

Evaluation of Zero-Till Seed Drill Performance in Relation to Tillage Parameters**Anjali Verma*, Pankaj Tiwari, Ravi Shukla, Manoj Gupta, and Nitesh Rathore*****Department of Agriculture and Environmental Sciences, Shobhit Institute of Engineering and Technology, Meerut – 250110, Uttar Pradesh, India****ABSTRACT**

The performance evaluation of zero-seed-drill was carried out in an area of about 0.15 ha at Agricultural Engineering Farm of IFTM University Moradabad Uttar Pradesh. It was observed that there was no effect of stubble on the performance of zero-seed-drill. However, the loose straw spread on the surface offers some hindrance in the working of the drill. The standards test code was adopted. Each test was replicated minimum three times. Forward speed and depth and sowing were taken as independent variables while wheel slippage field capacity field efficiency, fuel consumption bulk density after operation, wheel slippage & weed count were taken as dependent variables. The wheel slippage at 2.0 km/hr and 3.0 cm depth was found to be 2.2% (minimum) and was found to be 4.43% (maximum) at 3.0 km/hr speed and 4.0 cm depth of sowing in case of the operation. Field capacity was found to be highest of 0.2662 ha/h at 2.5 km/hr. The bulk density was found to be 1.002 gm/cc (minimum) at 1.8 km/hr at 3.0 cm depth and maximum at 1.44 gm/cc (maximum) at 2.5 km/hr at 4.0 cm in case of operations. The distance between plants to plant was 11 cm to 15 cm after 45 days in maize and 10 to 14 cm in ladyfinger after 45 days. Based on present study the following conclusions were drawn. The wheel slippage of drive wheel of tractor increased with increased in forward speed. It also increased with the increased in depth of operation. Field capacity increased with the increase in forward speed thereafter it decreased after the speed of 3 km/hr. Bulk density increased up to a depth of 4.5 after which it was increased with the increase in speed of operation.

KEYWORDS: zero-seed-drill, forward speed, depth of sowing, and fuel consumption,**INTRODUCTION**

Farm mechanization can play an important role for economic and social development. It acts as one of the best tools in improving the agriculture productivity of a country. Farm mechanization refers to the introduction of machine on agriculture land to accomplish different farm operations in order to get quicker, easier and higher Agricultural production. Hindus are said to have machine for seeding of crops. Sowing requires proper attention to place the seed in proper soil environment for germination.

Tillage may be defined as the mechanical manipulation of the soil that is used to provide necessary soil conditions favorable to the growth of crops. Soil tillage cuts and breaks the compactness of soil, so as to enable the roots of the plants to penetrate and spread into the soil tillage improves the physical condition of the soil increases the water holding capacity and reduces soil erosion. Tillage destroys weeds and keeps the soil free from insects during the growth of crops. The evolution of tillage implements and machinery has been one of the most striking features in enhancing the use of machine in farming. These are various types of tillage operation such as Primary tillage, secondary tillage, strip tillage, rotary tillage, mulch tillage and combined tillage.

Primary tillage constitutes the initial major soil working operation. It is normally designed in such a way, so as to reduce the soil strength, cover crop residues and rearranges. It refers to the operation performed to open up any cultivable land with to prepare a seed bed for growing crops.

Secondary tillage refers to the tillage operations following primary tillage which are performed to create proper soil tilth for seeding and planting. These are lighter and finer operations which consists of conditioning the soil to meet the different tillage objectives of farming. These operations are not very deep and generally done on surface soil of the field and do not cause much soil inversion and shifting of soil from one place to another. These operations consume less power per unit area as compare to the primary tillage operations.

The primary and secondary tillage implement may be tractor drawn or animal drawn. The primary tillage implement include indigenous plough mould board plough, sub-soil plough, chisel plough and other similar implements. The secondary tillage implements include different Types of harrows, cultivators, levelers, clod crushers, hoes, rollers and similar implements. Both primary and secondary tillage operations are generally recommended in the field in order to get a better pulverized and deeper seedbed. The primary tillage operations opens-up the hard soil, gives a deeper depth of cut providing a better root zone depth. This also depends on various

parameters like moisture content of the soil type and condition, energy requirement etc. The use of primary tillage implements is not always advised as their depth of cut is more and hence increase the moisture depletion rate it also not recommended where concept of minimum tillage is applied.

