DESIGN AND MANUFACTURE OF THE INJECTION MACHINE OF AGRICULTURAL RESIDUES AND SOLID MATERIALS IN THE SOIL

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ABSTRACT

This investigation carried out, to design and manufacture of the injection machine of agricultural residues after its chopping and solid materials into the soil. This machine consists of the injection device and subsoiler plow. ***The experimental and designing studies*** *were confined to determine the effect of : auger shape design, cross sectional area of the injection tube, screw (auger) rotational speed, gate area of straw discharge, tractor forward speed, residues density and mole depth* ***on*** *the theoretical volumetric capacity, actual volumetric capacity of an auger(m^3/ min), volumetric efficiency of an auger (%) the discharge rate (m^3/min), Mole filling efficiency (%), and some physical & chemical properties of soil after injection.* ***The machine was tested and evaluated*** *under four different forward speeds of 12, 15, 20 and 30 m/min. (0.72, 0.90, 1.2 and 1.8 km/h), four auger rotational speed of 100, 150, 200 and 250 rpm, three gate area of straw discharge of 250, 500 and 750 cm^2, one mole space of 4m, one mole constriction depth of 60 cm. and one organic plant residues (rice straw after chopping) and solid material (sand).*

Results indicated that *the highest value of discharge rate is 0.290 m^3 /min that obtained at the auger rotational speed of 250 rpm is adjusted at gate area of straw discharge of 750 cm2 and forward speeds of 30 m/min. (1.8 km/h) for a bulk density of 1.56 and 0.0802 g/cm^3 for sand and chopping straw respectively.* ***While the lowest value*** *was 0.105, m^3/min at the auger rotational speed of 100 rpm is adjusted at gate area of straw discharge of 250 cm^2 and forward speeds of 12 m/min. (0.72 km/h) for a bulk density of 1.56 and 0.0802 g/cm^3 for sand and chopping straw, respectively.*

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INTRODUCTION

Agricultural residues are considered treasures. The Egyptian farmer did not know its importance and the highest energies so far, the lack of equipment, machines and services that deal and interact with residues to make it stronger investment from the investment of the grains. Crop residues are one of the most critical problems, which face the Egyptian farmer. The quantity of crop residues in Egypt reached about 18.7-25 million ton per year and national income might be increased with 1.6 billion LE/year if we try recycle it, ***(El-Berry et al 2001 and Awady et al. 2001).*** This led to a study for the design and manufacture of machines to be added to deal with its main agricultural residues recycling. Therefore, the aim of present study was to design and manufacture of the injection machine (convening of crop residues into the soil) of agricultural residues in the soil.

There are several methods used to convey agricultural materials. The selection of convening method depends upon the nature of application and on the type of material being conveyed. The agricultural material may be liquid, granular, powder, fibrous or any combination of these. Generally, conveying is accomplished by a combination of mechanical, inertial, pneumatic and gravity forces. Conveyors utilizing primarily mechanical forces are screw, and chain conveyors. Oscillatory conveyors rely on the inertial and the friction forces. Pneumatic conveyors employ the aerodynamic drag to accomplish conveying. Conveying by throwing combines both the inertial and aerodynamic forces Silo loaders utilize these principles.

Screw Conveyors: Augers are used to convey materials that are free flowing such as grain to difficult fibrous materials and powders. For example, in a grain combine, augers are used to move cut crop on the platform to the feeder housing, clean grain at the bottom of the cleaning shoe to the grain tank, and to unload the grain tank on to a wagon or a truck. Augers are used at the grain elevators and farmstead to load grain storage bins and on the feedlot for feed distribution. **The auger length** is defined as the length of the tube assembly including any intake but not including the intake hopper and the head drive. The intake length is the visible flighting at the intake of the auger. The outside diameter of the tube is referred to as the auger size. A standard pitch auger is the one whose pitch is approximately equal to outside diameter of the helicoidal flighting. Generally, the pitch is not less than 0.9 and not more than 1.5 times the outside diameter. Standard pitch augers are used for horizontal and up to 20° inclination angles. For inclination angles greater than 20°, half standard pitch screws are used. **Srivastava et al. (1993)**

Miller and Aursted (1971) found that straw incorporation of the furrow bottom increased furrow infiltration in sandy loam soil during 3 years study period. Straw incorporation become less effective as the season progressed. The annual addition of 13.4 Mg of straw /ha increased infiltration over the control about 90% during the first season, 65% during the second and 35% during the third season.

I m (1982) concluded that the addition of organic materials improved the soil permeability to water even if the soil was severely compacted .The improvement of permeability was entirely due to the increase in total porosity. Since organic matter has high water holding capacity, its addition to soil should increase the amount of available water.

El-Maddah (2000) mentioned that the organic matter content in Egyptian soil gradually decreased and in order to increase it, the use of different sources of organic residues become necessary. **Dierickx (2003)** reported that torpedo diameter is 65 to100 mm is recommended, and the channel diameter will be slightly less immediately after molling. Moles less than 400 mm deep are liable to be damaged by tractor and animals during or immediately after rain. The use of mole plow need draft about 10kN per subsoiler shank was at operation depth about 46 cm **El-Ashry (2008)** mentioned that possibility to use the local ditcher for getting mole for depositing crop residuals as complete structure (without grinding). The optimum operating conditions for the ditcher were found at 2.12 km/h forward speed, 15 degree rake angle and 60 cm mole depth.

The aims of present study were to:

-Design and manufacture of the injection machine (convening of crop residues into the soil) of agricultural residues after its grinding in the soil.

-Test the feasibility of using the injection device (screw auger) for convey crop residues (rice straw after chopping) and sand into the soil.

-Evaluation the injection machine (injection device and subsoiler plow unit) performance under different operation parameters.

MATERIAL AND METHODS

3.1. Prototype structural design:

The present study included a design and manufacture of the injection machine (convening of crop residues into the soil) of agricultural residues in the soil. It was constructed in a private Workshop in Kafrelsheikh. A field study was conducted in heavy clay and salt affected soil at Meet El-Deeba in Nile Delta. The experimental work was carried out in one feddan at Meet El-Deeba Rice Mechanization Center of Agricultural Engineering Research Institute, Kafrelsheikh Governorate, in summer and winter seasons of 2009. The machine is consisted of two main units; injection device and subsoiler plow unit.

The first unit is injection device (the screw conveyor) consists of a shaft 45 mm dia. which carries helicoid flightings150 mm dia. on its outer surface and pitch auger 200 mm. These flightings are enclosed in a Tube 1270 mm length for elevating augers. The tube is held stationary while the rotation of the flightings causes the material to move longitudinally. Figure 1 shows the essential components of a screw conveyor (the injection machine).At the in let side, the auger flightings extend beyond the tube 350 mm. A feed hopper (Pyramid funnel has volume of about o.3 m^3 about 0.5 ton), has size 1000×1000×1050 mm is provided to hold the material while it is conveyed into the steel tube with diameter of about150 mm. Augers can be permanently installed in a machine. The auger is driven at the intake side. The injection machine was operated and pulled by Tractor (120 kW). The power is transmitted from P.T.O. Rotary motion can be transmitted from one shaft to another in this machine by using reduction unite 1: 2 , four gears and two chain one inch. The auger length (162 cm) is the length of the tube assembly including intake gate which controlling feed but not including the intake hopper and the head drive. Inclination angles 90°. In this design have used flights, variable pitch,(12 to 20 cm) and stepped-diameter screws(30 to 15 cm) at intake hopper after the head drive for moving difficult materials and controlling feed as shown in Fig1a.

