The Effect of Tillage and Planting Methods on Growth, Weed Population, and Yield in Semi-Dwarf Wheat (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was conducted at the Faculty of Agriculture Farm, Alfateh University, Tripoli, L.P.S.A.J., in the 1975–1976 season. The objective of this experiment was to study the combined effect of three planting methods (broadcast, manual drill, and mechanical drill) and six tillage treatments (no-tillage, tine cultivator, disk harrow, moldboard plow, disk plow, and rotavator) on growth, weed population, yield, and yield components in the semi-dwarf wheat cultivar 'Sidi Misri 1'.

In general, the tillage treatments had highly significantly increased the number of seedlings/m² (or plant density), when compared with the control (no-tillage). The highest plant density was obtained from the disk plow and the lowest from the no-tillage treatments. Planting with the mechanical drill gave the highest plant density while the broadcast method resulted in the lowest number of seedlings/m². A slight but significant enhancement occurred in the heading date as a result of the disk and moldboard plow treatments. The planting methods did not affect the heading date. Similar results were obtained in the case of plant height. It was concluded that tillage by disk plow and/or rotavator may be preferred in seedbed preparation for increasing plant density and improving the growth of wheat under Tripoli conditions. Moreover, planting of wheat should be done by mechanical grain drill for the same reasons.

The fresh weight of weeds during vegetative growth (4-months old) and at maturity (6-months old) and the dry weight of weeds during vegetative growth were more significantly decreased by tillage with the rotavator, disk plow, and moldboard plow than by the disk harrow and tine cultivator. There were more weeds in the case of the broadcast method than in the other two methods of planting. It was observed that the amounts of weeds were clearly decreased at maturity which was very important in affecting the wheat yield and its components in this study.

The total yield (grain plus straw) and grain and straw yields were more significantly increased by the tillage treatments than by the non-tillage practice. The highest mean yields resulted from rotovation and plowing with disk and moldboard plows. No-tillage gave the lowest yields. These yields were also significantly increased by the mechanical drill method. Consequently, it was concluded that tillage with either disk plow and/or

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rotavator may be the best for increasing wheat production under the present conditions. The broadcast method must not be followed for this reason.

The harvest index generally showed the same trend as the total, grain, and straw yields which indicates that this index may be considered an important criterion for grain yield studies of wheat.

In general, the number of spikes per plant and per square meter, number and weight of grains/spike, number of grains/m^2 and 1,000-grain weight were similarly affected by the different treatments of this study. Planting with the mechanical drill and tillage with the disk plow and rotavator resulted in high mean values for these components of yield.

INTRODUCTION

Wheat, *Triticum aestivum* L., is a principal cereal crop in the Libyan People's Socialist Arab Jamaheria. It is grown in regions of irrigated as well as dry land farming. The total annual production of wheat is low under these conditions due to the low average yield per hectare. One of the principal causes of such decreased productivity is the poor utilization of recent advances in agricultural practices, especially the use of farm machinery. Very few cultural practices are mechanized in the Libyan agriculture; namely, seedbed preparation and crop harvesting. Plowing is the only step which is done mechanically for seedbed preparation because the soil type and structure do not require other operations such as harrowing, disking, or pulverizing. However, plowing alone is insufficient for optimum crop yields. Plowing is done by several kinds of mechanical plows (10). The coastal strip farmers of the L.P.S.A.J. use mostly rotavators, disk plows, and cultivators alone or in combinations of their choice without any scientific basis. This necessitated the initiation of the present preliminary studies in this region.

A few workers studied the effect of some tillage practice on wheat yield in the L.P.S.A.J. El-Sharkawy and Sgaier (3) reported that the grain yield of wheat, in the sandy soils of the Al-Kufra desert, was increased by disking to different depths as against notillage. Grain size (1,000-grain weight) was slightly and nonsignificantly decreased by tillage treatments. Sorour *et al.* (14), in Tripoli, reported that deep plowing caused a delay in maize seedling emergence and a decrease in the number of emerging seedlings. On the other hand, surface tillage enhanced seedling emergence. The highest ear yield and the second highest were obtained from the 3-disk plow and rotary cultivator, respectively. No mechanical cultivation resulted in the lowest maize yield.