Tillage is the most important primary activity for crop production. The cost and the timeliness of operation assume critical importance while deciding the type of tillage tools and operations to be carried out. Surface tillage farming systems, such as those using the traditional tools like ploughs and harrows are not very effective in mixing the stubbles of the preceding crop in the soil. Following this, the secondary tillage is done by using the seed drill, cultivators, planks etc. This practice is followed in most of the northern states of India, including Punjab, Haryana and UP, where wheat-paddy rotation is in vogue. The time between harvesting the first crop and sowing of the next crop is quite limited, keeping in view the tillage operations, irrigation and manpower availability. During the course of preparing a satisfactory seedbed for the next crop, the primary and secondary tillage operations require as many as 2 to 3 disking, 2 to 3 operation of the field cultivator and 1 to 2 planking. To minimize the time, cost and energy requirements for field operations, considerable attention is now being focused on the use of multi-powered tillage tools. Keeping this view in mind a zero seed drill has been manufactured which is suitable for preparing seedbed in a single pass both in dry and wetland conditions. It is also suitable for incorporating straw and green manure in the field.

MATERIAL AND METHODS

The study was undertaken to evaluate the performance of zero seed drill for sowing of maize and ladyfinger crops at Agriculture Field, IFTM University, Moradabad.

Description of the machine

A tractor drawn zero seed drill consists of a steel frame, a rotary shaft with attached blower are mounted, traction wheel, power transmission system. The furrow opener are of shoe type, made from medium carbon steel or alloy steel, hardened and tempered to suitable hardness. The PTO of tractor drive's the zero seed drill. Rotary motion of the PTO is transmitted to the shaft carrying the blower. The zero seed drill is intended for use with tractors having 35-75 hp 540 or 1000 PTO and working widths of from 127cm to 229cm. The drive is via the universal joint assembly, safety clutch, multi-speed gear box and heavy duty chain drive to the rotor. Power to the blade was supplied from the tractor through a 2:1 speed reduction gear box and the chain and sprocket drive having a speed ratio 3:2 it is fitted with standard L shaped blades. These blades require less power and provide a coarser finish for better moisture penetration. The machine can be supplied with depth control skids or front steel wheels. The long trailing board has a special profile that provides a smooth level finish. The zero seed drill also consists of a seed box & fertilizer box for placement of seeds and fertilizer at proper depth. The frame of seed box is made up of angle iron. All the parts are connected to the frame whereas the furrow openers are suspended below its back. The seed box is made of galvanized iron or sheet metal. A power driven agitator is provided to fluted feed mechanism to drop the desired amount of seed in the with uniform distribution pattern. It consists of a fluted roller, feed cut-off and adjustable gate for different size of grains. The fluted roller carries grooves throughout its periphery. As it rotates, the grooves of the upper part comes down with seeds, and deliver them into the seed tube, from where it goes to the boot and then to the furrow opened by the furrow opener. The seed rate is adjusted by varying the exposed part of the roller inside the cup feed, with the help of adjusting lever. The zero seed drill is very versatile and it can be used in many different applications and conditions. Because of its modern design, with increased rotor clearance and reinforced frame, it can be used on tractors up to 57 kW in hard and difficult conditions. It is ideal for weed control and seed preparation of vegetables, vineyards and general crops.

The type of tillage is maintained by the:

- 1) Type and moisture content of the soil
- 2) Tractor power and speed
- 3) Type of wheel

The machine consists of following parts:

- 1) Seed metering device
- 2) Furrow opener
- 3) Covering device

Seed metering Device

Brush feed mechanism: It is distributing mechanism consisting of an auger which causes a substance to flow evenly in the field, through an aperture at the base or on the side of the hopper. Many of fertilizer drills of the country have got auger feed mechanism.

Picker while mechanism: It is a mechanism in which a vertical plate is provided with radically projected arms which drop the large seeds like potato in furrow which the help of suitable jaws.

Furrow opener: It is a simple device that works well the medium depth in mellow soil free of trash and weeds. It is suitable for average condition encountered by corn and cotton planter. Horizontal plate type depth gauges may be attached the runner for soft soils. The stub runner is sometimes used of corn planter in rough and the trashy ground.