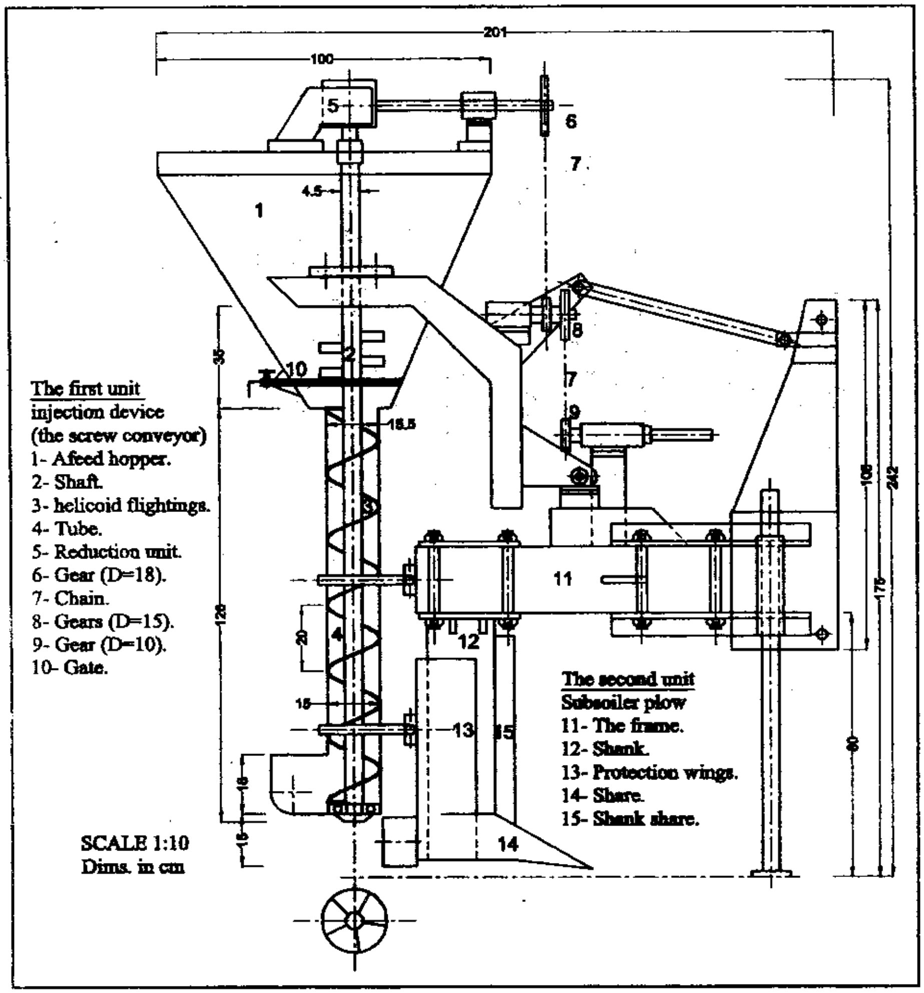

Fig.1a: A schematic diagram number 1 of the injection machine of agricultural residues in the soil constricted by Dr- Wagdy El-haddad .This machine has a good performance in the sand injection and low performance with the straw injection

<u>The second unit</u> is subsoiler plow contains the heavy design of the frame for protection during impact with buried rocks has three hitch points. Subsoiler is used to break through and shatter compacted or otherwise impermeable soil layers and to improve rainfall penetration. It can be operated at depths of 45 to 75 cm or more.

Fig.1 b: Prototype number 1 of the injection machine of solid materials and agricultural residues in the soil

The subsoiler plow mass is about 280 kg. To protect the tube of residues injection during plowing (mole construction), has been modified of shank by add two wings on two sides have the same shank length from steel take the form of triangle, his base at front the injection tube. Share wide increased for same propose as shown in figure 1c & d. With the installation of a sharp knife at shank front vertically and same his length in the form of an isosceles triangle to reduce the soil resistance as shown in figure 1c.