Under a rice-wheat crop rotation in Japan, Eguchi and Hirano (1) reported that an average tillage was better for wheat production than no-tillage or frequent tillage. Geiszler *et al.* (5), in the U.S.A., found that deep tillage was unimportant in grain yield and minimum tillage was recommended for wheat production. Poulson (13) reported similar results on wheat in Kenya. Keys *et al.* (7) noted a small difference in the yield of wheat due to tillage practices. Overson and Hall (12) found that a gradual increase in wheat yield occurred as the depth of plowing increased from four to seven inches. Plowing to ten inches deep, however, did not increase the yield.

However, tillage alone is insufficient for satisfactory crop yields. It is better to plant the seeds of field crops mechanically. Unfortunately, the majority of Libyan farmers plant wheat by the broadcast method rather than by mechanical drilling. The former is time consuming and low yielding but the latter is very efficient and highly productive. In Nebraska, U.S.A., broadcast winter wheat averaged 17% lower than drilled wheat (8).

The surface drill is used under humid conditions, while furrow and semi-furrow drill, are widely used under dryland conditions (6 and 10).

This work was initiated to investigate the combined effects of mechanical tillage and planting methods on growth, weed population, yield, and yield components in semi-dwarf wheat. It was further expected that the findings from this study will streamline the mechanization of wheat production in the L.P.S.A.J. to gain self-sufficiency in food grains.

MATERIALS AND METHODS

A field experiment was conducted at the Faculty of Agriculture Farm, Alfateh University, Tripoli, L.P.S.A.J., in the 1975–1976 season to study the combined effects of three planting methods and six tillage treatments on growth, weed population, yield, and yield components in the semi-dwarf wheat cultivar 'Sidi Misri 1' (*Triticum aestivum* L.). A strip-plot design, with four replicates and eighteen treatments, was used. The plot size was $2.5 \times 12.0 = 30\ m^2$. The east-west strip plots were assigned to the three planting methods; namely, broadcast, manual drill, and mechanical drill. The north-south strip plots were assigned to the six tillage treatments; viz., no tillage or control, tine cultivator, disk harrow, moldboard plow, disk plow, and rotavator. Plot width was made 2.5 m to coincide with the width of grain drill so that a single swath could complete each strip in the case of mechanical drill plots. An International Harvester grain drill was used. Each plot contained eight rows of 30 cm wide in the cases of manual and mechanical drill methods. Rows were marked by a normal wooden marker in the manual drill method. The experimental field was previously planted with alfalfa. Each plot received 300 g of dry wheat grains (in a dry soil of 69.7% sand, 19.2% silt, 10.1% clay, and 7.44% $CaCO_3$) which amounted to a seeding rate of 100 kg/ha.

The tillage treatments were applied on November 10, 1975. Then, the plots of all treatments, except the control, were compacted by a tractor-drawn roller to improve soil compaction. Plantings were done on November 12, 1975. Each plot was fertilized with two equal increments (600 g) of ammonium sulfate (20.0% N) which amounted to a fertilization rate of 80 kg N/ha. The two increments were applied on December 20, 1975, and February 3, 1976. All plots were irrigated by sprinklers as needed beside the natural precipitation.

Plant density was measured as an average number of normal seedlings that emerged in a random area of one square meter per plot.

Heading date was determined as the number of days from sowing to 50% heading of wheat plants in each plot.

Plant height was measured in centimeters as an average of five plants per plot, taken at random before harvest.

