Effect of Moldboard types, Two depths of Tillage and Two speeds of Tractor in some Physical Properties and Pulverization of Soil

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Abstract

A factorial experiment under randomized complete block design with three replication was conducted in the field in a collage of the Agricultural Engineering Science/ University of Baghdad in March 2022, to study the effect of two types of moldboard slatted and general purpose in some physical properties, pulverization of soil, the volume of disturbed soil and number of clods > 10 cm under two depths of tillage 15 and 25 cm and two speeds of tractor 4.146 and 7.224 km. h^{-1}. Slatted moldboard recorded a least (best) number of clods > 10 cm 4.58 clod. m^{-2}, soil bulk density 1.259 $g.cm^{-3}$, higher porosity 52.48 % and higher volume of disturbed soil 804.14 m^3. h^{-1}. Depth of tillage 25 cm a got higher volume of disturbed soil 967.21 m^3. h^{-1}. Depth 15 cm got lower number of clods > 10 cm 4.91 clod. M^{-2}, 1.209 $g.cm^{-3}$ and higher porosity 54.35 %. Speed of the tractor 7.224 km. h^{-1} got higher volume of disturbed soil 983.79 m^3/ h and least number of clods > 10 cm 7.50 clod/m^2. Speed of tractor is 4.146 km. h^{-1} got least bulk density 1.259 $g.cm^{-3}$ and best porosity 52.48 %.

Keywords: Field, Slatted Moldboard, Porosity, Soil, Plow and Tractor.

Introduction

In the Iraqi fields, the moldboard plow is the most implement common and widely used in primary tillage. The main purpose of the all kinds of moldboard plows for cut, lifting, inverting and pulverizing the furrow slice, therefore the moldboard plow achieve most of the aims of primary tillage. The bulk density is one of the physical properties of the soil that is affected by the movement of tractors and agricultural machinery over soil surface, which leads to compaction of the soil and increase soil density, while tillage operations leads to fragmentation, increasing soil size and decreasing soil density and increasing soil porosity (17). Choosing the tractor speed appropriate to the plowing depth, full tank tractor and operator skill increases the efficiency of the tillage process (1 and 15). Soil porosity is pore spaces facilitate the availability and movement of air or water within the soil environment, soil porosity determines how well liquids, gases, and heat can be stored and transmitted within the soil matrix, A greater porosity often indicates greater storage and transmission ability (25). Plowing agricultural fields improving the soil physical properties and prepared a suitable seedbed for germination and root growth (20). Muhsen (22) found in the silt loam soil decreased bulk density 7.09 and 3.03 % when increase speed of tractor from 2.54 to 5.77 km. h^{-1}, and soil porosity increased 6.57 and 3.44%. Volume of disturbed soil affected by the depth of tillage and the speed of tractor and increases with their increase. Alrweshdy *et.al* (8) fund the higher speed of tractor got the highest volume of disturbed soil. Alseah (9) fund increasing speed of tractor from 1.5 to 2.53 $km.h^{-1}$ increase the volume of disturbed soil from 441.4 to 813.5 $m^3. h^{-1}$. The pulverization index is a criterion for the ability of the plow to break up and moldering the soil, it is affected by the type of plow, depth of tillage, speed of tractor (plowing), texture of the soil and moisture of the soil (7 and 11). AL-Hashimy (6) mention that the appearance of tillage is one of the most important indicators of tillage efficiency. The aim of the study is to know and compare the performance of two types of moldboards, general purpose and slatted moldboard, which is designed and manufactured by the researchers, in volume distributed, number of clods > 10 cm, some physical properties of the soil (bulk density and soil porosity) and

Pulverization index.

Materials and Methods

Field Experiment

Field experiment was conducted University of Baghdad - collage of Agricultural Engineering Science in 2022. Soil moisture was 16 - 18 % when soil tilled. Soil samples were taken randomly from the field for analysis table (1).

Table 1. Field soil properties.