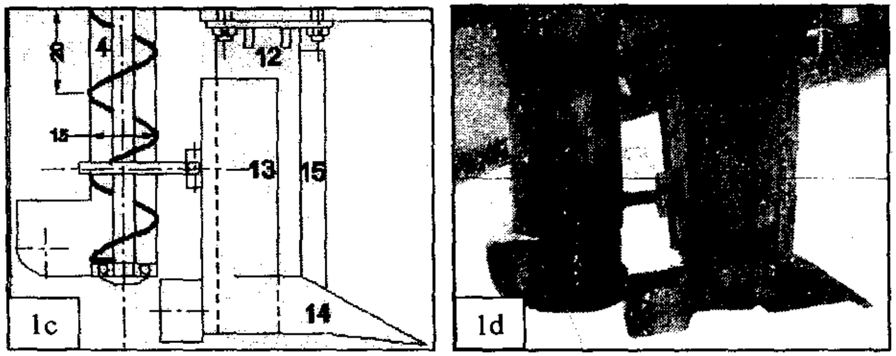

Fig.1c&d: Tube of residues injection and modified shank to protect the tube

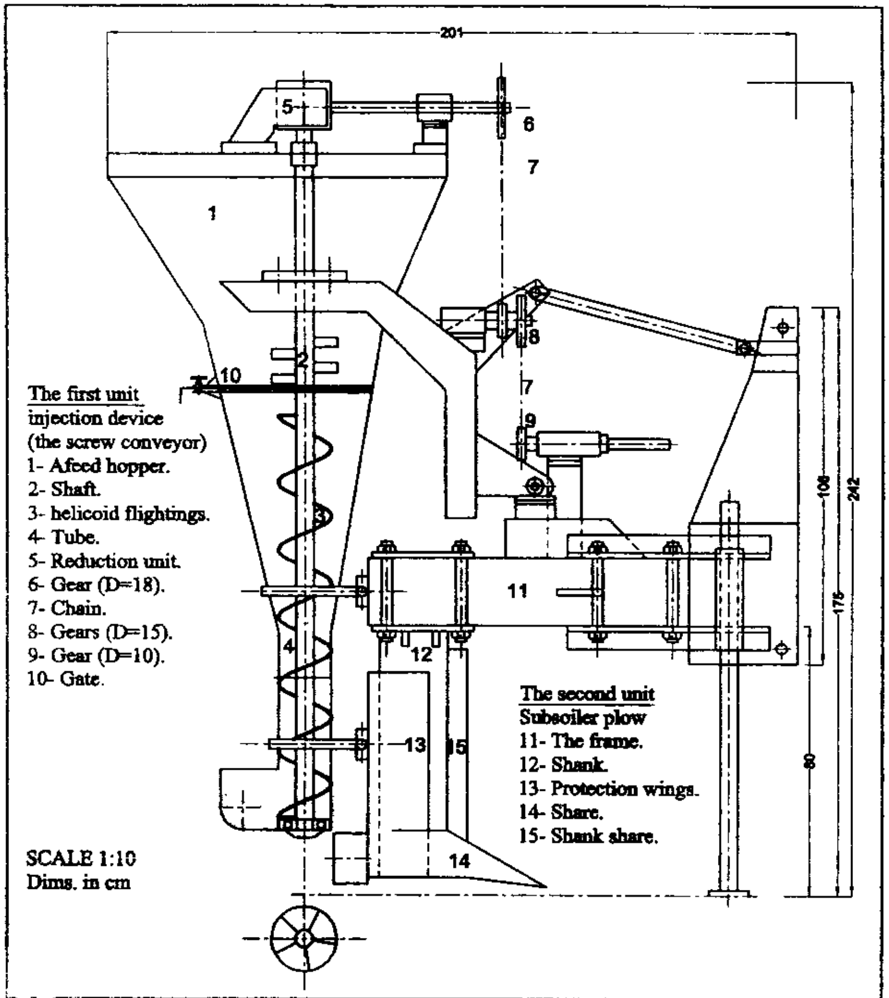

Fig.2 a: A schematic diagram number 2 of the injection machine (a screw conveyor and subsoiler plow), of agricultural residues and solid materials in the soil constricted by Dr- Wagdy El-Haddad. This machine has a good performance with the sand injection and chopping straw injection.
Field experiments were conducted on this machine

Fig 2c: Prototype NO.2 of the injection machine of agricultural residues and solid *materials in the soil*

Table 1: Specifications of the Injection machine

Items	Specifications
Length × Width × Height, cm	201× 100 ×242
Mass, kg	390
Source of power	Tractor engine, 160 hp (120 kW)
The first unit is injection device (screw conveyor)	
-The shaft dia, mm -------------------------------	45
-Helicoid flightings diameter, mm ------------------	150
-pitch auger, mm -----------------------------------	200
-Tube length of augers, mm ------------------------	1260
- Tube inside diameter, mm ------------------------	1550
-Auger flightings extend beyond the tube, mm. ----	350
-A feed hopper : (Pyramid funnel) L x W x H, mm -	1000×1000×1050
-The auger length, mm ------------------------------	1620
- Reduction unite of speed ------------------------	1: 2
-Inclination angles of auger (degrees) -----------	90°
The second unit (subsoiler plow):	
Mass, kg --	280
Shank length, mm ----------------------------------	700

Injection machine performance:

A mole drain is a tunnel 150 × 150 mm in square formed in clay soil by **injection machine**. These tunnels fill of sand or chopping straw in order to maintain tunnel form and not its collapse.

This unlined tunnel acts as a conduit to remove water from the soil, Figure 2. Mole drains are spaced about 4 m apart and are 0.6 m deep.

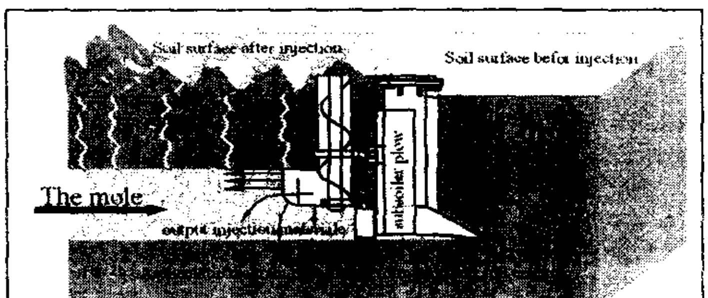

Fig.2b. Mole formation

This provides an intensive drainage system suitable for heavy clay soils that quickly removes excess water from the root zone and much less interception of saline groundwater than deeper traditional pipe drains.

Field experiments were conducted in heavy clay and salt affected soil at Meet El-Deeba Rice Mechanization Center - Kafrelsheikh Governorate. Some physical and chemical properties of the experimental field were measured and summarized in table 2.

Table 2. Physical and chemical properties of soil before injection

ECe* dsm^{-1} at 26 °C	SAR*	pH**	Basic I.R. (cm/hr)	Cum. (cm)	Particle size distribution Sand%	Silt%	Clay%	Texture
4.5 - 6.69	12.3	8.2	2.0	3.5	23.1	25.3	51.6	Clay

* Measured in soil paste extract ECe= electrical conductivity SAR = sodium adsorption ratio
** Measured in 1:2.5 soil water suspension. Basic I.R.= Infiltration rate Cum = Cumulative infiltration

The mean of soil moisture content from 0 level to 60 cm deeps were measured and summarized in Table (3).

Table3: Average moisture content of soil before plowing and injection

Soil depth, cm	0 - 15	15 - 30	30 - 45	45 - 60
Moisture content, %	12.31	21.34	28.94	31.78

The average of some physical properties and analysis results in table (4)

Table 4: Some characteristics of the used organic residues and sand

Residual type and Solid materials	Straw length, (cm)	Sand diameter, (mm)	Coef.of friction μ_1	μ_2	Bulk density, g/cm^3	mc,% (db)
Rice straw	0.5 to 5	-------	0.4	0.6	0.0802	4.30
Sand	--------	1 to 3	0.8	0.9	1.560	6.4

μ_1 = material-metal friction μ_2 = material- material friction

3.3. Experimental Procedures:

Fig 2d: Showing each straw residues (chopping) and sand samples were weighted and fed gradually to the feed opening

The machine was evaluated with operating parameters such as: four different forward speeds of 0.20, 0.25 0.333 and 0.50 m/s (0.72, 0.90, 1.2, and 1.8 km/h). Four screw (auger) rotational speed of 100,150,200 and 250 r.p.m, Three gate area of discharge of 250 , 500 and 750 cm^2 .One mole depth of 60 cm. and one organic plant residues (rice straw after chopping) and solid material (sand). Mean of three replications of each variable was taken to represent the effect of this variable. The machine was run and each crop residues sample (grinding) was weighted and fed gradually to the feed opening manually within approximately 120 second.

3.4. The Measurements: were carried out to evaluate the residues flow inside the soil, three parameters were determined. The discharge rate (D) g/min, the volumetric efficiency percentage (η_v) and penetration resistance (N/cm^2). Bulk density was measured by filling a known container volume with the straw residues and solid material (sand) then the mass of straw residues and the sand was determined and the bulk density was calculated from principle equation.

$$\rho b = m/v \qquad \text{-----------------} \; 1$$

Where:

ρb =The bulk density of the residues, g/cm^3;

m =The mass of the residues, g;

v =The volume of the residues, cm^3.

The moisture content of residues (rice straw stalks after chopping) were determined. Samples were oven dried at 105°C for 24 hours. All moisture percentages were determined on wet basis to the following equation:

$$M_w = \frac{W_1 - W_2}{W_1} \times 100, \quad \% \qquad \text{--------------} 2$$

Where:

M_w =The moisture content of sample on wet basis, %;

W_1 =Weight of wet sample, N and

W_2 =Weight of dry sample, N.