Fresh weight of weeds (in kg/m^2) was determined twice; during the vegetative growth (after four months from planting) and at maturity (before harvest). During the vegetative growth, weeds growing in a randomly selected one square meter area per plot were cut by sickles at soil surface and weighed. These samples were oven-dried at 70°C for 24 hours and the dry weight of weeds (in kg/m^2) was recorded. At maturity, only the fresh weight of weeds (in kg/m^2) from a randomly selected area of $12\ m^2$ per plot was recorded.

Before harvesting, the number of spikes per plant, number of grains per spike, and grain weight per spike were recorded as averages of five wheat plants chosen at random per plot. The numbers of spikes and grains per square meter were counted in a randomly selected one square meter area per plot.

At harvesting (on May 26, 1976), wheat plants were cut by sickles in a randomly selected area of 12 m^2 per plot and the total yield (grain plus straw) in tons per hectare was determined. Then, plants were threshed and the grain yield (in tons/ha) was recorded. The straw yield (in tons/ha) was calculated by subtracting the grain yield from the total yield (grain plus straw). The 1,000-grain weight (in grams) was determined from random grains chosen from threshed crop in each plot. The harvest index (or percentage of grain to total yield) was derived from the following formula:

$$\text{Harvest index} = \frac{\text{Grain yield/plot}}{\text{Total yield (grain + straw)/plot}} \times 100$$

Data were statistically analyzed according to Le Clerg *et al.* (9).

RESULTS AND DISCUSSION

I. Effects on growth

Tillage and planting treatments showed highly significant effects upon plant density (an average number of wheat seedlings per square meter), as presented in Table 1. The general mean of plant density was significantly increased by the application of tillage treatments as compared to no-tillage. This was expected due to the improved seedbed and proper conditions for seed germination caused by the different tillage methods. Sorour *et al.* (14) reported similar results. Tillage by rotavator and disk plow gave the two highest mean values (105.82 and 107.74 seedlings/m^2, respectively). The lowest plant density (58.88) resulted from the no tillage treatment. Highly significant differences among the mean values of plant density were given by the planting methods. Mechanical drill and broadcast methods gave the highest (121.46) and the lowest (71.14) values. Manual drill resulted in an intermediate mean (90.82 seedlings/m^2). These findings agreed with those reported by Kiesselbach *et al.* (8) and Martin *et al.* (10). A highly significant interaction was obtained between the planting methods and tillage treatments (Table 1). This was indicated by the differences in average number of plants per square meter within the tillage treatments and planting methods. For example, the lowest average value (35.46) was that of no-tillage and broadcast method, while the

Table 1 The effect of tillage treatments and planting methods on the average plant density (number of seedlings/m^2) of wheat.

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Mold-board plow	Disk plow	Rotavator	Mean[a]
Broadcast	35.46[c]	73.50	75.86	80.50	90.20	71.30	71.14
Manual drill	62.20	92.96	96.80	93.86	98.00	101.16	90.82
Mechanical drill	79.00	117.80	123.30	128.70	135.00	145.00	121.46
Mean[b]	58.88	94.76	98.66	101.02	107.74	105.82	—

[a] L.S.D. (for planting methods): (0.05) = 4.80 & (0.01) = 7.28 seedlings/m^2.
[b] L.S.D. (for tillage treatments): (0.05) = 5.26 & (0.01) = 7.28 seedlings/m^2.
[c] L.S.D. (for interaction): (0.05) = 7.10 & (0.01) = 8.24 seedlings/m^2.

Table 2 The effect of tillage treatments and planting methods on the average heading date of wheat (days).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Mold-board plow	Disk plow	Rotavator	Mean
Broadcast	111.00[b]	111.25	111.75	110.75	110.00	111.75	111.08
Manual drill	114.50	112.00	113.00	111.00	110.00	112.75	112.21
Mechanical drill	113.50	112.00	112.50	111.50	111.50	115.00	112.67
Mean[a]	113.00	111.75	112.42	111.08	110.50	113.17	—

[a] L.S.D. (for tillage treatments): (0.05) = 1.02 & (0.01) = 1.42 days.
[b] L.S.D. (for interaction): (0.05) = 1.64 days.

highest value (145.0) resulted from rotavator and mechanical drill. This coincided with the general overall mean values.