Soil texture	Sandy Loam	
Sand	g. kg^{-1}	572
Silt		340
Clay		88
PH	5.86	

Bulk density g/cm^3	1.44
Porosity %	45.66

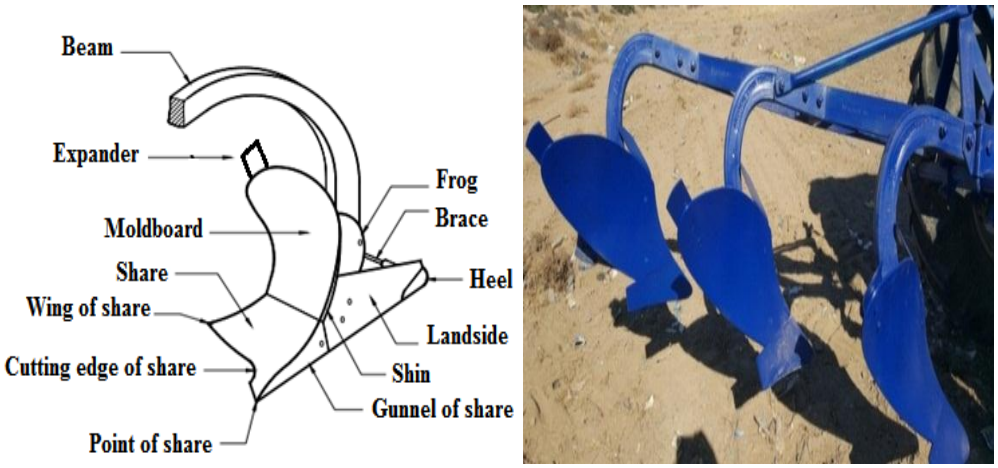
Experiment Design

Factorial experiment under randomized complete block design with three replication using least significant design (L.S.D) 5 % was used to compare the mean of treatments. Statistical analysis system (SAS) was used (26). Three factors were used in this experiment, first one was depths of tillage 15 and 25 cm, second factor was speed of tractor 4.146, 7.224 km.hr^{-1}, third factor was types of moldboard plow one of them designed and manufactured by researcher which slatted moldboard plow and second was general purpose moldboard. Experiment included 8 treatments with three replication for each treatment (2×2×2×3= 24 Treatments).

Tractor and Plow

New Holland tractor TD 80 with 75 hp was used in this experiment, four cylinder engine tractor and water cooling system, standard tires used as specified by the manufacturer with no damaged and all the tires pressures were adjusted. Operation tillage conducted with 2000 rpm engine tractor by put and control on lever fuel hand in tractor for all treatments in these experiment.

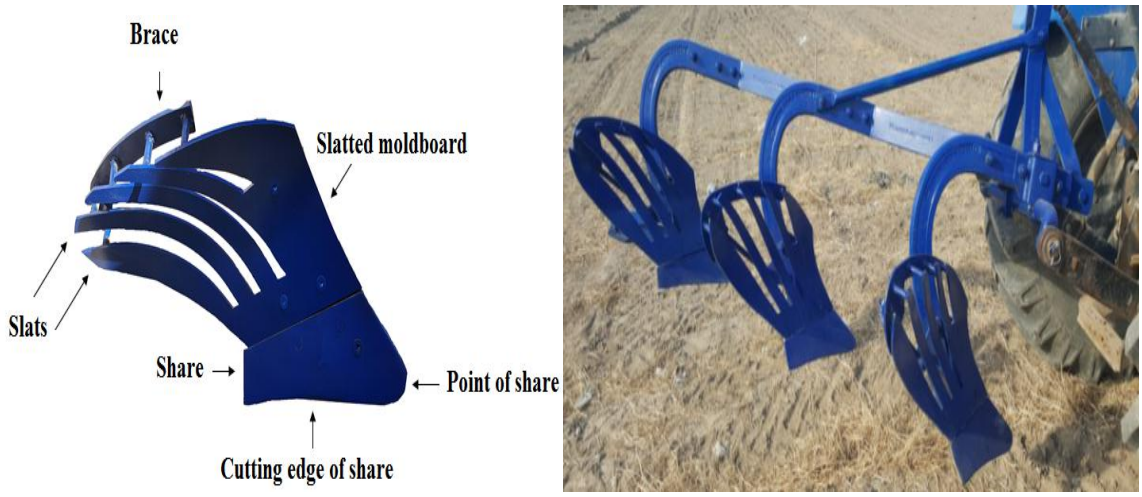
Moldboard plow contain 3 general purpose moldboard, total width 1.05 m, maximum depth work 27 cm and weight 316 kg, (fig.1).



a b

Fig.1 a- Schematic general purpose mold-board, b- Moldboard plow.

Slatted moldboard designed and manufactured by researcher, consist of five slats, tied in the plow instead of the original moldboard which was general purpose moldboard during the field experiment according to experiment design (fig.2).



a b

Fig. 2. a- Slatted moldboard, b- slats moldboard plow.

Performance Parameters

Volume of disturbed soil

The amount of soil raised by the plow during the plowing process for a known time and depends on the depth of plowing and the practical productivity, its unit is cubic meters per hour, and calculated by followed the equation (13 and 18):

$$SVD = 10000 \times EFC \times dt \qquad (1)$$

$$EFC = 0.1 \times V_a \times W_p \times ft \qquad (2)$$

Where *SVD* is soil volume disturbed in $m^3.h^{-1}$, *EFC* is Effective Field Capacity in (ha/h), *dt* was depth of tillage (m), *Va* was actual speed tractor in km/h, *Wp* was working actual width plow in m, *ft* coefficient estimate time for primary (0.75 – 0.85), and used 0.80 in these experiments (19) and 0.1 and 10000 was factor conversion.