Shovel type openers: shovel type furrow opener are widely used in seeds drills. There are three type of shovel in use:

1. **Hoe type openers:** hoe type openers when equipped with spring trips are suitable for stony or root infested .They are similar to shovel types open and may also be used for deep placement of seed if the soils is relatively free of trash.
2. **Fluted feed type:** It is the simplest type of seed metering mechanism and is most commonly used on seed drills. It consists of fluted roller, feed cut off and adjustable gate for different size of grains. The fluted roller carries grooves throughout its periphery. It rotates with axel over which it is mounted. As it rotates, the grooves of the upper part come down with seed which are delivered into the seed tube where they go to the boot and then to the furrow opened by the furrow opener.
3. **Internal double run type:** This type of metering mechanism is found in American drills for sowing cereals. It consists of a discs mounted on a spindle and housed in a casing fitted below the seed box. The edges of the disc are corrugated at both the sides. On one side the corrugation is fine while on the other side it is coarse to suit different size of seed.

Cup feed mechanism: It is used in both coarse and seed drills. It consists of a disc with a ring of cups throughout its periphery mounted on a spindle. The seed hopper is divided into two parts i.e. the upper grains box and lower feed box. The feed box contains an adequate amount of seeds, not in excess which is adjusted by placed in between the feed box.

Cell feed mechanism: It is a mechanism in which seed are collected and delivered by a series of equally spaced cell on the periphery of a circular plate or wheel.

Disc type openers: These are suitable for trashy or relatively hard ground. In wet sticky soils they performs better than fixed openers because they can be kept reasonably clean with scraper the single disc openers used on some grain drill, is more effective than double disc in regard to penetration and cutting of trash. Single disc openers mould board attachment is used of furrow planting of grain. Double disc openers are particularly well adapted to medium or shallow seeding of row crop which are crucial in regard to planting depth, because the depth can be controlled rather accurately with removal depth band. In case of curved runner because of its length. It has higher contact area with soil thus may be require higher draft, it may not be suitable gore manually garlic planter. Case of stub runner due to its heavy weight also may not be suited for manually operated garlic plant

Open centre concave steel press wheels: These are common for corn and other large seed crops. Zero pressure pneumatic press wheels are used extensively for vegetable and some other crops. Their continual flexing tends to make them self-cleaning. Tires with narrow centre ribs press soil down firmly around the seed and have given good result in sugar beets

Drag chain behind the flanged press wheel: It fills the remaining groove with loose soil. Narrow rubber tired seed packer wheels running directly behind the openers to press the seed into the bottom of the furrow before the seed covered, sometime improve emergence especially with cotton

Drag bar: It fills the furrow with loose soil and makes the field level but it prohibitive in dry areas where moisture conservation is the main factor

Variables under study: To study the performance of zero seed drill the variable under study are classified as follow:

- **Independent variables**
- **Dependent variable**

Independent variables

Forward speed and depth of sowing were taken as independent variables. Levels of independent variables under study

S. no	Forward speed (Km/h)	Depth of sowing (cm)
1	S ₁ =1.8-2.0	D ₁ =3
2	S ₂ = 2-2.5	D ₂ =3.5
3	S ₃ = 2.5-3.0	D ₃ =4.0

Dependent variables

Field capacity, field efficiency, fuel consumption, bulk density after operation, wheel slippage, and weed count is taken as the dependent variable for the present study.

The effective field capacity, theoretical field capacity and field efficiency were calculated by recording the time consumed for actual work and the time lots of other miscellaneous activity such as turning adjustment under field operating conditions

Theoretical field capacity is rate coverage of the implements based on 100 percent of the rated speed & covering 100 per cent of its rated width.

$$Tf_c = ws/10..... (3.1)$$

The effective field capacity is calculated by recording the actual area covered by the implement, based on its total time consumed & its total time consumed & its width.

$$Ef_c = A / (T_p + T_1).....(3.2)$$

It is the ratio of effective field capacity and theoretical field capacity expressed in percent.

$$Ef = Efc/Tfc..... (3.3)$$

Where

- Ef_c = Effective field capacity, ha/hr.
- Tf_c = theoretical field capacity, ha/hr.
- Ef = field efficiencies, %
- A = total area covered, ha
- T_p = productive time, h
- T₁ = non-productive time, h
- W = effective working width, m
- S = effective speed of operation, km/h

Fuel consumption

Fuel consumption is a dependent variable that directly shows the economy of the operation with different speeds and depth. Fuel consumption was measured by top up method. The tank is filled to full capacity before and after the test. Amount of refueling after the test is the fuel consumption for the test.