Data in Table 2 indicate that the tillage treatments had highly significantly affected the heading date of wheat. The earliest date (110.5 days) resulted from disk plowing. This date was delayed by no-tillage and rotovation. The planting methods did not significantly affect the heading date. A significant interaction was obtained between the tillage treatments and planting methods within the no-tillage and rotavator treatments.

Plant height of wheat was highly significantly influenced by the tillage treatments. The lowest significant mean value (60.9 cm) resulted from the no-tillage treatment. Comparable values were obtained from the other tillage treatments. Plant height was unaffected by the planting methods. There was no interaction between the tillage treatments and planting methods in this case, as presented in Table 3.

Table 3 The effect of tillage treatments and planting methods on the average plant height of wheat (cm).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean
Broadcast	59.95	68.95	69.95	73.75	71.15	68.80	68.76
Manual drill	63.70	69.60	70.85	71.30	71.45	69.35	69.38
Mechanical drill	59.05	68.60	68.05	70.50	72.90	68.25	67.89
Mean[a]	60.90	69.05	69.62	71.85	71.83	68.80	—

[a] L.S.D. (for tillage treatments): (0.05) = 4.03 & (0.01) = 5.58 cm.

From these results, it was concluded that tillage by either disk plow or rotavator may be preferred in seedbed preparation for increasing plant density and improving growth of wheat under the present conditions. Moreover, wheat planting should be done by mechanical grain drills for the same reasons.

II. Effects on weed population

The fresh weight of weeds (in kg/m^2) was highly significantly reduced by the application of tillage treatments when the weeds were four months old (during vegetative

growth). This was attributed to the efficiency of tillage equipment in weed control, as was reported by Martin *et al.* (10) and Muzik (11). The untilled plots gave the highest significant mean weight (1.54 kg/m^2). Tillage by disk plow, moldboard plow and rotavator resulted in the lowest mean fresh weights of weeds (0.78, 0.70, and 0.66 kg/m^2, respectively), as presented in Table 4.

Table 4 The effect of tillage treatments and planting methods on the average fresh weight of weeds during vegetative growth (4-months old) in wheat (kg/m^2).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	2.00	2.14	1.26	0.94	0.90	0.90	1.20
Manual drill	1.54	0.78	0.88	0.66	0.78	0.82	0.92
Mechanical drill	1.08	1.08	0.66	0.48	0.66	0.28	0.70
Mean[b]	1.54	1.04	0.94	0.70	0.78	0.66	—

[a] L.S.D. (for planting methods): (0.05) = 0.38 kg/m^2.
[b] L.S.D. (for tillage treatments): (0.05) = 0.30 & (0.01) = 0.42 kg/m^2.

The planting methods resulted in significant differences among the mean values of fresh weight of weeds during the vegetative stage (Table 4). The lowest significant value was that of the mechanical drill (0.70 kg/m^2) as against 1.20 kg/m^2 for the broadcast method. This means that mechanical planting of wheat reduced weed population during vegetative growth. This reduced the competition with wheat plants and might have positive effects on the yield. There was no significant interaction between the tillage treatments and planting methods in this case. Comparable results were obtained in the case of dry weight of weeds during the same stage of growth (Table 5).

Table 5 The effect of tillage treatments and planting methods on the average dry weight of weeds during vegetative growth (4-months old) in wheat (kg/m^2).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	0.430	0.283	0.258	0.230	0.187	0.181	0.261
Manual drill	0.363	0.169	0.212	0.155	0.170	0.168	0.206
Mechanical drill	0.231	0.220	0.140	0.074	0.143	0.066	0.146
Mean[b]	0.341	0.224	0.203	0.153	0.166	0.138	—

[a] L.S.D. (for planting methods): (0.05) = 0.080 kg/m^2.
[b] L.S.D. (for tillage treatments): (0.05) = 0.058 & (0.01) = 0.080 kg/m^2.