Number of clods > 10 cm

Represents the appearance of tillage, the number of clods that appear after plowing the soil whose size is greater than 10 cm per square meter of the plowed soil. It calculated by calculating the number of clods with a size of more than 10 cm remaining above a half- square meter sieve (0.5 m × 0.5 m), the distance between one wire sieve and another 10 cm, then multiply the number of clods by four, so that its expression becomes the number of clods per square meter (18 and 8).

Bulk density

Bulk density of soil is usually determined from a core sample (cylindrical section) which is taken by driving a metal corer in to the soil at the desired depth and horizon.

Bulk density was measure before and after soil tillage by used core sample 5×5 cm. Three replication (samples) for each treatment we dried in oven at 105 C for 24 hours and weighed, then calculated from equation (12):

$$bd = \frac{ms}{vt} \qquad (3)$$

Where *bd* is the dry bulk density ($g.cm^{-3}$), *ms* is weight of the dried soil sample (g), and *vt* is total volume of the soil sample (cm^3).

Soil Porosity

Soil porosity refers to the fraction of the total soil volume that is taken up by the pore space (21). Porosity was measure by equation 3 according to (12), an assumed Practical density was 2.65 g. cm^{-3}.

$$P = \left(1 - \frac{bd}{td}\right) \times 100 \qquad (4)$$

Where *P* is porosity %, *td* is practical density (g. cm^{-3}) and *bd* is Practical density 2.65 $g.cm^{-3}$.

Pulverization Index

After conducting the tillage operation according to the experimental design, the field was left to dry for a week, then three random samples were taken from each treatment according to depths of tillage 15 and 25 cm and weighed, then sieved manually using six different diameters sieves 100, 50, 30, 12, 5 and 2 mm, weigh the remaining soil above each sieve according to the total weight of the sample by collecting soil accumulated weights on each sieve and then calculated the percentage of each weight on each weight on each sieve, according to the method mentioned in (7, 10, 16 and 21)

$$PI = \frac{\sum W_i \times X_i}{W} \qquad (5)$$

Where *PI* is Pulverization Index (mm), $\sum W_i$ is weight of soil collected on each sieve (kg), X_i is average diameter of the sieve used before and the sieve used after (mm), *W* is sample total weight (kg).

Results and Discussion

Volume of disturbed soil

Result showed the depth of tillage was significant effect on volume of disturbed soil, depth 25 cm recorded higher volume of disturbed soil 967.2 $m^3.h^{-1}$, while 15 cm was 632.8 $m^3.h^{-1}$, and that because of depth of tillage is one of the compounds in an equation for calculating the volume of disturbed soil, that result agree with (4 and 11). Tractor speed was significant effect on volume of disturbed soil, speed 7.224 km. h^{-1} was recorded higher value 983.7 $m^3.h^{-1}$, while speed 4.146 $km.h^{-1}$ recorded 616.2 $m^3.h^{-1}$, and that because of the speed of tractor is one of the components in practical productivity and increasing the productivity result to increase the volume of disturbed soil, and that result agree with Hamid (14). Moldboards types were significant effect on volume of disturbed soil, slatted moldboard recorded a slight increasing 804.1 m^3/h, while general purpose moldboard was 795.9 $m^3.h^{-1}$. Interaction depths of tillage and speeds of tractor were significant effects on volume of disturbed soil, interaction depth of tillage 25 cm and speed of tractor 7.224 $km.h^{-1}$ recorded higher value 1196.7 $m^3.h^{-1}$, while depth 15 cm and speed 4.146 $km.h^{-1}$ recorded least value 494.8 $m^3.h^{-1}$. Interaction depth of tillage and moldboard types were significant effects on volume of disturbed soil, depth 25 cm and slatted moldboard recorded higher value 971.4 $m^3.h^{-1}$, while depth 15 cm and general purpose moldboard got least value 628.8 $m^3.h^{-1}$. Interaction speed of tractor and moldboard types were significant effects on volume of disturbed soil, speed of tractor 7.224 $km.h^{-1}$ and slatted moldboard recorded higher value 989.7 $m^3.h^{-1}$, while speed 4.146 $km.h^{-1}$ and general moldboard got least value 613.9 $m^3.h^{-1}$. Interaction among depth of tillage, speed of tractor and moldboard types were significant effects on volume of disturbed soil, depth 25 cm, speed of tractor 7.224 $km.h^{-1}$ and

slatted moldboard recorded higher value 1202.2 $m^3.h^{-1}$, while interaction depth 15 cm and speed 4.146 km/h and general purpose moldboard was 492.9 $m^3.h^{-1}$ (fig.3).