The time of run of the experiment was measured by means of a stop watch. A tachometer that engaged to the rotational speed of screw conveyor. **Physical properties of soil** variety was evaluated ***(as shown in table2)*** which was very important to modify the machine No. 2. An average of three replicates of this procedure was taken. The bulk density g/cm^3, discharge rate g/min, power consumption (kW), Specific power requirements of an auger (W.s / kg.m) were estimated for each test

3.6. The discharge rate, kg/s (Injection machine discharge):

The discharge rate was calculated as follows:

$$D = W3600/t \qquad \dots\dots\dots\dots\dots\dots 3$$

Where:

D = discharge rate, g/s
W = the mass of sample, g and
t = Injection time in second.

$$Q_a = D/\rho \qquad \text{------------------------4}$$

Where:

Q_a = actual volume capacity, cm^3 /min
D = discharge rate, g / min
ρ = bulk density of the material, g /cm^3

3.6. The theoretical volumetric capacity of an auger is expressed as

$$Q_t = \frac{\pi}{4}\left(d_{sf}^2 - d_{ss}^2\right) L_p \times n \qquad \text{-------------5}$$

Where:

Q_t = theoretical volumetric capacity (m^3/s)

d_{sf} = screw flighting diameter (m)

d_{ss} = screw shaft diameter (m)

L_P = pitch length (m)

n = screw rotational speed (rev/s)

3.5. Actual volumetric capacity; cm^3/min

In reality the actual capacity of an auger is considerably less than the theoretical capacity. This results in loss of volumetric efficiency. The volumetric efficiency is defined as:

$$\eta_v = \frac{Q_a}{Q_t} \times 100 \qquad \text{----------------6}$$

Where:

η_v = volumetric efficiency; %

Q_a = actual volumetric capacity; cm^3/min

3.6. Screw conveyor performance was determined by using the application of dimensional analysis methods (Rehkugler and Boyd, 1962).

$$\frac{Q_a}{\frac{\pi}{4}\left(d_{sf}^2 - d_{ss}^2\right) l_p\, n} = 432 \times 10^{-6}\left(2\pi n \sqrt{\frac{l_p}{g}}\right)^{-0.44}\left(\frac{l_t}{l_p}\right)^{0.31} \times [f_1(\theta)]^{1.35}(\mu_1)^{-4.59}(\mu_2)^{-2.72}$$

Where:

g = acceleration due to gravity (m/s^2)

l_t = exposed screw intake length (m)

θ = angle of conveyor inclination, (degrees) $f1(\theta) = 1 + \cos^2\theta$

μ_1 = material-metal friction μ_2 = material- material friction

3.7. The power requirement of an auger: is expressed by the specific power. The specific power is defined as follows:

$$P' = \frac{P/L}{Q_a \rho_b} \qquad \text{------ ----------------------8}$$

Where:

P' = specific power, W.s / kg.m

P = total power, W

L = auger length, m

ρ_b = material bulk density, kg/m^3

Thus, the specific power is the power required to convey a unit mass throughput rate per unit auger length.

3.8. The draft force for pulling the injection machine (the subsoiler plow and injection device) measured by using two tractors and a calibrated hydraulic force dynamometer (5000 kg force capacity, accuracy of 50 kg) connected between the two tractors by a chain and the subsoiler plow was mounted on the rear tractor.

3.9. Power required for injection.

The power could be estimated according to the following equation:

Power =Net draft force (k N) × Injection forward speed (m/s), kW -----9

3.10. Width and depth of molling measurements.

The actual width and depth of mole were measured and determined by using across section into soil at depth 60 cm.

3.11. The penetration resistance of soil were measured before plowing and irrigation (without injection the residues) and after plowing and irrigation (with injection the residues). Japanese con penetrometer, model SR-2 Dik 5500 was used to measure the penetration resistance of soil.

3.12. Soil bulk density (Db g/cm^3) was determined by using the core methods (Vomocil, 1986).

3.13. Total porosity (E,%) and void ratio (e) were calculated by using the following equation :-

$$E,\% = (1 - \frac{Db}{Dr}) \times 100 \qquad \textbf{and -------- 10}$$

$$e = \frac{Dr}{Db} - 1 \qquad \textbf{--------- 11}$$

Where:

Db : is the bulk density, g/cm^3

Dr : is the real density, taken as 2.65 g/cm^3

***Before plowing and injection** (without injection the residues) and after plowing and injection (with injection the residues) soil samples (0-20, 20-40 and 40 – 60) cm depths) were collected from each plot to determine some soil physical properties above mentioned.

3.14. The soil infiltration rate

Double ring infiltrometer was used to determine the soil infiltration rate according to Garcia (1978). Electrical conductivity (EC).and sodium adsorption ratio (SAR) were measured according to the methods described by Iackson (1958)

3.15. The mole filling efficiency was calculated by using the following equation:

$$\text{Mole filling efficiency (\%)} = \frac{\text{Volume of injected material into mole,} (m^3/\,min)}{\text{Volume of constructed mole into soil,} (m^3/\,min)} \times 100$$

Where :

Volume of injected material into mole , (m^3/ min) = Actual volumetric capacity of an auger; (m^3/min)

Volume of constructed mole into soil, (m^3/ min) = Theoretical (Design) mole cross Sectional area (m^2) × Length of molling line (m)

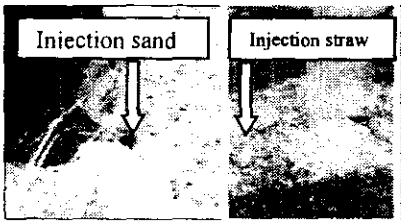

Fig2e: Volume of injected material into mole,(m^3/ min) =Actual volumetric capacity of auger; m^3/ min

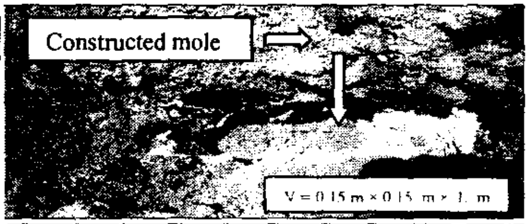

Fig 2f: Volume of constructed mole into soil, (m^3/ min) = Theoretical (Design) mole cross sectional area (m^2) ×Length of molling line (m)

RESU LTS AND DISCUSSION

4.1. Effect of screw (auger) rotational speed and gate area of discharge on actual volumetric capacity of the auger; (m^3/ min):

The effects of auger speeds on actual volumetric capacity of the auger as affected by different variables are shown in Table 5 and Figure 3. The results indicated that, the actual volumetric capacity of the auger increased as the auger speed increased when other variables were kept constant.

At auger speed of 100 r.p.m, gate area of discharge of 250 cm^2 and forward speed of 0.72 km/h, when the auger speed increased from 100 to 250 r.p.m. It was found that actual volumetric capacity of the auger increased from 0.105 to 0.152 m^3/ min (by increasing ratio of 44.76 %). while it slightly decreased to 0.132 m^3/ min when forward speed increased to 1.8 km/h, (by decreasing rate of 25.71 %) This result may be due to increasing forward speed tends to decreasing volume of injected material into mole. Also, at the same auger speed, the actual volumetric capacity of the auger was generally increased by increasing gate area of

discharge materials. At auger speed of 250 r.p.m, the actual volumetric capacity of the auger increased from 0.257 to 0.290 m^3/ min at gate area of discharge 750 cm^2 (by increasing ratio of 12.84 %). The highest actual volumetric capacity was obtained with 250 r.p.m auger speed , 750 cm^2 gate area of discharge and forward speed of 1.8 km/h,

The data in Table 5 indicated that, the actual volumetric capacity of an auger is considerably less than the theoretical volumetric capacity. This results in loss of volumetric efficiency of an auger due to variables affecting screw conveyor performance such as tube inside diameter, outside screw diameter, screw length, screw pitch length, exposed screw intake length, angular speed, angle of conveyor inclination, material bulk density, material- material friction and acceleration due to gravity.