Data in Table 6 show that the tillage treatments and the planting methods had highly significantly decreased the weed population in terms of fresh weight (in kg/m^2) at maturity. The most efficient tillage treatments in weed control was those of moldboard plow, disk plow, and rotavator. Furthermore, planting with the mechanical drill was

Table 6 The effect of tillage treatments and planting methods on the average fresh weight of weeds at maturity (6-months old) in wheat (kg/m²).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	0.599	0.386	0.292	0.162	0.178	0.162	0.296
Manual drill	0.474	0.193	0.261	0.141	0.130	0.109	0.218
Mechanical drill	0.438	0.157	0.130	0.104	0.094	0.083	0.168
Mean[b]	0.503	0.245	0.228	0.136	0.133	0.118	—

[a] L.S.D. (for planting methods): (0.05) = 0.035 & (0.01) = 0.052 kg/m².
[b] L.S.D. (for tillage treatments): (0.05) = 0.060 & (0.01) = 0.084 kg/m².

very effective in reducing the weeds in this case. These results coincided with those presented in Tables 4 and 5. It was also observed that the amounts of weeds were obviously decreased at maturity (Table 6) as compared to those of the vegetative growth (Tables 4 and 5). This decrease was very important in affecting the wheat yield and its components in the present investigation. The lowest fresh weights of weeds resulted from the rotavator, disk plow, and moldboard plow tillage treatments within the mechanical drill method. Their corresponding values were 0.083, 0.094, and 0.104 kg/m², as given in Table 6.

III. Effects on yield

The total yield of wheat (grain plus straw) was highly significantly affected by the tillage treatments and planting methods, as presented in Table 7. The mean total yield was the lowest (1.583 tons/ha) in the case of no-tillage treatment under all planting methods. Among the tillage treatments, high total yields resulted from the disk plow treatment (5.498 tons/ha) followed by the moldboard plow (5.448 tons/ha) and rotavator (4.615 tons/ha). Low yields were obtained from the tine cultivator and disk harrow treatments. This means that tillage with disk plow, moldboard plow, and rotavator increased wheat production under the present conditions. These results agreed with

Table 7 The effect of tillage treatments and planting methods on the average total yield (grain plus straw) of wheat (tons/ha).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	1.250[c]	3.024	4.115	5.106	3.957	3.649	3.515
Manual drill	1.566	5.415	4.582	5.731	5.881	4.215	4.565
Mechanical drill	1.924	4.690	4.740	5.523	6.664	5.989	4.923
Mean[b]	1.583	4.373	4.482	5.448	5.498	4.615	—

[a] L.S.D. (for planting methods): (0.05) = 0.610 & (0.01) = 0.924 ton/ha.
[b] L.S.D. (for tillage treatments): (0.05) = 0.922 & (0.01) = 1.277 tons/ha.
[c] L.S.D. (for interaction): (0.05) = 1.569 tons/ha.

those reported by Eguchi and Hirano (1), Overson and Hall (12), and Sorour *et al.* (14). However, Geiszler *et al.* (5), Poulson (13), and Keys *et al.* (7) recorded dissimilar findings.

Planting wheat with the broadcast method resulted in a significantly lower mean total yield than that of the manual and mechanical drill methods. The corresponding mean values (Table 7) were 3.515, and 4.923 tons/ha. The mechanical drill method nonsignificantly outyielded the other two planting methods. These results were similar to those reported on growth (Tables 1, 2, and 3). As was reported earlier, the superiority of total yield in case of the mechanical drill method may be attributed to the increased plant density of wheat and the reduced weed population which resulted from this method of planting.