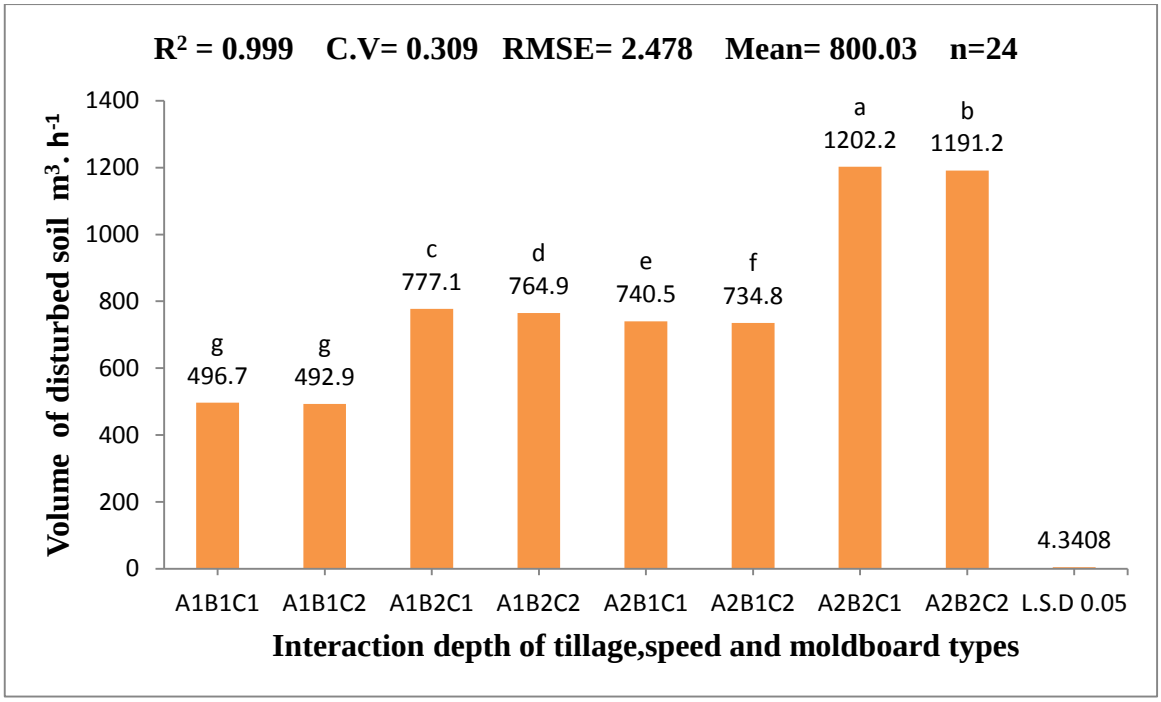


Fig. 3. Effect of depth of tillage, speed of tractor and moldboard types on volume of disturbed soil. A1=15 cm A2=25 cm B1= 4.146 B2= 7.224 km/h C1= Slatted moldboard C2= General purpose moldboard. (The same latter meaning No Significant).

Number of clods > 10 cm

Result showed depth of tillage was significant effect on number of clods > 10 cm, depth 15 cm recorded least value 4.9 clods.m^{-2}, while 25 cm got 12.2 clods/m^2, and that because of increase the soil depth is more solid and more density than surface soil. Tractor speed was significant effect on number of clods > 10 cm, speed 7.22 $km.h^{-1}$ was recorded least value 7.5 clods.m^{-2}, while speed 4.146 km/h recorded 9.6 clods.m^{-2}, and that result because of high speed tractor lead to throwing clods to further distances, which leads to more fragmenting and reduce the number of clods> 10 cm. Moldboard was significant effect on number of clods> 10 cm,

Slatted moldboard recorded least value 4.5 clods.m^{-2}, while general purpose moldboard got 12.5 clods. m^{-2}, because the soil slice slip and collides with the slats in slatted moldboard, which is exposed to dismantling and broken, while in general purpose the soil

Slice slip on moldboard. Interaction depths of tillage and speeds of tractor were significant effects on number of clods > 10, depth of tillage 15 cm and speed of tractor 7.224 $km.h^{-1}$ recorded least value

4.3 clods.m^{-2}, while interaction depth 25 and speed 4.146 km/h got 13.8 clods.m^{-2}. Interaction depths of tillage and moldboards were significant effects on number of clods > 10, depth 15 cm and slatted moldboard recorded least value 1.5 clods.m^{-1}, while depth 25 cm and general purpose moldboard got higher value 16.8 clods.m^{-2}. Interaction speeds of tractor and moldboards types were significant effects on number of clods > 10, speed of tractor 7.224 km.h^{-1} and slatted moldboard recorded leas value 4 clods .m^{-2}, while speed 4.146 km. h^{-1} and general moldboard got higher value 14.1 clods.m^{-2}. Interaction among depth of tillage, speeds of tractor and moldboards types were significant effects on number of clods > 10, depth 15 cm, speed of tractor 7.224 km.h^{-1} and slatted moldboard recorded least value 1.3 clods.m^{-2}, while interaction depth 25 cm and speed 4.146 km.h^{-1} and general purpose moldboard got higher value 19 clods.m^{-2} (fig.4).