Bulk density

Bulk density is defined as the mass of a unit volume of a dry soil there are several method of determining soil bulk density by obtaining

Known volume of soil, drying it to remove water, and weighing the dry Mass. it was measured by using core sampler having 100 mm diameter and 120 mm length, by taking different soil sample from different location of the field

The bulk density is calculated by using formula

$$P = M/V..... (3.4)$$

Where

- P = Bulk density-of soil, g/cm³
- M = oven dry mass of soil contained in core sampler, g
- V = volume of core sample, cm³

Wheel slippage

To calculate the wheel slip the tractor was operated at implement with load and without. A mark on the rear wheel was put to count the number of revolution. The distance travelled by the tractor in 10 revolution of the tractor rear wheel was measured and wheel slip was calculated as follows

$$\text{Wheel slip (\%)} = [(A_1 - A_2) \times 100] / A_1 \dots \dots \dots (3.5)$$

Where

A_1 = distance travelled by the rear wheel for given no. of revolution under no load.

A_2 = distance travelled by the rear wheel for a given no. of revolution under load.

Calibration

The procedure of testing the zero seed drill for correct seed rate is called calibration of seed drill. The following steps are followed for calibration of zero seed drill:

W = normal working width, m
No. of rows x row spacing, m

D = Diameter of ground wheel, m

The delivery rate can be calculate from delivery in a given number of revolution of ground wheel in the laboratory,

$$Q = L \times 10,000 / x d N \times W \dots \dots (3.6) \text{ Where } q = \text{Delivery rate, kg ha}$$

L = Delivery in a given number of revolution (n) of ground Wheel, kg

N = Number of revolution of ground wheel

Depth and width of operation

The depth of sowing was measured at different location with the help of scale and average was taken. For measurement of actual width of operation of the machine was measured with tape and actual width of operation was calculated.

Speed of operation.

To calculate the speed of operation two poles 20m apart were placed approximately in the middle of the test run. The speed was calculated from the time required for the machine to travel the distance of 20m.

Time required

Total time for each operation and time required in turning was recorded in each operation with the help of stop watches and after the completion of the operation the time lost in turning and total time of operation was calculated.

Experiment procedure

For study the performance of tillage and zero seed drill, standard test code has been adopted. Each test was replicated minimum three times.

Test condition

The performance of zero seed drill varies considerable according to condition of field, seed, and operator. Therefore the condition of the test is stated below:

Condition of field

A. area and shape of test field: size of plot 20x10 m

B. type and character of soil: sandy loam soil

Condition of seed and fertilizer

A. name and variety of seed: miter hybrid and ankur-40

B. variety and from (for fertilizer); DAP, Granular

Condition of machine and operator

A. source of power: 50hp tractor

B. adjustment for maize and ladyfinger seed rate @ 19kg/hect, 25kg/hect

C. travel pattern: continuous turn-strip at each end

D. traveling speed: 1.8-2km/hr-2.5km/hr, 2.5-3km/hr.

E. skilled operator: experience of working for 10year

For conducting experiment one plots of 20x10m size were taken and irrigated, if needed .the machine was operated at different speed and depth and for each operation dependent variable such as fuel consumption, wheel slippage,

productive & non-productive time of the operation were recorded. Soil sample for determining bulk density were collected experiments were repeated for three different speed and depth of operation and their corresponding values were recorded.

Calibration of seed cum fertilizer drill

The seed-drill was calibrated for wheat sowing using the metering mechanism. The seed-drill was placed on a level ground and jacked up to facilitate the rotation of ground drive wheel freely. Laboratory test was carried for ten revolution of ground drive wheel for each exposure length of fluted rollers. The following steps were followed for calibration of seed-cum fertilizer drill (Sashay, 1990).

Determine the nominal width (W) of drill

$$W = M \times S$$

Where M is the number of furrow openers and S is the spacing between the openers in meter and W is in meter.

Find the length of a strip (L) having nominal width W necessary to cover 1/25 Pth

P of a hectare

$$L = 10000 \times \frac{1}{W} \times 25 = \frac{400}{W} \text{metres}$$

Determine the number of revolutions (N) the ground wheel has to make to cover the length of strip (L)

$$\pi \times D \times N = 10000 \times \frac{1}{W} \times 25 = \frac{400}{\pi \times D \times W} \text{rev/min}$$

Jack up the drill so that the ground wheel turns freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the drill to help in counting the revolutions of the drive wheel.

Put the selected seed and fertilizer in the respective hoppers. Place a sack or a container under each boot for seeds and fertilizers. Set the rate control adjustment for the seed and the fertilizer for maximum drilling. Mark this position on the control for reference.