4.2. Effect of screw (auger) rotational speed and gate hole area of discharge on volumetric efficiency of an auger; % at different forward speed of tractor:

Table 6 and Figure 4 show the results of volumetric efficiency of an auger; % as affected by screw (auger) rotational speed, gate hole area of discharge and forward speed of tractor. The data indicated that , generally, the volumetric efficiency of an auger was decreased with increasing screw (auger) rotational speed at all gate hole area of discharge, while , it increased with increasing gate area of discharge at constant auger speed. At 750 cm^2 gate hole area of discharge, increasing auger rotational speed from 100 to 250 r.p.m tends to decrease volumetric efficiency of the auger from 46.10 to 30.84% (by decreasing ratio of 33.10 %), while, at 100 r.p.m auger rotational speed, when increasing

Table 5: Effect of screw (auger) rotational speed and gate area of straw discharge on the theoretical volumetric capacity and actual volumetric capacity of the auger; (m^3/ min) at various forward speeds, km/h.

Screw rotational speed, (r.p.m)	Gate area of straw discharge to auger, cm^2	Forward speeds, km/h					Forward speeds, km/h				
		0.0	**0.72**	**0.90**	**1.2**	**1.8**	**0.0**	**0.72**	**0.90**	**1.2**	**1.8**
		Theoretical volumetric capacity of the auger, (m^3/ min.)					Actual volumetric capacity of the auger; (m^3/min.)				
100	**250**	0.321	0.386	0.418	0.449	0.482	0.088	0.105	0.114	0.123	0.132
	500	-	-	-	-	-	0.114	0.137	0.148	0.160	0.172
	750	-	-	-	-	-	0.148	0.178	0.193	0.208	0.224
150	**250**	0.482	0.514	0.546	0.579	0.611	0.110	0.117	0.124	0.132	0.139
	500	-	-	-	-	-	0.143	0.152	0.161	0.172	0.181
	750	-	-	-	-	-	0.186	0.198	0.209	0.223	0.235
200	**250**	0.643	0.675	0.707	0.739	0.771	0.130	0.136	0.143	0.149	0.156
	500	-	-	-	-	-	0.169	0.177	0.186	0.194	0.203
	750	-	-	-	-	-	0.220	0.230	0.242	0.252	0.264
250	**250**	0.801	0.835	0.867	0.899	0.931	0.146	0.152	0.158	0.164	0.170
	500	-	-	-	-	-	0.190	0.198	0.205	0.213	0.221
	750	-	-	-	-	-	0.247	0.257	0.267	0.281	0.290

Table.6: Effect of screw (auger) rotational speed and gate area of straw discharge to auger on volumetric efficiency of an auger; % at various forward speeds, km/h. (without and with forward movement of tractor).

Screw rotational speed, (r.p.m)	Gate area of straw discharge to auger, cm^2	Forward speeds, km/h				
		0.0	0.72	0.90	1.199	1.8
		Volumetric efficiency of an auger; %				
100	250	27.41	27.20	27.27	27.39	27.40
	500	35.51	35.50	35.41	35.35	35.70
	750	46.10	46.11	46.17	46.33	46.47
150	250	22.82	22.76	22.71	22.80	22.75
	500	29..66	29.57	29.49	29.71	29.62
	750	38.59	38.52	38.28	38.51	38.46
200	250	20.22	20.15	20.23	20.16	20.23
	500	26.28	26.22	26.31	26.25	26.33
	750	34.21	34.10	34.22	34.10	34.24
250	250	18.23	18.20	18.22	18.24	18.26
	500	23.72	23.71	23.64	23.69	23.74
	750	30.84	30.78	30.80	31.26	31.15

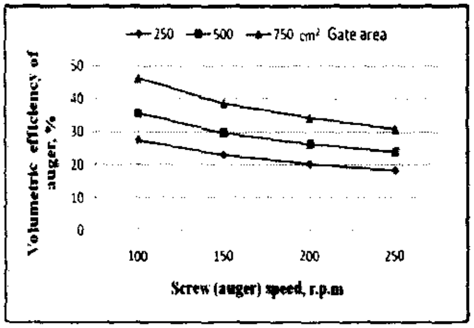

Fig.3: Effect of Screw (auger) rotational speed and gate area of straw discharge to auger on volumetric efficiency of an auger; % without forward movement of tractor.

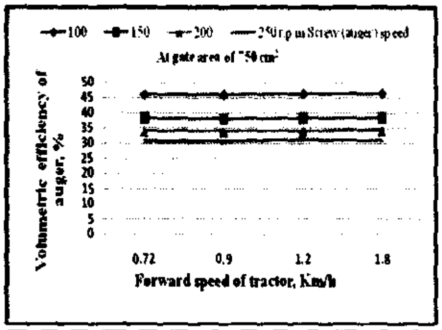

Fig.4: Effect of forward speed of tractor and screw (auger) rotational speed on volumetric efficiency of an auger; % at gate area of 750 cm^2 of straw discharge to auger.

gate area of discharge from 250 to 750 cm^2, the volumetric efficiency of the auger increased from 27.71 to 46.10%. From the results revealed above, it can be seen that volumetric efficiency of the auger is low with lower auger rotational speed. Also, is high with higher gate hole area of discharge.

Table.7: Effect of screw (auger) rotational speed and gate area of straw discharge on actual sand discharge rate into soil and actual straw discharge rate into soil; (kg/ min) at various forward speeds, km/h.

Screw rotational speed, (r.p.m)	Gate area of straw discharge to auger, cm²	Forward speeds, km/h					Forward speeds, km/h				
		0.0	0.72	0.90	1.2	1.8	0.0	0.72	0.90	1.2	1.8
		Actual sand discharge rate into soil , kg/min					Actual straw discharge rate into soil, kg/min				
100	250	137.3	163.8	177.8	191.9	205.9	7.042	8.402	9.129	9.840	10.56
	500	177.4	213.7	230.9	249.6	268.3	9.122	10.96	11.84	12.80	13.76
	750	230.9	277.7	301.1	324.5	349.4	11.84	14.24	15.44	16.64	17.92
150	250	171.6	182.5	193.4	205.9	216.8	8.802	9.362	9.922	10.56	11.23
	500	223.1	237.1	251.2	268.3	282.4	11.44	12.16	12.88	13.76	14.48
	750	290.2	308.9	326.0	347.9	366.6	14.88	15.84	16.72	17.84	18.80
200	250	202.8	212.2	223.1	232.4	243.4	10.40	10.88	11.44	11.92	12.48
	500	263.6	276.1	290.2	302.6	316.7	13.52	14.16	14.88	15.52	16.24
	750	343.2	358.8	377.5	393.1	411.8	17.60	18.40	19.36	20.17	21.13
250	250	227.8	237.1	246.5	255.8	265.2	11.68	12.16	12.64	13.12	13.60
	500	296.4	308.9	319.8	332.3	344.8	15.20	15.84	16.40	17.04	17.68
	750	385.3	400.9	416.5	438.4	452.4	19.76	20.57	21.37	22.49	23.21