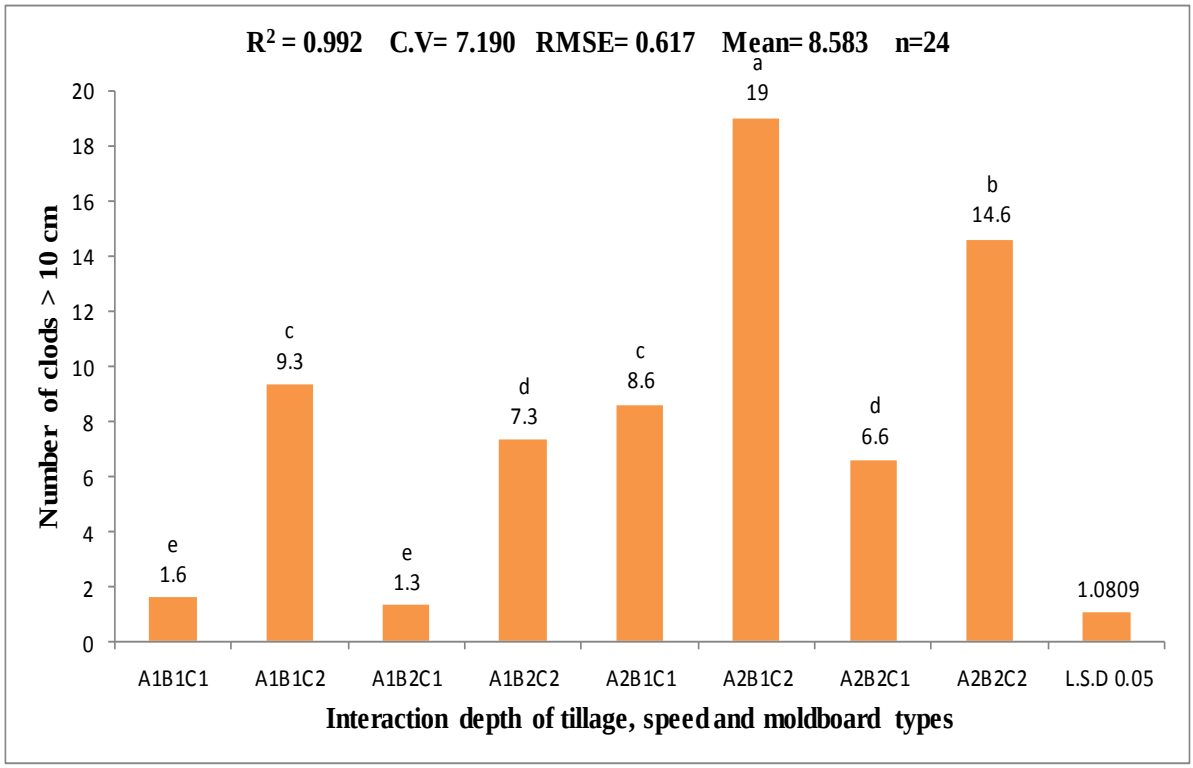


Fig.4. Effect of depth of tillage, speed of tractor and moldboard types in number of clods >10 cm.

Bulk density

Result showed depths of tillage was significant effects on bulk density, depth of tillage 15 cm recorded least bulk density 1.209 g.cm^{-3}, while 25 cm was 1.329 g.cm^{-3}, and that because of increase the load of up sheets of soil on, which lead to pressing the soil and increase the bulk density, that result agree with (3 and 5). Speed of tractor was significant effects on bulk density, increase speed result to increase the bulk density, speed 4.146 km.h^{-1} was recorded least value 1.259 g.cm^{-3}, while speed 7.146 km.h^{-1} recorded 1.280 g.cm^{-3}, and that because of increase fragmentation soil factor when increase speed of tractor, that result agree with (5). Moldboard was significant effects on bulk density, slatted