A significant interaction was obtained between the tillage treatments and planting methods (Table 7). The mechanical drill methods of planting increased the total yield of wheat under all tillage practices except the tine cultivator and moldboard plow treatments in which the manual drill method nonsignificantly increased the total yield. The highest average total yields were obtained from tillage with either the disk plow or rotavator and planting with the mechanical drill. The respective values were 6.664 and 5.989 tons/ha.

Data in Tables 8 and 9 indicate similar effects on both grain and straw yields. This

Table 8 The effect of tillage treatments and planting methods on the average grain yield of wheat (tons/ha).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	0.234[c]	0.857	1.084	1.417	1.126	1.091	0.968
Manual drill	0.338	1.458	1.491	1.854	1.861	1.612	1.436
Mechanical drill	0.518	1.515	1.535	2.694	2.260	2.434	1.726
Mean[b]	0.363	1.277	1.370	1.788	1.749	1.612	—

[a] L.S.D. (for planting methods): (0.05) = 0.273 & (0.01) = 0.413 ton/ha.
[b] L.S.D. (for tillage treatments): (0.05) = 0.313 & (0.01) = 0.433 ton/ha.
[c] L.S.D. (for interaction): (0.05) = 0.566 ton/ha.

Table 9 The effect of tillage treatments and planting methods on the average straw yield of wheat (tons/ha).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	1.015[c]	2.162	3.029	3.685	2.831	2.606	2.555
Manual drill	1.224	3.955	3.090	3.873	4.027	2.605	3.129
Mechanical drill	1.408	3.171	3.203	3.425	4.404	3.554	3.194
Mean[b]	1.216	3.096	3.107	3.661	3.754	2.922	—

[a] L.S.D. (for planting methods): (0.05) = 0.313 ton/ha.
[b] L.S.D. (for tillage treatments): (0.05) = 0.679 & (0.01) = 0.940 ton/ha.
[c] L.S.D. (for interaction): (0.05) = 1.185 ton/ha.

confirms the superiority of tillage by rotavator and disk and moldboard plows over no-tillage, tine cultivation and disk harrowing for yield increase. Moreover, the high means of grain and straw yields, which resulted from the mechanical drill method, explains the high mean values of total yield obtained from the same treatment. The highest two averages of grain yield (2.434 and 2.260 tons/ha) resulted from planting with the mechanical drill and tillage with the rotavator and disk plow, respectively. This means that these two tillage equipments may be the best for increasing wheat production under conditions similar to those in this study. The broadcast method must not be followed for this reason.

The harvest index (or the percentage of grain to total yield) was also highly significantly influenced by the tillage treatments and planting methods, as indicated in Table 10. The lowest (22.07%) and the highest (35.96%) mean values were those of the no-tillage and rotovation, in this order. The mechanical drill method resulted in the highest mean value of harvest index (33.95%) followed by the manual drill (30.36%) and broadcast methods (25.91%). These results explain the higher total, grain, and straw yields presented in Tables 7, 8, and 9, respectively. Therefore, it is concluded that a combination between tillage by rotavator and/or disk plow and planting with mechanical drill may increase wheat grain yields through increasing the percentages of grain to total yield (harvest index) beside the other advantages previously mentioned. This corroborates the views of Fisher (4) that the harvest index was an important criterion for grain yield studies in wheat.

Table 10 The effect of tillage treatments and planting methods on the average harvest index (grain/total yield %) of wheat.

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	17.33	25.95	26.25	28.13	28.48	29.35	25.91
Manual drill	21.08	26.40	32.53	32.35	31.95	37.85	30.36
Mechanical drill	27.80	32.18	32.03	37.63	33.43	40.68	33.95
Mean[b]	22.07	28.18	30.27	32.70	31.28	35.96	—

[a] L.S.D. (for planting methods): (0.05) = 1.58 & (0.01) = 2.40%.
[b] L.S.D. (for tillage treatments): (0.05) = 3.70 & (0.01) = 5.13%.