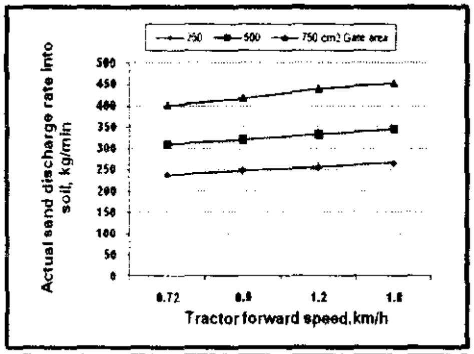

Fig.5: Effect of tractor forward speeds and gate area of sand discharge on actual sand discharge rate into soil; (kg/ min) at auger rotational speed of 250 r.p.m

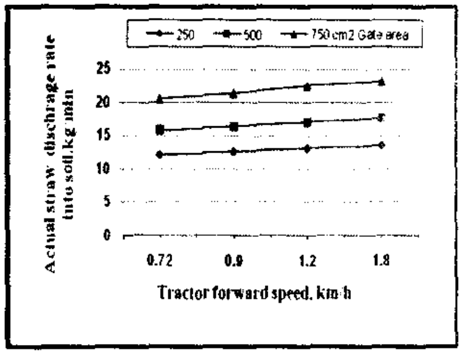

Fig.6: Effect of tractor forward speeds and gate area of straw discharge on actual straw discharge rate into soil; (kg/ min.) at auger rotational speed of 250 r.p.m

Table 8: Effect of screw (auger) rotational speed, gate area of straw discharge and forward speeds on mole filling efficiency (%)

Screw rotational speed, (r.p.m)	Gate area of straw discharge to auger, cm^2	Forward speeds, km/h (m/min.)					Forward speeds, km/h (m/min.)					Forward speeds, km/h (m/min.)				
		0.0	0.72 (12)	0.90 (15)	1.2 (20)	1.8 (30)	0.0 (0.0)	0.72 (12)	0.90 (15)	1.2 (20)	1.8 (30)	0.0 (0.0)	0.72 (12)	0.90 (15)	1.2 (20)	1.8 (30)
		Volume of constricted mole into soil, (m^3/ min.)					Volume of injected material into mole, (m^3/ min.) = (Actual volumetric capacity of the auger; (m^3/min.)					Mole filling efficiency (%)				
100	250	-	0.270	0.338	0.450	0.675	-	0.105	0.114	0.123	0.132	-	38.89	33.73	27.33	19.65
	500	-	0.270	0.338	0.450	0.675	-	0.137	0.148	0.160	0.172	-	50.74	43.79	35.56	25.48
	750	-	0.270	0.338	0.450	0.675	-	0.178	0.193	0.208	0.224	-	65.93	57.10	46.22	33.19
150	250	-	0.270	0.338	0.450	0.675	-	0.117	0.124	0.132	0.139	-	43.33	36.69	29.33	20.59
	500	-	0.270	0.338	0.450	0.675	-	0.152	0.161	0.172	0.181	-	56.30	47.63	38.22	26.81
	750	-	0.270	0.338	0.450	0.675	-	0.198	0.209	0.223	0.235	-	73.33	61.83	49.56	34.81
200	250	-	0.270	0.338	0.450	0.675	-	0.136	0.143	0.149	0.156	-	50.37	52.96	33.11	23.11
	500	-	0.270	0.338	0.450	0.675	-	0.177	0.186	0.194	0.203	-	65.56	55.03	43.11	30.07
	750	-	0.270	0.338	0.450	0.675	-	0.230	0.242	0.252	0.264	-	85.19	71.90	56.00	39.11
250	250	-	0.270	0.338	0.450	0.675	-	0.152	0.158	0.164	0.170	-	56.30	46.75	36.44	25.19
	500	-	0.270	0.338	0.450	0.675	-	0.198	0.205	0.213	0.221	-	73.33	60.65	47.33	32.74
	750	-	0.270	0.338	0.450	0.675	-	0.257	0.267	0.281	0.290	-	95.19	78.99	62.44	42.96

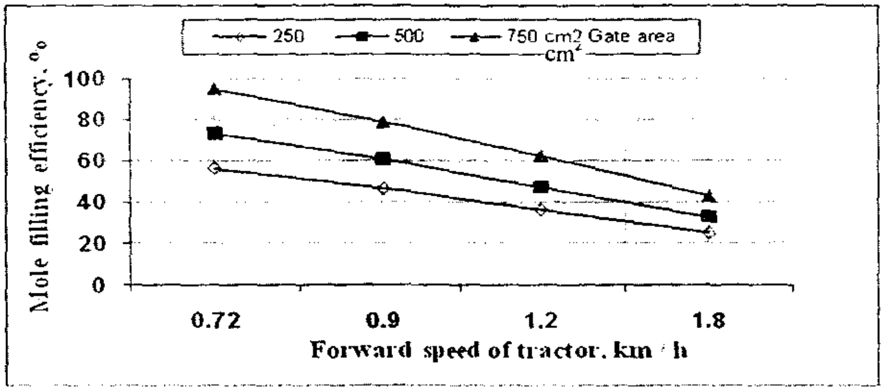

Fig 7: Effect of tractor forward speeds, gate area of straw discharge on mole filling efficiency (%) at auger rotational speed of 250, r.p.m

4.3. Effect of tractor forward speeds, km/h and gate hole area of discharge on mole filling efficiency (%):

Table 8 and Figure 7 show the results of tractor forward speeds, km/h and gate hole area of discharge on mole filling efficiency (%). The data indicated that, generally, the mole filling efficiency was decreased with increasing tractor forward speeds, while, it increased with increasing gate area of discharge at constant auger speed. At 750 cm^2 gate hole area of discharge, increasing tractor forward speed from 0.72 to 1.8 km/h tends to decrease mole filling efficiency from 65.93 to 33.19% (by decreasing ratio of 49.66 %), while, at 250 r.p.m auger rotational speed, when increasing gate area of discharge from 250 to 750 cm^2, the mole filling efficiency increased from 56.30 to 95.19% at 0.72 km/h tractor forward speed. From the results revealed above, it can be seen that mole filling efficiency is low with lower tractor forward speed. Also, is high with higher gate hole area of discharge.