moldboard recorded 1.259 g. cm^{-3}, while general purpose moldboard was 1.280 g. cm^{-3}, and that because of increased fragmentation and volume of soil occupied by the plowed in slatted moldboard more than general purpose moldboard. Interaction depths of tillage and speeds of tractor were significant effects on bulk density, depth 15 cm and speed of tractor 4.146 km. h^{-1} recorded least value 1.204 g. cm^{-3}, while depth 25 cm and speed 7.224 $km.h^{-1}$ recorded higher value 1.345 $g.cm^{-3}$. Interaction depth of tillage and moldboards types were significant effects on bulk density, depth15 cm and slatted moldboard recorded least value 1.201 g. cm^{-3}, while depth 25 cm and general purpose moldboard got higher value 1.342 g. cm^{-3}. Interaction speeds of tractor and moldboards types were No significant. Interaction among depth of tillage, speed of tractor and moldboards were significant effects on bulk density, depth 15 cm, speed of tractor 4.146 $km.h^{-1}$ and slatted moldboard recorded best value 1.194 g. cm^{-3}, while interaction depth 25 cm and speed 7.224 km/h and general purpose moldboard was 1.359 g. cm^{-3} (fig.5).

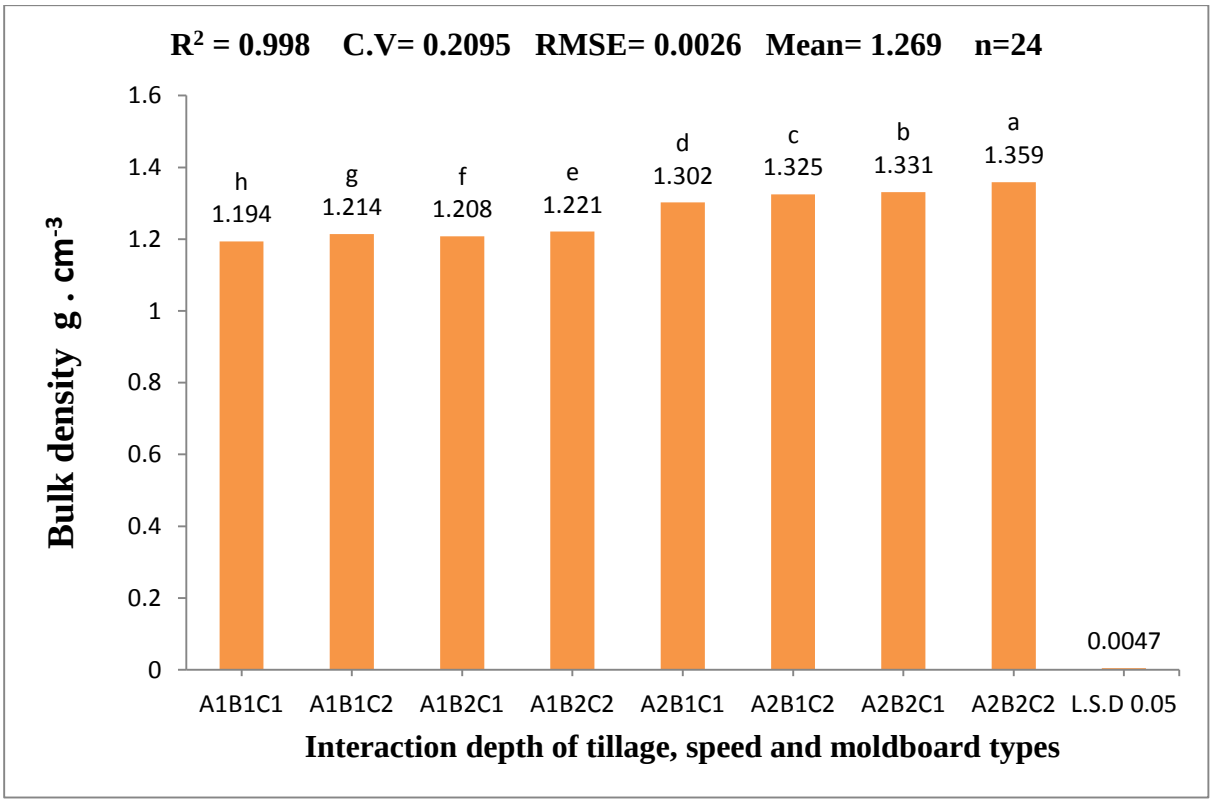


Fig. 5. Effect of depth of tillage, speed of tractor and moldboard types in bulk density.