IV. Effects on components of yield

Obviously, the tillage treatments resulted in a highly significant increase in the mean number of spikes per plant as compared to the no-tillage treatment for which the lowest mean value (2.10) was obtained, as shown in Table 11. The differences were not significant among the tillage treatments, although the rotavator treatment gave a nonsignificant higher mean value (2.80 spikes/plant). The planting methods exerted a highly significant effect on the average number of spikes per plant. Mechanical drill planting resulted in the highest significant mean (2.93). The manual drill and broadcast methods gave significantly lower mean values (2.38 and 2.29 spikes/plant, respectively). There

Table 11 The effect of tillage treatments and planting methods on the average number of spikes per plant of wheat.

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	1.95	2.40	2.15	2.40	2.55	2.30	2.29
Manual drill	1.85	2.75	2.15	2.45	2.50	2.60	2.38
Mechanical drill	2.50	2.80	2.65	2.90	3.20	3.50	2.93
Mean[b]	2.10	2.65	2.32	2.58	2.75	2.80	—

[a] L.S.D. (for planting methods): (0.05) = 0.30 & (0.01) = 0.46 spike/plant.
[b] L.S.D. (for tillage treatments): (0.05) = 0.36 & (0.01) = 0.49 spike/plant.

was no significant interaction in this case. The number of spikes per square meter was similarly affected by the tillage treatments and planting methods (Table 12) with two exceptions. First, the moldboard plow, disk plow, and rotavator treatments resulted in higher numbers of spikes/m^2 (their respective values were 138.00, 158.84, and 153.00) than the no-tillage and tine cultivator treatments (their values being 77.66 and 97.34, correspondingly). Second, the differences were highly significant among the three planting methods. The mean values, in a descending order, were 152.16 (for mechanical drill), 123.66 (for manual drill), and 97.00 spikes/m^2 (for broadcast).

Table 12 The effect of tillage treatments and planting methods on the average number of spikes/m^2 of wheat.

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	55.50	79.50	87.50	115.50	126.50	117.50	97.00
Manual drill	84.50	87.50	128.50	137.50	153.50	150.50	123.66
Mechanical drill	93.00	125.00	146.50	161.00	196.50	191.00	152.16
Mean[b]	77.66	97.34	120.84	138.00	158.84	153.00	—

[a] L.S.D. (for planting methods): (0.05) = 22.26 & (0.01) = 33.68 spikes/m^2.
[b] L.S.D. (for tillage treatments): (0.05) = 25.14 & (0.01) = 34.82 spikes/m^2.

The combined effect of the tillage treatments and planting methods on the average number and weight of grains/spike was similar (Tables 13 and 14). That is, the tillage treatments resulted in a highly significant increase in the two components. The rotavator, moldboard plow, and disk plow treatments gave the highest mean number of grains/spike (42.33, and 37.30). The highest mean weights of grains/spike were those of rotavator (1.53 g) and moldboard plow (1.31 g). Planting with the mechanical drill resulted in the highest mean number (39.15) and the highest mean weight (1.48 g) of grains/spike, as indicated in Tables 13 and 14. No significant interactions were obtained, although the combination between the rotavator treatment and mechanical drill method increased both components.

Table 13 The effect of tillage treatments and planting methods on the average number of grains/spike of wheat.

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	23.70	34.45	33.18	35.35	36.00	39.38	33.68
Manual drill	27.85	36.73	35.55	35.43	34.65	39.85	35.01
Mechanical drill	28.78	37.28	37.73	42.10	41.25	47.75	39.15
Mean[b]	26.78	36.15	35.48	37.63	37.30	42.33	—

[a] L.S.D. (for planting methods): (0.05) = 3.50 grains/spike.
[b] L.S.D. (for tillage treatments): (0.05) = 3.83 & (0.01) = 5.30 grains/spike.

