

Article

# Tillage Method and Plow Type Impact on Corn Growth and Yield

Sabah Mahdi Jassim\*, Hamed Ajil Habib

Al-Mussaib Technical Institute, Al-Furat Al-Awsat Technical University, Al-Najaf, Kufa, Iraq.

\*Correspondence: [Outaiba@uomustansiriyah.edu.iq](mailto:Outaiba@uomustansiriyah.edu.iq)

**Abstract:** This autumn season (2021) field experiment investigated the impact of three plow types (Chisel, Moldboard, Disc) and three plow methods (once, twice perpendicular, three times) on soil physical properties and the growth and yield of Bohuth 106 corn cultivar. Results revealed significant superiority of the Chisel plow in enhancing moisture content, mean weight diameter, water conductivity, and seed germination percentage, followed by Moldboard and Disc plows. Tillage twice emerged as the most effective method, showing superior performance across measured traits. Chisel plow treatments exhibited averages of 15.1% moisture content, 1.40 g/cm<sup>3</sup> bulk density, 0.82 mm mean weight diameter, 12.2 cm/min water conductivity, 166.8 kPa.m<sup>2</sup> soil penetration, 87.7% seed germination, 173.4 cm plant height, 47.7 cm<sup>2</sup> leaf area, and 7.160 tons/ha total grain yield. These findings underscore the importance of tillage method and plow type selection in optimizing soil physical properties and crop performance, providing valuable insights for agricultural practices aiming at sustainable crop production.

**Keywords:** Tillage Method, Plow, Physical Soil Traits, Growth, Corn Plant, Bohuth 106 Cultivar

## 1. Introduction

The entry of agricultural machines and heavy machinery into the soil and the failure to follow scientific methods in their use has led to a negative or positive impact on some characteristics of the soil and plant growth. [1], indicated that the percentage of aggregates greater than (0.34 mm) in a mixture of two plowed soils is greater than it compared to that plowed four and eight, and twelve times and [2,] showed that the mean weight diameter (MWD) of loam soil was higher when using the inverted plow compared to the non-tillage soils. [3] he showed that the shallow plowing to a depth of (5-7 cm) using a toothed cultivator increased the values of the bulk density to an insignificant degree compared to using Moldboard plows with a depth of (15-25 cm). [4], when comparing them to the plowing treatment with the disc plow and the non-tillage treatment and their effect on the moisture content of the soil, noticed a decrease in the moisture content of the plowed treatment to a depth of (50 cm), then the moisture begins to homogenize in both cases and to a depth of more than that. [5], found that when they studied the effect of conventional tillage and non-tillage treatment, the total water content and depth (84 cm) were significantly higher in the uncultivated boards for the first year of the study. [6], when studying the plowing method and its effect on soil characteristics and plant growth, obtained that the soil moisture content increased with increasing soil depth, and that this trait had a significantly excelled in the treatment of tillage soils compared to the non-tillage treatment and for the first depth (zero - 15 cm) and that the number of growing plants per m<sup>2</sup> are more in the tillage treatment, and the number of plants increased as the depth of tillage increased. [7], found that there was a

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difference in plant height using the Moldboard plows and disc plows for two locations in northern Iraq, but these differences were not significant, while the increase was significant when the traits of the number of branches per plant of wheat. [8], mentioned that no significant differences were obtained in the total yield of wheat planted in northern Iraq using different plows. The study aims to know the effect of the plowing method and the types of plows used on some soil characteristics and their effect on the growth and yield of corn.

## 2. Materials and Methods

The study was conducted using two factors, and the first factor represented three types of plows:(Chisel plow ,Moldboard plow ,Disc plow) The following table shows the specifications of the above plows:

**Table 1. Specifications of the Plows.**

|                            | <b>Moldboard plow</b> | <b>Chisel plow</b> | <b>Disc plow</b> |
|----------------------------|-----------------------|--------------------|------------------|
| <b>Number of tines</b>     | <b>3</b>              | <b>13</b>          | <b>3</b>         |
| <b>Tines Depth (cm)</b>    | <b>20</b>             | <b>15</b>          | <b>20</b>        |
| <b>Required power (HP)</b> | <b>80</b>             | <b>60</b>          | <b>90</b>        |
| <b>Tines Width (cm)</b>    | <b>21</b>             | <b>8</b>           | <b>60</b>        |
| <b>Tines type</b>          | <b>Moldboard</b>      | <b>Chisel</b>      | <b>Disc</b>      |

The second factor represents three types of tillage method :1- once tillage 2- twice and perpendicular tillage 3- three times tillage .