Table.9: Effect of tractor speed on draft power, specific power of an auger and mole filling efficiency at auger rotational speed of 250 r.p.m , gate area of 750 cm^2 of straw discharge to auger and mole depth, 60 cm

Tractor speed, m/s (km/h)	Net draft, kg	Net draft, kN	Net draft power, kW	Specific power of an auger, W.s / kg.m		Mole filling efficiency (%)
				Sand	Straw	
0.20 (0.72)	1950	19.13	3.83	0.0983	1.912	95.19
0.25 (0.9)	2200	21.58	5.40	0.1334	2.594	78.99
0.33 (1.2)	2800	27.47	9.15	0.2147	4.177	62.44
0.50 (1.8)	3150	30.90	15.45	0.4239	8.248	42.96

Net draft = draft, (with load) - draft, (no load) Net draft power, kW = draft, kN (with load) - draft, kN (no load)

4.4. Effect of mole constriction depth, mole space and treatments type on Infiltration rate, electrical conductivity, sodium adsorption ratio, bulk density, total porosity void ratio and penetration resistance :

The data in Table 10 indicated that, infiltration rate was decreased with increasing mole depth and it recorded the results best with treatment of (Subsoiler +Sand) and treatment of (Subsoiler +Chopping rice straw). Sodium adsorption ratio and electrical conductivity were decreased and gave results best with treatment of (Subsoiler +Sand) and treatment of (Subsoiler+Chopping rice straw).This refer, successful injection machine in improvement some physical and chemical properties of soil after injection. Table10. In conclusion soil penetration resistance decreased with soil bulk density decreased. It decreased with void ratio increased. Hence, decreasing of soil penetration resistance increased plant ability to penetrate the soil surface and effect in crop yield as shown in Table10&11.

Table10: Effect of mole constriction depth and treatments type on soil Infiltration rate, electrical conductivity, sodium adsorption ratio, bulk density, total porosity, void ratio and penetration resistance at mole space of 4 m. after harvesting.

Treatments type	Mole constriction depth, (cm)	Mole space, 4 m						
		Infiltration rate (cm /h)	Electrical conductivity, (EC) (dS /m)	Sodium adsorption ratio, (SAR) (meq.Lit)	Bulk density, kg/cm^3	Total porosity, (E,%)	Void ratio, (e)	penetration resistance, N/cm^2
(Control) Without subsoiler and residues	0 - 20	2.0	4.5	10.46	1.45	54.72	0.83	210
	20 - 40	1.7	6.69	15.36	1.55	58.49	0.71	280
	40 - 60	1.5	5.1	11.14	1.62	61.13	0.64	300
Subsoiler	0 - 20	2.8	2.8	8.25	1.25	52.83	1.12	200
	20 - 40	2.4	1.8	6.62	1.34	49.43	0.98	260
	40 - 60	2.2	1.85	6.71	1.40	47.16	0.89	268
Subsoiler + Sand	0 - 20	3.2	2.2	7.32	1.36	48.67	0.95	195
	20 - 40	2.7	1.75	6.53	1.44	45.66	0.84	255
	40 - 60	2.3	2.2	7.32	1.51	43.01	0.75	270
Subsoiler + Chopping rice straw	0 - 20	2.9	2.4	8.15	1.36	49.06	0.95	197
	20 - 40	2.5	1.9	6.57	1.42	46.42	0.87	258
	40 - 60	2.15	2.0	6.95	1.53	42.26	0.73	271

4.5: Effect of treatment type on some characteristics of the corn stalks crop and productivity. Table (11): Shows the results of corn stalks crop and productivity after harvesting where productivity was increased from 14.293 to 27.172 ton/fed with treatment of (Subsoiler +Sand), while it slightly increased from 14.293 to 20.027 with treatment of (Subsoiler +Chopping rice straw) at moisture content of 75 %.

Table (11): Some characteristics of the corn stalks crop and productivity after harvesting under moisture content of 75%, at different treatments

Treatment type	NO	Stalks Length (cm)	Stalks diameter(mm)		Round ness, %	Mass, g	Productivity in m^2 (kg)	Productivity in fed (ton)
			Minimum dim.	Maximum dim.				
(Control) Without subsoiler and residues	1	99.00	10.18	11.78	86.42	72.89	3.573	14.293
	2	143.00	12.50	13.65	91.58	137.84		
	3	135.00	11.05	12.07	91.55	96.01		
	4	140.00	12.59	14.20	88.66	202.97		
	5	157.00	13.33	15.42	86.45	154.20		
	6	170.00	13.00	15.55	83.60	182.32		
	7	189.00	11.42	12.84	88.94	167.38		
	8	154.00	12.66	15.02	84.29	164.15		
	9	110.00	11.98	13.31	90.01	133.92		
	10	96.00	12.87	13.55	94.98	110.25		
Total		1393.00	122.03	137.39	888.24	1421.93		
Mean		139.30	12.203	13.739	88.82	142.93	3.573	14.293
Subsoiler	1	112.00	8.56	9.59	89.26	61.41	4.769	19.076
	2	140.00	10.72	11.78	91.00	101.71		
	3	125.00	12.87	13.04	98.69	113.26		
	4	160.00	10.44	10.82	96.49	98.47		
	5	140.00	11.46	12.53	91.46	123.73		
	6	145.00	10.79	13.44	80.28	125.14		
	7	219.00	16.53	19.52	84.68	364.47		
	8	226.00	15.76	17.23	91.47	308.14		
	9	174.00	15.98	17.59	90.85	264.69		
	10	239.00	17.34	19.82	87.49	407.94		
Total		1688.0	130.47	147.55	884.24	1907..55		
Mean		168.80	13.047	14.755	88.42	190.755	4.769	19.076
Subsoiler + Sand	1	160.00	16.30	17.22	94.66	242.63	6.786	27.172
	2	178.00	16.11	18.07	89.15	278.01		
	3	185.00	14.42	16.97	84.97	248.90		
	4	177.00	17.91	18.57	96.45	206.73		
	5	150.00	17.25	18.01	95.78	291.91		
	6	183.00	16.68	18.71	89.15	296.57		
	7	177.00	16.35	19.00	86.05	482.78		
	8	188.00	19.41	21.54	90.11	317.50		
	9	184.00	15.46	16.33	94.67	208.58		
	10	150.00	12.07	14.69	82.16	140.62		
Total		1732.00	161.96	179.11	904.3	2714.01		
Mean		173.20	16.196	17.911	90.43	271.423	6.786	27.172
Subsoiler + chopping rice straw	1	145.00	11.52	12.34	93.35	136.86	5.005	20.027
	2	153.00	12.32	13.73	89.73	198.26		
	3	187.00	16.27	22.93	70.96	384.61		
	4	152.00	11.24	13.56	82.89	123.35		
	5	175.00	12.85	14.17	90.68	148.23		
	6	183.00	14.70	16.95	86.73	223.74		
	7	190.00	14.77	16.43	89.89	345.28		
	8	185.00	12.01	13.50	88.96	167.18		
	9	160.00	12.24	13.57	90.19	133.37		
	10	180.00	12.10	13.03	92.86	141.09		
Total		1710.00	130.02	150.21	854.8	2001.97		
Mean		171.00	13.002	15.21	85.48	200.197	5.005	20.027

CONCLUSION

The conclusions of this study are summarized as follow:

1-The actual volumetric capacity of an auger increased as the auger speed increased. The highest actual volumetric capacity of 0.290 m^3/ min was obtained with 250 r.p.m auger speed, 750 cm^2 gate area of discharge and forward speed of 1.8 km/h.

2-The gate area of straw discharge (750 cm^2) gave the highest values of machine productivity

3-The volumetric efficiency of the auger was decreased with increasing screw (auger) rotational speed at all gate holes area of discharge.

4-The mole filling efficiency was decreased with increasing tractor forward speeds, while, it increased with increasing gate area of discharge.