Porosity

Result showed the depths of tillage was significant effects on the porosity, increase depth of tillage result decreasing porosity, depth 15 cm recorded higher porosity 54.351 %, while 25 cm was 49.820 %, and that because of increase the bulk density which lead to decrease the porosity, that result agree with (5). Speed of tractor was significant effects on the porosity, increasing speed of tractor result to decrease the porosity, speed 4.146 km. h^{-1} was recorded higher value 52.480 %, while speed 7.224 km. h^{-1} recorded 51.691 %, and that because of increase the speed of

tractor lead to increase press the soil and increase the bulk density which lead to decrease the porosity, that result agree with (5). Moldboard was significant effects on the porosity, slatted moldboard recorded higher porosity 52.483 %, while general purpose moldboard was 51.688 %, and that result affected by bulk density. Interaction depths of tillage and speed of tractor were significant effects on porosity, depth of tillage 15 cm and speed of tractor 4.146 km. h^{-1} recorded higher value 54.546 %, while depth 25 cm and speed 7.224 km. h^{-1} recorded least value 49.226 %. Interaction depth of tillage and moldboards types were significant effects on bulk density, depth 15 cm and slatted moldboard recorded higher value 54.672 %, while depth 25 cm and general purpose moldboard got least value 49.345 %. Interaction speeds of tractor and moldboard types were No significant. Interaction among depth of tillage, speeds of tractor and moldboards types were significant effects on porosity, interaction depth 15 cm, speed of tractor 4.146 km. h^{-1} and slatted moldboard recorded best value 54.930 %, while interaction depth 25 cm and speed 7.224 km. h^{-1} and slatted moldboard was 49.748 %, (fig.6).

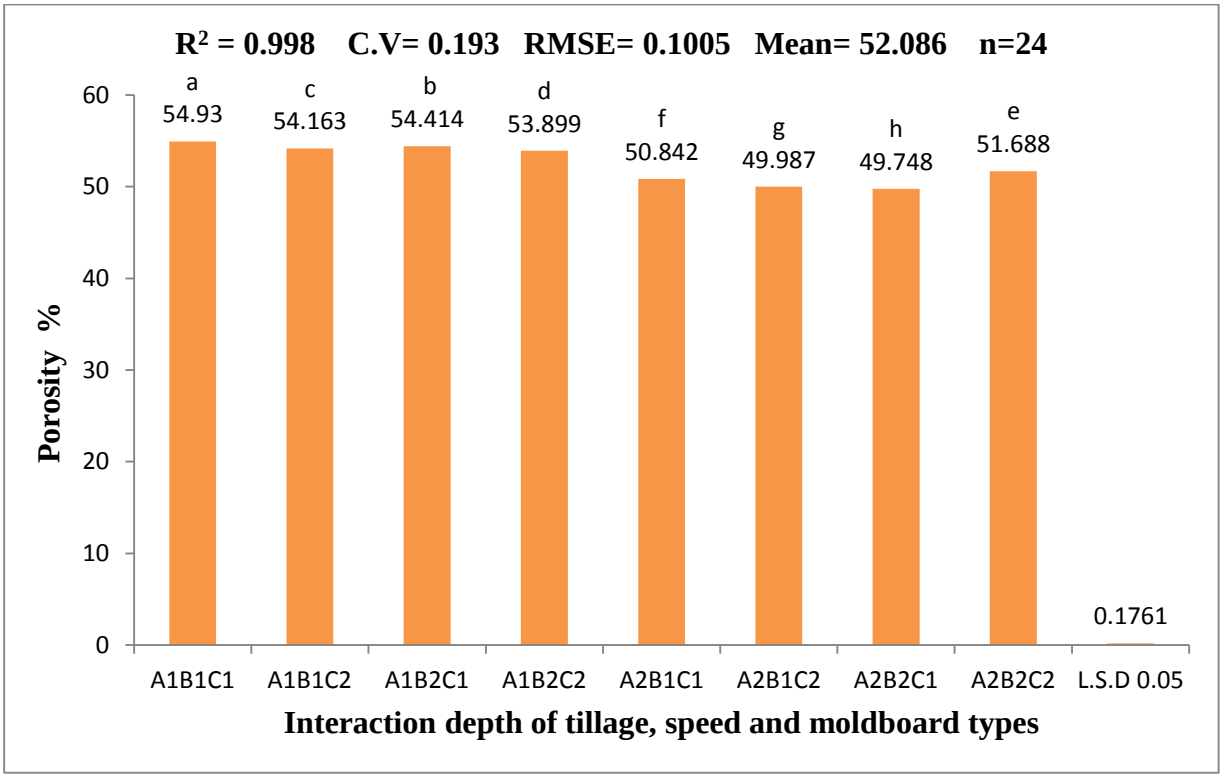


Fig. 6. Effect of depth of tillage, speed of tractor and moldboard types in porosity.