Note that the repetition of plowing was conducted on the same day, a Completely Randomized Design was used with three replicates, and the area of the experimental unit was (40 x 16 m).The yellow sorghum cultivar (Bohuth 106) was used and the seeds were sown manually directly on the surface of the soil and in the autumn season of the year (2021) and in sedimentary soil. The amount of nitrogen fertilizer used was (180 kg/ha) (urea 46% nitrogen).and it was added in two batches, the first two weeks after cultivation and the second after planting a month, while phosphate fertilizer was added at an average of (120 kg. H-1) (Super Phosphate 45% P2O5) when preparing the soil for cultivation, Also, potassium fertilizer was added after planting at an average of 120 kg.ha-1 in the form of potassium sulfate (21% potassium), All service operations of the crop, including fertilization, irrigation, weeding, and management, were conducted in a homogeneous manner and for all experiment treatments. The studied characteristics were:

1. Soil characteristics: it is the moisture content as it was estimated by the weighted method, the mean weight diameter (MWD), the water conductivity, the bulk density, and the penetration ability of the soil according to the methods mentioned in [10].

2. Plant traits: It represents the percentage of germination after (15 days) from planting, plant height, leaf area, and total grain yield.

The results were statistically analyzed and differences between the means were tested using the least significant difference test at the 5% probability level, according to the methods mentioned before. [12]

**Table 2. Some Characteristics of the Study Soil.**

| values | units              | traits               | values | units            | traits            |
|--------|--------------------|----------------------|--------|------------------|-------------------|
| 24     | %                  | sand                 | 0 – 40 | cm               | depth             |
| 38     | %                  | silt                 |        |                  |                   |
| 38     | %                  | Clay                 |        |                  |                   |
| 3.2    |                    | texture              | 7.6    | ds/m             | pH                |
| 0.71   | mm                 | mean Weight diameter | 0.83   | -----            | Organic matter    |
| 1.252  | g/cm <sup>3</sup>  | bulk density         | 23.1   | %                | Calcium carbonate |
| 2.59   | g/cm <sup>3</sup>  | true density         | 20.5   | %                | Exchange capacity |
| 7.55   | cm/min             | water conductivity   | 8.2    | cmol charge/kg % | moisture content  |
| 160.4  | kPa.m <sup>2</sup> | soil penetration     |        |                  |                   |

### 3. Results and Discussion

#### 1. Effect of plow type and tillage method on soil moisture content (%).

Table (3) indicates the significantly excelled of the digger plow in increasing the average moisture content of the soil, while the plowing treatment twice performed the same behavior, where this treatment was significantly excelled on the rest of the other plowing times treatments, The value of the average moisture content in Chisel plow was (15.17%) compared to other plows, as gave the treatment of using Moldboard plow(13.13%), followed by the treatment of using the disc plow, which gave (12.07%)While the twice perpendicular tillage excelled and gave the highest average soil moisture content (15.27%), compared to the one-time tillage method, which gave (13.10%), followed by the 3-times tillage method, which gave (12.10%). Where, the interaction treatment between the two factors indicated the combination (Chisel plow and the twice tillage method), which gave the highest average for this trait (16.70%) compared to the other treatments.

Table 3. Effect of Tillage Method and Type of Plow on Soil Moisture Content.

| average                                                              | tillage method      |               |              | plow type      |
|----------------------------------------------------------------------|---------------------|---------------|--------------|----------------|
|                                                                      | three times tillage | twice tillage | once tillage |                |
| 15.17                                                                | 13.6                | 16.7          | 15.2         | Chisel plow    |
| 12.07                                                                | 10.6                | 14.2          | 11.4         | Disc plow      |
| 13.13                                                                | 12.1                | 14.9          | 12.4         | Moldboard plow |
|                                                                      | 12.1                | 15.27         | 13.1         | average        |
| <b>plow type: 1.24    tillage method : 1.24    interaction: 2.48</b> |                     |               |              | <b>LSD0.05</b> |