5- The maximum of actual sand and straw discharge rate into soil were 452.4 and 23.21 (kg/ min.) respectively at forward speed of 1.8 km/h, screw speed of 250 r.p.m and gate area of 750 cm^2.

6- The maximum of the mole filling efficiency was 95.19 % at gate area of discharge 750 cm^2 and 0.72 km/h tractor forward speed.

7- Infiltration rate was decreased with increasing mole depth and it recorded the results best with treatment of (Subsoiler + Sand) and treatment of (Subsoiler + Chopping rice straw).

RECOMMENDATIONS: Take care not stand of the tractor during the auger operate, during the injection process because it leads to the absence of a tunnel for the discharge of material transmitted in the inside it, of which increases the load on the injection machine and the tractor and lead to cut the chain.

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الملخص العربي

تصميم وتصنيع جهاز حقن المخلفات الزراعية والمواد الصلبة فى التربة

د/وجدى زغلول الحداد*

ان تزايد الطلب في الاونة الاخيرة على ماكينات حقن المواد الصلبة وغير الصلبة داخل التربة مع ندرة وجودها ورغم عيوبها الكثيرة وادائها السيئ الا ان الطلب عليها يزيد عام بعد عام ويرجع هذا الى ضعف الأراضى المستصلحة حديثا وضعف الصرف بها الأمر الذى دعانا الى دراسة الألة ووضع حلول تطبيقية وتصميمية لأيجاد الة حقن تحقق متطلبات المزارع ومتطلبات عملية الحقن دون مشاكل فى اداء العملية نفسها أو فى الألة. ومن ابرز العيوب التى تم التعرف عليها الأتى:-

١-ضيق مقطع انبوبة الحقن وعدم وجود حماية لها أثناء عملية الشق والحقن , والذى يشكل صعوبة فى السريان خلال الأنبوب والذى يؤدى بدوره الى عملية الدق المستمر على الأنبوب لتسهيل حركة المادة المحقونة الى التربة.

٢-عدم وجود قلاب داخل انبوبة الحقن وعدم امكانية تعديل المتاح وذلك لضيق مقطع الانبوب.

٣- فى بعض الأحيان يتواجد مقلب أعلى انبوب الحقن لا يؤدى العمل بكفاءة لأنه يحدث تفريغ حول المقلب من المادة المحقونة مما يعوق سريان المادة داخل الأنبوب وخاصة عند محتويات الرطوبة المرتفعة وهذا المقلب دائماً قابل للكسر.

٤-فشل عملية حقن المخلفات الزراعية بهذا التصميم المتعارف عليه. و تعتبر المخلفات الزراعية كنز لم يعرف المزارع المصرى اهميته وطاقته القصوى حتى الان لعدم توافر المعدات والالات والخدمات التى تتعامل وتتفاعل معه . حيث يصل حجم المخلفات الزراعية الى ما يقرب من ٢٥ مليون طن والاستفادة منها يزيد الدخل القومى بما يقرب من ١.٦ مليار جنية مصرى سنويا (البرى واخرون ٢٠٠١) . الامر الذى دعا الى اجراء دراسة موضوعية عن تصميم وتصنيع الات يضاف لعملها الاساسى التعامل مع المخلف المحصولى فتم تصميم وتصنيع محراث تحت التربة مزود بجهازلحقن التربة بالمخلفات (قش الارز) بعد فرمه وتقطيعه والمواد الصلبة (الرمل) ياخذ حركتة من عمود الادارة الخلفى للجرار .وفكرة الجهازمبنيةعلى قيام السلاح بشق التربة وعمل النفق على عمق ٦٠ سم وفى نفس الوقت اتمام عملية نقل المخلفات الزراعية (القش) والمواد الصلبة (الرمل) داخل النفق بواسطة بريمة داخل جهاز الحقن . وهذا التصميم أنهى جميع المشاكل.

وقد تم دراسة المتغيرات الآتية على أداء الآلة الجديدة و الخواص الطبيعية والكميائية للتربة والانتاجية وهى:-

- اربعة سرعات لبريمة حقن للمخلفات ١٠٠, ١٥٠, ٢٠٠, ٢٥٠ لفة/دقيقة
- وثلاث مساحات لبوابة تصرف الرمل او القش الى بريمة الحقن ٢٥٠, ٥٠٠ , ٧٥٠ سم^2
- واربعة سرعات امامية للجرار (٠.٧٢, ٠.٩٠ , ١.٢, ١.٨كم/ساعة)

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أوضحت نتائج التجارب أن :

١-السعة الحجمية الحقيقية للناقل البريمى زادت بزيادة السرعة الدورانية للبريمة وسجلت اقصى قيمة لها ٠.٢٩٠ م³ / دقيقة عند سرعة دورانية للبريمة ٢٥٠ لفة/ دقيقة ومساحة فتحة البوابة ٧٥٠سم² .

٢- **مساحة فتحة البوابة المغذية للناقل البريمى ٧٥٠سم² حققت اعلى تصرف** حقن للمادة المحقونة

٣ – **الكفاءة الحجمية للبريمة** تناقصت مع زيادة السرعة الدورانية للبريمة وذلك عند كل فتحات البوابة المغذية للناقل البريمى .

٤ – **كفاءة ملئ النفق** تناقصت مع زيادة السرعة الأمامية **للجرار** .

٥ – **أقصى تصرف فعلى للمادة المحقونة الرمل** داخل التربة كانت ٤٥٢.٤ كجم/دقيقة ولمادة القش المقطع كانت ٢٣.٢١ كجم/دقيقة وذلك عند سرعة امامية للجرار ١.٨ كم/ساعة ومساحة فتحة بوابة ٧٥٠ سم² وسرعة البريمة الدورانية ٢٥٠ **لفة/دقيقة.**

٦- **أقصى كفاءة ملئ** كانت ٩٥.١٩% عندما كانت **فتحة بوابة** التصرف للناقل البريمى٧٥٠ سم٢ والسرعة الأمامية للجرار ٠.٧٢ كم/ساعة

٧ – **معدل التشرب** تناقص مع زيادة عمق النفق. وزاد معدل التشرب مع الشريحة من الأرض المعاملة (بالمحراس تحت سطح التربة + **حقن الرمل) واعطت اعلى انتاجية** لمحصول الذرة الدراوة (٢٧.١٧٢ طن /فدان) ثم تلاه فى الترتيب الشريحة من الأرض المعاملة (بالمحراس تحت سطح التربة + حقن القش المقطع) **واعطت انتاجية** لمحصول الذرة الدراوة (٢٠.٠٢٧ طن /فدان)

وهذه النتائج مؤشر على مدى فاعلية ماكينة الحقن المصممة والمصنعة محليا واتمامها عملية الحقن داخل التربة على العمق المطلوب **للمخلفات الزراعية (القش)** والمواد الصلبة (الرمل). مما أدى الى تحسين الصرف وتحسين **الخواص الطبيعية والكميائية للتربة**

<u>**التوصيات:**</u> يراعى عدم وقوف الجرار أثناء تشغيل **الناقل البريمى أثناء** عملية الحقن لأن ذلك يؤدى الى عدم وجود نفق لتصريف المادة **المنقولة بداخلة** مما يزيد الحمل على ماكينة الحقن والجرار ويؤدى الى قطع الكاتينة .