Pulverization Index

Result showed the depths of tillage was significant effects on pulverization index, depth of tillage 15 cm recorded best (least) pulverization index value 34.08 mm, while 25 cm got 51.32 mm, because of increase depth of tillage leads to increase the volume of distributed soil, which contain large diameters of clods, so the pulverization index increasing, that result agree with (7, 10, 23 and 24). Speed of tractor was significant effects on

pulverization index, Tractor speed 7.224 km. h^{-1} was recorded best value 39.02 mm, while speed 4.146 km. h^{-1} recorded 46.38 mm, because of the high plowing speed lead to a fast movement of the soil clods, which leads to ear crushing and fragmentation, and that result agree with (2, 7, 22 and 24). Slatted moldboard got best 34 mm, while general purpose moldboard got 51.40 mm, that because of slatted moldboard consist of five slats which make more fragmentation of soil. Interaction depths of tillage and speeds of tractor were significant effects on pulverization index, depth of tillage 15 cm and speed of tractor 7.224 km. h^{-1} got best value 29.99 mm, while depth 25 cm and speed 4.146 km. h^{-1} got 54.59 mm. Interaction depth of tillage and moldboards types were significant effects on pulverization index, depth 15 cm and slatted moldboard got best value 26.32 mm, while depth 25 cm and general purpose moldboard got higher value 60.97 mm. Interaction speeds of tractor and moldboards types were significant effects on pulverization index, speed 7.224 km. h^{-1} and slatted moldboard got 30.31 mm, while speed 4.146 km. h^{-1} and general moldboard got 55.07 mm. Interaction among depth of tillage, speeds of tractor and moldboards types were significant effects on pulverization index, depth 15 cm, speed of tractor 7.224 km. h^{-1} and slatted moldboard got best value 22.11 mm, while interaction depth of tillage 25 cm and speed 4.146 km. h^{-1} and general purpose moldboard got 64.33 mm (fig.7).

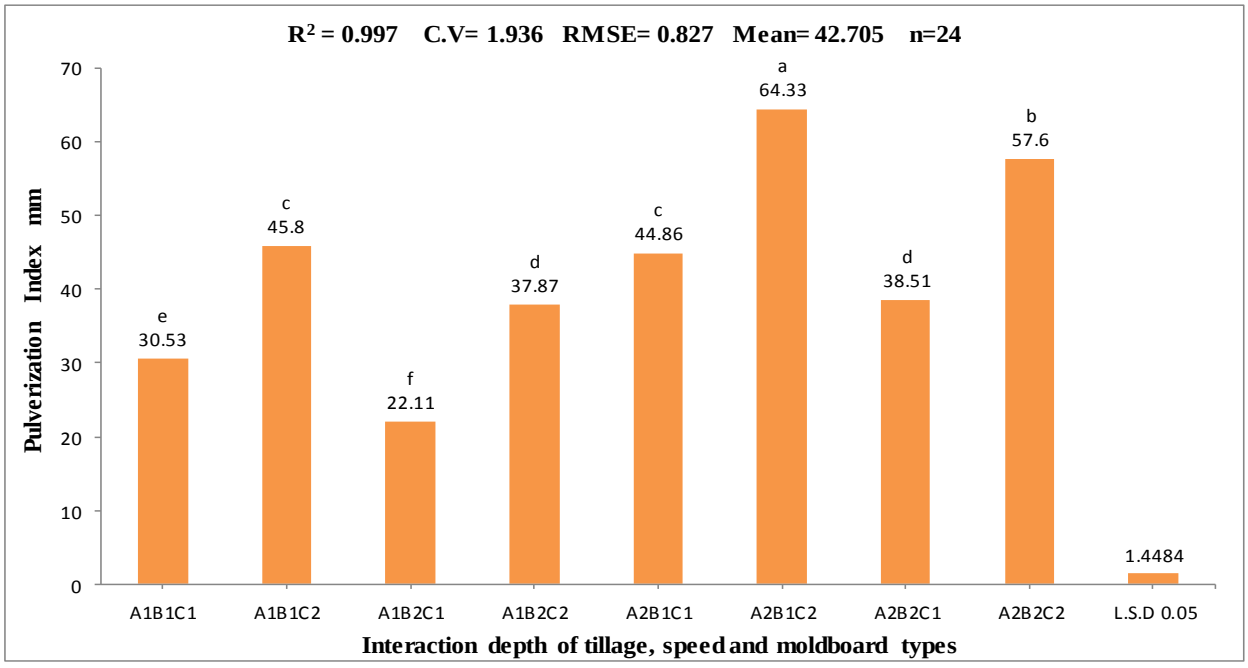


Fig. 7. **Effect of depth of tillage, speed of tractor and moldboard types in pulverization index.**

Conclusion

Finally, in light of these findings, it can be concluded slatted moldboard were achieved best results, volume of disturbed soil, minimum number of clods > 10 cm, bulk density, porosity and better pulverization index. Depth of tillage 15 cm got least number of clods > 10 cm, bulk density, high (best) porosity and best

pulverization index. High speed of tractor 7.224 km. h^{-1} achieved higher volume of disturbed soil, least number of clods> 10 cm and least pulverization index.

Conflict of interest

The authors have no conflict of interest.

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