Table 14 The effect of tillage treatments and planting methods on the average weight of grains/spike of wheat (g).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	0.66	1.12	1.06	1.30	1.17	1.32	1.10
Manual drill	0.77	1.16	1.06	1.21	1.10	1.44	1.12
Mechanical drill	1.18	1.55	1.41	1.42	1.50	1.83	1.48
Mean[b]	0.87	1.28	1.18	1.31	1.26	1.53	—

[a] L.S.D. (for planting methods): (0.05) = 0.07 & (0.01) = 0.11 g/spike.
[b] L.S.D. (for tillage treatments): (0.05) = 0.10 & (0.01) = 0.14 g/spike.

Data in Table 15 show that the average number of grains/m² was highly significantly increased by both the tillage treatments and the planting methods. Such increase was obvious when tillage was done by the rotavator, disk plow, and moldboard plow. Their

Table 15 The effect of tillage treatments and planting methods on the average number of grains/m² of wheat.

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	1826.50[c]	2771.50	2939.00	4057.50	4602.00	4666.00	3393.76
Manual drill	2361.00	3207.00	4567.00	4868.50	5338.00	6053.00	4399.08
Mechanical drill	2642.50	4643.50	5415.00	6805.00	7733.00	9156.50	6065.92
Mean[b]	2110.00	3540.66	4307.00	5243.66	5891.00	6625.16	—

[a] L.S.D. (for planting methods): (0.05) = 1073.78 & (0.01) = 1626.02 grains/m².
[b] L.S.D. (for tillage treatments): (0.05) = 1035.26 & (0.01) = 1433.82 grains/m².
[c] L.S.D. (for interaction): (0.05) = 1118.90 & (0.01) = 1508.32 grains/m².

corresponding mean values were 6625.16, 5891.00, and 5243.66 grains/m^2. There was also a significant increase in this component of yield due to planting with the mechanical drill as opposed to the manual drill method. The broadcast method resulted in the lowest mean number of grains/m^2 (3393.76). A highly significant interaction was obtained in this respect. The lowest and the highest average values resulted from the broadcast method of planting and the no-tillage treatment, and from the mechanical drill planting and the rotavator treatment, respectively. These results coincided with the previous data on yield (Tables 7, 8, and 9). This indicates that the number of grains/m^2 may be taken as an essential criterion for grain yield of wheat, as reported by El-Sharkawy *et al.* (2).

The 1,000-grain weight was highly significantly affected by the tillage treatments and planting methods, as presented in Table 16. The highest significant mean value for the 1,000-grain weight (35.10 g) resulted from the rotavator treatment. The other tillage methods gave comparable results to the control. On the other hand, planting with the mechanical drill significantly increased the 1,000-grain weight over the other two planting methods. El-Sharkawy and Sgaier (3) reported different results. A highly significant interaction was obtained. The highest average 1,000-grain weight (39.98 g) was obtained from the combination between mechanical drill and rotavator. The no-tillage treatment and the broadcast methods resulted in the lowest value (25.70 g). These results indicate that the 1,000-grain weight was another important component of wheat yield under the present circumstances.

Table 16 The effect of tillage treatments and planting methods on the average 1000-grain weight of wheat (g).

	Tillage treatments						
Planting methods	No-tillage	Tine cultivator	Disk harrow	Moldboard plow	Disk plow	Rotavator	Mean[a]
Broadcast	25.70[c]	29.10	28.78	30.55	29.68	29.38	28.86
Manual drill	26.93	31.58	31.90	32.35	30.55	35.95	31.54
Mechanical drill	27.53	31.10	32.28	33.85	33.40	39.98	33.02
Mean[b]	30.59	30.59	30.98	32.25	31.21	35.10	—

[a] L.S.D. (for planting methods): (0.05) = 0.51 & (0.01) = 0.77 g.
[b] L.S.D. (for tillage treatments): (0.05) = 1.75 & (0.01) = 2.43 g.
[c] L.S.D. (for interaction): (0.05) = 3.33 & (0.01) = 4.48 g.

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