## 2. Effect of Plow Type and Tillage Method on the Average Bulk Density of Soil (gm/cm<sup>3</sup>).

Table (4) indicates the Chisel plow significantly excelled in reducing the average bulk density of the soil, while the plowing treatment twice performed the same behavior and was significantly superior in reducing the average of this traits. The value of the average bulk density of soil in the Chisel plow was (1.40 g/cm<sup>3</sup>) compared to the other plows, where it gave the treatment of using the Moldboard plow (1.47 g/cm<sup>3</sup>), followed by the treatment of using the disc plow, which gave (1.55 g/cm<sup>3</sup>). Whereas, the twice perpendicular tillage was excelled and gave the lowest average bulk density (1.43 g/cm<sup>3</sup>) compared to the one-time tillage method, which gave (1.48 g/cm<sup>3</sup>), followed by the three -times tillage method, which gave (1.50 g/cm<sup>3</sup>). While the interaction treatment between the two factors indicated the combination (the Chisel plow and the twice tillage method), which gave the lowest average for this trait amounted to (1.35 g/cm<sup>3</sup>) compared to the other treatments.

**Table 4. Effect of Tillage Method and Type of Plow on The Bulk Density of Soil (g/cm<sup>3</sup>).**

| average                                                                                   | tillage method      |               |              | plow type             |
|-------------------------------------------------------------------------------------------|---------------------|---------------|--------------|-----------------------|
|                                                                                           | three times tillage | twice tillage | once tillage |                       |
| <b>1.40</b>                                                                               | <b>1.44</b>         | <b>1.35</b>   | <b>1.41</b>  | <b>Chisel plow</b>    |
| <b>1.55</b>                                                                               | <b>1.56</b>         | <b>1.53</b>   | <b>1.55</b>  | <b>Disc plow</b>      |
| <b>1.47</b>                                                                               | <b>1.51</b>         | <b>1.41</b>   | <b>1.48</b>  | <b>Moldboard plow</b> |
|                                                                                           | <b>1.50</b>         | <b>1.43</b>   | <b>1.48</b>  | <b>average</b>        |
| <b><u>plow type: 0.06</u>    <u>tillage method : 0.06</u><br/><u>interaction:0.12</u></b> |                     |               |              | <b>LSD0.05</b>        |

### 3. Mean Weight Diameter (mm)

Table (5) indicates the Chisel plow significantly excelled increasing the mean weight diameter of the soil, while the tillage treatment twice took the same behavior, where this treatment was significantly excelled on the rest of the treatments of the first tillage times. The value of the mean weight diameter of the Chisel plow was (0.82 mm) compared to the other plows, where it gave the treatment of using the Moldboard plow (0.76 mm), followed by the treatment of the use of the disc plow, which gave (0.60 mm). Whereas, the twice and perpendicular tillage was excelled and gave the highest average of the mean weight diameter (0.82 mm), compared to the one-time plowing method, which gave (0.68 mm), followed by the 3-times plowing method, which gave (0.67 mm). While the interaction treatment between the two factors indicated the combination (the Chisel plow and twice perpendicular tillage method), which gave the highest average for this trait (1.01 mm) compared to the other treatments. The reason for this is that the Chisel plow can give a degree of coarse construction that causes the formation of blocks of large sizes, and tillage the soil for more than two times may lead to the destruction of those gatherings (2).

**Table 5. Effect of the Tillage Method and Plow Type on the Characteristic of Mean Weight Diameter of the Soil (mm).**

| average                                                                                  | tillage method      |               |              | plow type             |
|------------------------------------------------------------------------------------------|---------------------|---------------|--------------|-----------------------|
|                                                                                          | three times tillage | twice tillage | once tillage |                       |
| <b>0.82</b>                                                                              | <b>0.78</b>         | <b>1.01</b>   | <b>0.68</b>  | <b>Chisel plow</b>    |
| <b>0.60</b>                                                                              | <b>0.55</b>         | <b>0.63</b>   | <b>0.61</b>  | <b>Disc plow</b>      |
| <b>0.76</b>                                                                              | <b>0.69</b>         | <b>0.82</b>   | <b>0.77</b>  | <b>Moldboard plow</b> |
|                                                                                          | <b>0.67</b>         | <b>0.82</b>   | <b>0.68</b>  | <b>average</b>        |
| <b><u>plow type: 0.04</u>    <u>tillage method : 0.04</u>    <u>interaction:0.08</u></b> |                     |               |              | <b>LSD0.05</b>        |