Engage the clutch or on-off adjustment for the hoppers and rotate the drive wheel at the Speed N

$$N = \frac{400}{\pi \times D \times W} \text{rev/min}$$

Weigh the quantity of seed and fertilizer dropped from each opener and record on the data sheet.

Calculate the seed and fertilizer dropped in kg/ha and record on the data sheet.

Repeat the process by suitable adjusting the rate control till desired rate of seed and fertilizer drop is obtained.

RESULT AND DISCUSSION

The results of the experiment described in order to fulfill the objective for which this project was undertaken. The experiment were conducted in the field as well as in Laboratory to evaluate the performance of zero seed drill

Performance of zero seed drill in two different crops Condition

The seed drill was performed for two crops maize and lady finger in case of maize, data are presented in table 4.1 the average variation in distance between plant to plant are 20cm, 21cm and 18.66cm. After 15 days it is also observed after 30 days the distance was 16 cm, 18cm and 18cm distance between plant to plant after 45 days was 11.33cm, 13.33 cm and 14.66. cm the reduction in distance between plant because more plant was germinated observation taken in lady finger are presented in table 2 the average variation in distance between plant to plant 10.33 cm, 14.33 Cm and 15.33 cm after 15 days it is also reported that after 30 days the distance was 10.33 cm 14.66cm and 13.66cm. The reduction insistence between plants to plant because more plant was germinated.

Table-1 Distance between plant to in maize crops at different engine RPM

Replication	After 15 days			After 30 days			After 45 days		
	1200 rpm	1500 rpm	1800 rpm	1200 rpm	1500 rpm	1800 rpm	1200 rpm	1500 rpm	1800 rpm
R ₁ (cm)	19.2	21.0	18.0	15.0	17.0	16.0	11.0	12.0	14.0
R ₂ (cm)	20.0	22.0	18.0	16.0	18.0	18.0	13.0	15.0	16.0
R ₃ (cm)	21.0	22.0	20.0	17.0	19.0	20.0	11.0	13.0	14.0
Average	20	21	18.66	16	18	18	11.33	11.33	14.66

Effect of different speed on Wheel Slippage, Field capacity & bulk density**Wheel slippage**

The slippages of drive wheel of the tractor at various depth of sowing and at different operational speed are presented. The wheel slippage at 2.0 km/hr. and 3.0cm depth was found to be 2.2 (minimum) and was found to be 4.43% (maximum) at a speed of 3.0km/hr. at 4.0cm depth of sowing. Under field conditions other factor were almost constant it was seen that speed of operation affect the wheel slippage

It may be seen that with the increase of forward speed of the machine wheel slip increase linearly. This was due to more traction requirement of the wheel to gain more than speed which results in shear failure of the soil under the tyres. The shear strength the soil depends of the Moisture content and bulk density of the soil. This was more due to more draft requirement of the machine. The wheel slippage at 2.0 km/hr speed and 3.0 cm depth of sowing was found to be 1.81% (minimum) and it was found to be 3.48% (maximum) value at a speed of 3.0 km/hr having depth of 4.0cm. Wheel slippage increased with increased in depth since resistance of soil increased due to more draft requirement of the machine.

Field capacity

The field capacity basically depends upon size shape of field and method of operation. The effective field capacity, of the machine at the different operational speed and depth are presented.

Bulk density

Soil with the proportion of pore space to solid have lower bulk densities than those that are more compact and have pore less space consequently, any factor that influence soil pore space will effect bulk density . The bulk density was found to be minimum at 1.8 km/hr and 3.0cm depth as 1.002 gm/cc and maximum at 1.44gm/cc at 2.5 km/hr at 4.0 cm as show in table 3

Table 3 Effect of Forward speed and depth of operation on bulk density

S. No	Speed(km/h)	Depth cm)	Bulk Density(gm/cm ³)
1.	1.8	3.0	1.002
2.	2.5	3.0	1.38
4.	3.0	3.0	1.20
5.	2.0	4.0	1.44
6.	3.0	4.0	1.28
7.	2.0	5.0	1.01
8.	2.5	5.0	1.42
9.	3.0	5.0	1.23

Cost of Operation

The cost of sowing maize and ladyfinger for zero seed drill was found to be Rs. 797.21 per ha. The cost operation for convectional sowing was found to be 1588.04 per ha in Meerut region so there was saving of Rs. 790.93 per ha in cost of operation.

