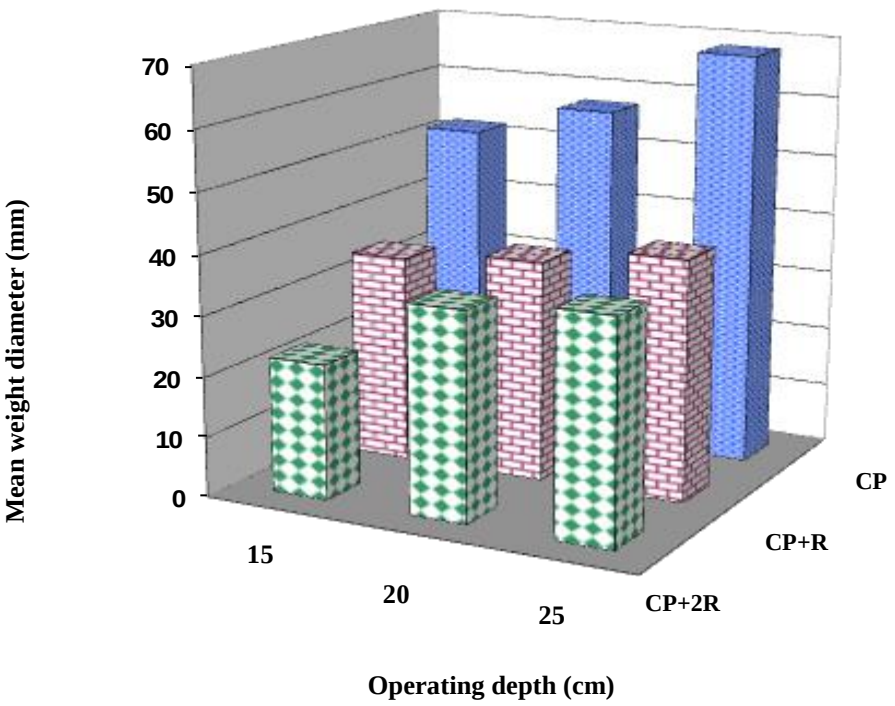

Figure (4): Plow operating depth versus mean weight diameter for three chisel plow combinations

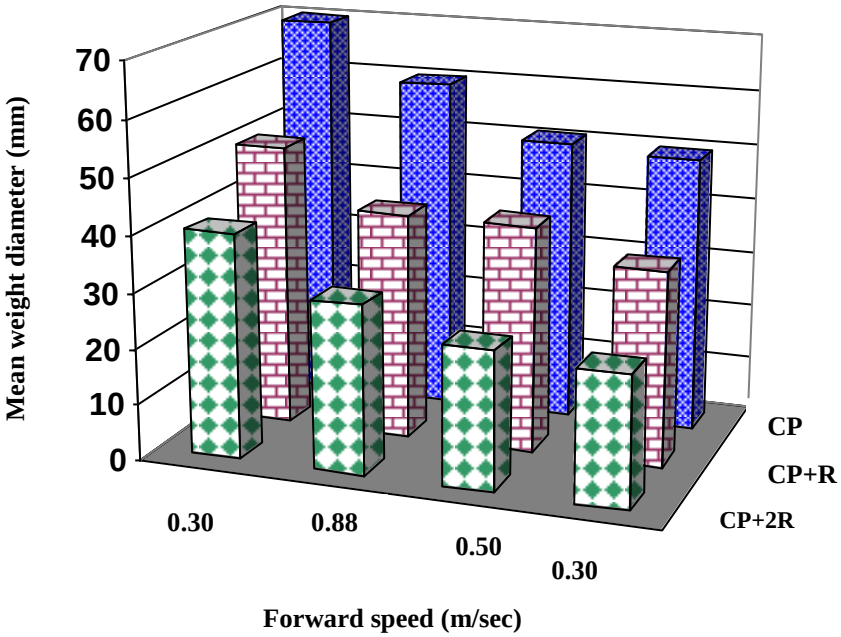

Figure (5): Plow forward speed versus mean weight diameter for three chisel plow combinations