#### **4. Effect of Plow Type and Tillage Method on Average Soil Water Conductivity (cm/min).**

Table (4) indicates the Chisel plow significantly excelled in increasing the average water conductivity of the soil, while the tillage treatment twice took the same behavior and was significantly excelled in increasing the average of this traits. The average value of the water conductivity of the soil in the Chisel plow was (12.25) compared to the other plows, where it gave the treatment of using the Moldboard plow (10.83), followed by the treatment of using the disc plow, which gave (8.68), While the twice perpendicular tillage treatment was excelled and gave the highest average water conductivity of the soil, which amounted to (11.56), compared to the one-time tillage method, which gave (10.22), followed by the 3-times tillage method, which gave (9.97). While the interaction treatment between the two factors indicated the combination (Chisel plow and the twice tillage method), which gave the highest average for this trait amounted to (13.44) compared to the other treatments.

**Table 6. Effect of Tillage Method and Plow Type on Soil Water Conductivity (cm/min).**

| average                                                                       | tillage method      |               |              | plow type      |
|-------------------------------------------------------------------------------|---------------------|---------------|--------------|----------------|
|                                                                               | three times tillage | twice tillage | once tillage |                |
| 12.25                                                                         | 11.08               | 13.44         | 12.23        | Chisel plow    |
| 8.68                                                                          | 8.77                | 9.25          | 8.01         | Disc plow      |
| 10.83                                                                         | 10.07               | 11.99         | 10.43        | Moldboard plow |
|                                                                               | 9.97                | 11.56         | 10.22        | average        |
| <u>plow type:1.32</u> <u>tillage method : 1.32</u><br><u>interaction:2.64</u> |                     |               |              | LSD0.05        |

**5. Effect of the Plow Type and Tillage Method on the Average Permeability of the Soil (kPa.m<sup>2</sup>).**

Table (4) indicates the significant excelled of the Chisel plow in reducing the average permeability of the soil, while the tillage treatment twice performed the same behavior and was significantly excelled in increasing the average of this traits .The value of the average soil penetration in the Chisel plow was (166.8 kPa.m<sup>2</sup>) compared to other plows, as it gave the treatment of using the Moldboard plow (174.1 kPa.m<sup>2</sup>), followed by the treatment of using the disc plow, which gave (194.7 kPa.m<sup>2</sup>) While the twice perpendicular tillage method was excelled and gave the lowest average soil permeability, which amounted to (163.3 kPa.m<sup>2</sup>) compared to the one-time tillage method, which gave (178.8 kPa.m<sup>2</sup>), followed by the 3-time tillage treatment, which gave (193.6 kPa.m<sup>2</sup>)While the interaction treatment between the two factors indicated the superiority of the combination (Chisel plow and twice tillage method), which gave the lowest average for this trait amounted to (152.1 kPa. m<sup>2</sup>) compared to the other treatments.

**Table 7. Effect of Tillage Method and Type of Plow on Soil Permeability Trait (kPa.m<sup>2</sup>).**

| average                                                                                            | tillage method      |               |              | plow type             |
|----------------------------------------------------------------------------------------------------|---------------------|---------------|--------------|-----------------------|
|                                                                                                    | three times tillage | twice tillage | once tillage |                       |
| <b>166.80</b>                                                                                      | <b>183.1</b>        | <b>152.1</b>  | <b>165.2</b> | <b>Chisel plow</b>    |
| <b>194.77</b>                                                                                      | <b>209.2</b>        | <b>176.5</b>  | <b>198.6</b> | <b>Disc plow</b>      |
| <b>174.07</b>                                                                                      | <b>188.4</b>        | <b>161.3</b>  | <b>172.5</b> | <b>Moldboard plow</b> |
|                                                                                                    | <b>193.6</b>        | <b>163.3</b>  | <b>178.8</b> | <b>average</b>        |
| <b><u>plow type: 12.32</u>    <u>tillage method : 12.32</u></b><br><b><u>interaction:24.64</u></b> |                     |               |              | <b>LSD0.05</b>        |