CONCLUSION

The summary of the work done on performance evaluation of zero seed drill for sowing maize and ladyfinger crops. The study was conducted behind IFTM University Moradabad. For performance evaluation of zero seed drill, the standards test code was adopted. Each test was replicated minimum three times. Forward speed and depth and sowing were taken as independent variables while wheel slippage field capacity field efficiency, fuel consumption bulk density after operation, wheel slippage& weed count were taken as dependent variables. The wheel slippage at 2.0 km/hr and 3.0 cm depth was found tube 2.2% (minimum) and was found to be 4.43%(maximum) at 3.0km/hr speed and 4.0cm depth of sowing in case of the operation Field capacity was found to be highest of 0.2662ha/h at 2.5km/hr.

The bulk density was found to be 1.002 gm/cc (minimum) at 1.8 km/hr at 3.0 cm depth and maximum at 1.44gm/cc (maximum) at 2.5 km/hr at4.0cm in case of operations.

The distance between plants to plant was 11cm to 15cm after 45 days in maize and 10 to 14 cm in ladyfinger after 45 days

Based on present study the following conclusions were drawn.

1. The wheel slippage of drive wheel of tractor increased with increased in forward speed. It also increased with the increased in depth of operation.
2. Field capacity increased with the increased in forward speed there after it decreased after the speed of 3 km/hr.

Bulk density increased up to a depth of 4.5 after which it where as it increased with the increase in speed of operation.

REFERENCES

- [1] Abbas, S.G, Choudhary, M.A, and Wall, G.L. 1999. Managing technology Changed: Zero tillage in Pakistan, AMA.30 (4):12-15 Development and adoption of no till technology for sowing wheat, AMA. 25 (4):24-28.
- [2] Alien, R.R, Musik, J.T. and Dusk, A.D. 1980. Limited tillage and energy Used with furrow irrigated grain sorghum. Trans. ASAE: 346-350.
- [3] Ambassa-kiki, R. Aboubakar, Y. And Boulama, T. 1996. Zero –tillage for Rice production on Cameroonians vertisols, Soil and till. Res.39. 75-84.
- [4] Arshad, M.A.; Gill, K.S and Coy, G.R.1994. Wheat yield and wheat Population as influence by three tillage system on a clay soil in Temperate continental climate. Soil and Till Res. 28(3-4): 227-238
- [5] Ashlam M. Majid, A.; Hobbs, P.R.; Hashmi, N.J and Byerlee, D.1989. Wheat in rice-wheat cropping system of Punjab. A synthesis of on farm research results 1981 -1988. PARC/CJMMYT paper NO.-89-3.
- [6] Ball, .B.C.1989, Reduced tillage in Great AT Britin: Partical and Research Experience. EUR, report, UK.
- [7] Bolton, E. Floyd and Booster, E. Dean. 1981. Strip till planning in dry land cereal production. Trans. ASAE: 59-62.
- [8] Bukhari, S.B.; S.Pal, L.; Laszlo and Devrajani. 1981. Performance of tillage implement combination. AMA. Summer. JAPAN.
- [9] Carter, M.R. and Sanderson, J.B. 2001. Influence of conservation tillage and rotation length and potato productivity, tuber disease and soil quality parameters on a fine sandy loam in eastern Canada. Soil and till Res. 63:1-13
- [10] Channel, R.Q. 1985, reduced tillage in northwest Europe –A review, soil and Till Res.5; 129-177.
- [11] Choudhary, Md. SU.; Al-Fakhary Abdullah, A.K.; Smail, Laith k. and Vartanian, Karekin Y. 1977. Mechanized tillage dry farming in Iraq. AMA. SPRING:11-16.
- [12] Collins, B.A. and fowler, D.B. 1996. Effect of soil characteristics, seeding depth, operating speed opener design on draft force during direct seeding. Soil and till. Res.39:199-211.
- [13] Damora, D. and Pandey, K.P. 1995. Evaluation of performance of furrow openers of combined seed and fertilizer drills. Soil and Till Res.34(1):127-139.
- [14] Dhiman, S.D. and Sharma, A.P. 1986. Zero tillage in wheat crop under heavy soil. AMA.13(2):15-16.
- [15] Dubey, A.K. and Srivastava, N.S.L. 1981. Standardisation and performance evaluation of different types of furrow openers for black soil. Annual report, CIAE, Bhopal, India.37.