#### **6. Effect of Plow Type and Plowing Method on the Average Percentage of Plant Seed Germination (%).**

Table (4) indicates the Chisel plow significantly excelled in increasing the average percentage of germination of corn seeds after 15 days of cultivation, while the tillage treatment twice performed the same behavior and was significantly excelled in increasing the average of this trait. The value of the average percentage of germination in the Chisel plow was (87.7%) compared to the other plows, where it gave the treatment of using the Moldboard plow (79.9%), followed by the treatment of using the disc plow, which gave (74.1%). Whereas, the twice perpendicular tillage was excelled and gave the highest average seed germination average of (84.6%), compared to the one-time tillage method, which gave (79.6%), followed by the three-times tillage treatment, which gave (76.4%). While the interaction treatment between the two factors indicated the combination (the Chisel plow and twice perpendicular tillage), which gave the highest average for this trait amounted to (93.3%) compared to the other treatments.



**Table 8. The Effect of Tillage Method and Plow Type on the Trait of the Percentage of Germination.**

| average                                                                                                                                | tillage method      |               |              | plow type      |
|----------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------|--------------|----------------|
|                                                                                                                                        | three times tillage | twice tillage | once tillage |                |
| 87.73                                                                                                                                  | 83.4                | 93.3          | 83.5         | Chisel plow    |
| 74.07                                                                                                                                  | 71.6                | 77.4          | 73.2         | Disc plow      |
| 79.90                                                                                                                                  | 75.4                | 84.2          | 80.1         | Moldboard plow |
|                                                                                                                                        | 76.47               | 84.63         | 79.60        | average        |
| <p style="text-align: center;"><b><u>plow type: 4.25</u>      <u>tillage method : 4.25</u></b><br/> <b><u>interaction:8.50</u></b></p> |                     |               |              | LSD0.05        |

#### 7. Effect of Plow Type and Tillage Method on Average Plant Height (cm).

Table (4) indicates the Chisel plow significantly excelled in increasing the average plant height, while the tillage treatment twice performed the same behavior and was significantly excelled in increasing the average of this trait. The value of the average plant height in the Chisel plow was (173.4 cm) compared to the other plows, where it gave the treatment of using the Moldboard plow (167.7 cm), followed by the treatment of using the disc plow, which gave (173.4 cm). Whereas, the twice perpendicular tillage was excelled and gave the highest average plant height (176.1 cm), compared to the one-time tillage method, which gave (166.2 cm), followed by the three -times tillage method, which gave (162.1 cm). While the interaction treatment between the two factors indicated the combination (the Chisel plow and the twice tillage method ), excelled which gave the highest average for this trait amounted to (183.3 cm) compared to the other treatments.

Table 9. Effect of Tillage Method and Plow Type on Trait of Plant Height (cm).

| average                                                                                                                                 | tillage method      |               |              | plow type      |
|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------|--------------|----------------|
|                                                                                                                                         | three times tillage | twice tillage | once tillage |                |
| 173.40                                                                                                                                  | 165.7               | 183.3         | 172.2        | Chisel plow    |
| 162.27                                                                                                                                  | 156.4               | 169.6         | 160.8        | Disc plow      |
| 167.70                                                                                                                                  | 163.2               | 174.3         | 165.6        | Moldboard plow |
|                                                                                                                                         | 162.1               | 176.1         | 166.2        | average        |
| <p style="text-align: center;"><b><u>plow type: 5.65</u>      <u>tillage method : 5.65</u></b><br/> <b><u>interaction:11.30</u></b></p> |                     |               |              | LSD0.05        |

#### 8. Effect of the Plow Type and Plowing Method on the Average Leaf Area of Plant (ds.m2).

Table (4) indicates the Chisel plow significantly excelled in increasing the average leaf area of the plant, while the tillage treatment twice conducted the same behavior was significantly excelled in increasing the average of this trait. The value of the average leaf area of the plant in the Chisel plow was (47.7 ds.m2) compared to the other plows, where it gave the treatment of the use of the Moldboard plow (44.47 ds.m2), followed by the treatment of the use of the disc plow, which gave (40.4 dm2). The twice and perpendicular tillage treatment was excelled and gave the highest average leaf area, which was (52.3 cm2), compared to the one-time tillage method, which gave (40.9 cm2), followed by the three-times tillage method, which gave (39.8 cm2). While the interaction treatment between the two factors indicated the combination (the Chisel plow and the two-tillage method), which gave the highest average for this trait amounted to (58.1 ds.m2) compared to the other treatments.

**Table 10. Effect of Tillage Method and Plow Type on the Trait of Leaf Area (ds.m<sup>2</sup>).**

| average                                                                        | tillage method      |               |              | plow type      |
|--------------------------------------------------------------------------------|---------------------|---------------|--------------|----------------|
|                                                                                | three times tillage | twice tillage | once tillage |                |
| 47.73                                                                          | 41.7                | 58.1          | 43.4         | Chisel plow    |
| 40.47                                                                          | 36.5                | 46.3          | 38.6         | Disc plow      |
| 44.47                                                                          | 39.8                | 52.7          | 40.9         | Moldboard plow |
|                                                                                | 39.33               | 52.37         | 40.97        | average        |
| <u>plow type: 2.35</u> <u>tillage method : 2.35</u><br><u>interaction:4.70</u> |                     |               |              | LSD0.05        |

**9- Effect of the Plow Type and the Tillage Method on the Average Total Grain Yield of the Plant (Mcg.ha<sup>-1</sup>).**

Table (11) indicates that the Chisel plow was significantly excelled on Chisel plow in increasing the average of the total grain yield, while the tillage treatment twice took the same behavior and was significantly excelled in increasing the average of this trait. The value of the total grain yield of the Chisel plow was (7,160 mcg.ha<sup>-1</sup>) compared to the other plows. It gave the treatment of using the Moldboard plow (6,620 mcg.ha<sup>-1</sup>), followed by the treatment of using a disc plow, which gave (6,500 mcg.ha<sup>-1</sup>), While the twice and perpendicular tillage method was excelled and gave the highest average of total grain yield of (7.004 mcg.ha<sup>-1</sup>) compared to the one-time tillage method, which gave (6.657 mcg.ha<sup>-1</sup>), followed by the three-times tillage method, which gave (6.611 mcg.ha<sup>-1</sup>) Where the interaction treatment between the two factors indicated the superiority of the combination (the Chisel plow and the twice tillage method ), which gave the highest average for this trait amounted to (7.465 mcg.ha<sup>-1</sup>) compared to the other treatments.

**Table 11. Effect of Tillage Method and Plow Type on the Trait of Total Grain Yield (Mcg.ha-1).**

| average                                                                                                    | tillage method      |               |              | plow type      |
|------------------------------------------------------------------------------------------------------------|---------------------|---------------|--------------|----------------|
|                                                                                                            | three times tillage | twice tillage | once tillage |                |
| 7.160                                                                                                      | 6.898               | 7.465         | 7.115        | Chisel plow    |
| 6.500                                                                                                      | 6.490               | 6.678         | 6.318        | Disc plow      |
| 6.620                                                                                                      | 6.445               | 6.870         | 6.537        | Moldboard plow |
|                                                                                                            | 6.611               | 7.004         | 6.657        | average        |
| <p><b><u>plow type: 0.32</u>      <u>tillage method : 0.32</u></b><br/> <b><u>interaction:0.64</u></b></p> |                     |               |              | <b>LSD0.05</b> |

#### 4. Conclusion

The findings of this study underscore the significant influence of tillage method and plow type on soil physical properties and the growth and yield of Bohuth 106 corn cultivar. The superior performance of the Chisel plow, particularly when employed in the tillage twice method, highlights its effectiveness in enhancing soil moisture content, mean weight diameter, water conductivity, seed germination percentage, plant height, leaf area, and total grain yield. This positive effect is attributed to the reduction of soil resistance to penetration and bulk density, creating a conducive environment for seed growth. Furthermore, the study emphasizes the importance of considering both plow type and tillage method in agricultural practices to optimize crop production and ensure sustainability. Future research directions could focus on exploring additional factors influencing soil-plant interactions and expanding the scope to encompass diverse cultivars and environmental conditions, thereby contributing further insights into agricultural management strategies.

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