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Yield Performance of Wheat Under Different Practices of Tillage and Integrated Inorganic and Organic Fertilizers

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Abstract. Tillage management and fertilizer application are important components of wheat plant growth and productivity. Yet limited data are available on the consequences of simultaneous tillage and integrated fertilization on wheat production and soil chemical characteristics in the heavy soil of Sothern parts of Iraq. Hence, split-split plots were used to conduct a field experiments at two locations. The primary plots were divided into three tillage techniques that are no tillage (NT), tine cultivator (TC) and moldboard plow (MP). Five selected combinations of organic and inorganic nutrient sources were arranged in sub plots including the traditional chemical fertilizer application of nitrogen, phosphorus and potassium (CF), farm yard manure (FYM), poultry manure (PM), 50% CF+FYM and 50% CF+PM application, in addition to control treatment, and three wheat cultivars (Al-Rasheed, IPA-99 and Abu Ghraib-3) were allocated to sub-sub plots. The results showed positive superiority of MP and TC in the growth parameters, yield components, wheat yield and some soil properties at both experimental locations. Likewise, the MP and TC had the lowest bulk density, while MP had the lowest electrical conductivity and the highest soil pH. The results also revealed that organic and inorganic amendments affected plant growth, yield components, grain yield significantly. The 50% CF+PM and 50% CF+FYM gave significantly higher thousand grain weight, spikes number at the 2nd location, wheat yield, and tillers per square meter at the 2nd location. Furthermore, soil bulk density, pH and electrical conductivity were significantly affected by all organic and inorganic treatments. The results also indicated that the highest spikes number, grain yield, chlorophyll content SPAD were recorded by IPA-99 cultivar at both locations. Moreover, under experiment conditions, the flag leaf chlorophyll content was significantly related to grain yield.

Keywords. Bulk density, Electrical conductivity, pH, SPAD, Yield components.

1. Introduction

Agricultural strategies exist to enhance the growing conditions of crops. These strategies include many interventions methods. One of these methods is agricultural methods. Falls under the agricultural practices, the implementation of various tillage techniques, which have an important role in changing the growing conditions. To ensure agricultural sustainability and preserve soil resources from degradation, soil and water use and management must be optimized. The way the soil is managed through tillage and fertilization, as well as the cultivars selected, are crucial elements of crop production [1]. Tillage impacts soil structure directly through mechanical rupturing of soil so the soil is subject to water and wind erosion [2]. The flipping and mixing crop leftovers plus grass in the soil due to tillage increased the stability of soil aggregates and increased soil health [3]. However, tillage is credited with damaging soil aggregates by crushing and compacting them when agricultural machinery passes irregularly during tilling, which has been cited as one of the direct negative effects, and it has an indirect effect on the long-term aggregation of soil group units, by accelerating oxidation rates of organic matter when it is mixed with soil [4]. By using five N rates and four tillage practices, North China, this study's findings revealed that yields of wheat and maize produced by conventional (moldboard), harrow or rotary tillage were not significantly different; however, the yields produced by No-tillage were significantly lower [5].

Providing nutrients exclusively through chemical fertilizers increases crop yield. However, excessive chemical fertilizer use contributes to soil fertility loss, soil compaction, loss of soil organic matter, and soil carbon loss [6]. Furthermore, over time, chemical fertilizers have proven less effective at increasing crop yields [7, 8]. So organic fertilizers as sources of nutrients have gained widespread attention as of late. Nitrogen, along with other macronutrients, can be controlled in the upper soil layer by the application of organic fertilizers and mineral fertilizers [9, 10]. The major nitrogenous components in organic fertilizers such as poultry manure (PM) are readily mineralized to ammonia and nitrate, as with chemical fertilizers [11]. As an important source of nutrients for crop production, cow manure (CM) is regarded as a good substitute for inorganic fertilizers due to its rich N content [12]. Organic fertilizers affect soil microbial biomass [13]. The organic carbon content of the soil is also positively influenced by organic fertilizers [14]. The production of wheat is determined by the genetic potential of cultivars, agro-ecological conditions and the technology used to produce it. The purpose of the research is therefore aims to estimate the growth of wheat cultivars and their production under the influence of different tillage and fertilization treatments.

2. Materials and Methods

2.1. Study Sites Description

A field experiment was conducted at two private farms situated at two locations in Iraq. The first location was located at Al Tannumah, which is situated at 15 km East Basrah province, while the second location was at Al Qurna, 74 km to the north of Basrah. It has a continental monsoon climate that is warm and mild, with a cool dry winter from November to February. The basic description of the experimental field is shown in Table 1.

2.2. Treatments and the Design of the Experiment

During the growing season of 2021-2022, the experiment was carried out. A randomized full block design was used in this study with three replications in a split-split configuration. The study included three tillage practices that are moldboard plow (MP) at 25 cm tillage depth, tine cultivator (TC) at 12 cm tillage depth and no-tillage (NT), which consisted of a narrow slot into which the seed was placed, as the main plot factors. Then, the three plots were divided into six subplots including the control treatment. The subplot factors were control without added fertilizer, Chemical fertilizer NPK 160:80:120 (CF) (The recommended dose for traditional farming), Farmyard manure (FYM) (based on N equivalency of chemical fertilizer), Poultry manure (PM) (based on N equivalency of chemical fertilizer), 50% Chemical fertilizer + FYM (50% CF+FYM) and 50% Chemical fertilizer + PM (50% CF+PM). The experiment mainly focused on nitrogen application from chemical fertilizer, farmyard manure and poultry manure. The sub-subplots factors were allocated to three certified winter wheat cultivars (Al-Rasheed, IPA-99 and Abu Ghraib-3). Moldboard plow and tine cultivator tillage treatments were achieved by two orthogonal passes followed by leveling. The organic manure was decomposed well and applied to the experimental field one month before sowing. The experiment field was ploughed down immediately after organic manure application. Urea 46% N, triple super phosphate (46% P_2O_5) and potassium sulfate (48% K_2O) were used as sources of N, P and K, respectively. The full dose of phosphorus and potash and half dose of nitrogen were applied at the time of seeding. The second half dose of nitrogen was applied 30 days after sowing. The size of each plot was 4×3 m. A distance of 1.5 meters has been established among plots within each replication. The same distance was left among replicates. Winter wheat seeds were sown on November 15, 2021, with a 3-4 cm seed depth and rate of 120 kg ha^{-1}. The seeds of wheat cultivars were sown in rows with a spacing of 15 cm. During the growth period, hand weeding was carried out when needed.

2.3. Growth Data Collection

The number of tillers and spikes per square meter was counted from one square meter sampled randomly from the central rows at harvesting. Chlorophyll content was measured at the end of the flowering stage with the use of a chlorophyll meter (Konica Minolta Japan Leaf Chlorophyll Meter 502 Plus, which is a portable Soil Plant Analysis Development SPAD chlorophyll meter). The SPAD meter was used by taking the reading on three locations on the flag leaf blade. Twenty measures were performed from each treatment and the readings were averaged [15]. Thousand grain weight in (g) was determined by counting 1000 grains from the harvested area and weighed using an electronic balance. Grain yield was determined with a 14% moisture base by threshing the harvested spikes from the entire plot. The grain yield per plot was weighed and converted into kg ha^{-1}.

2.4. Soil and Organic Manure Analyses

Soil sampling was carried out to measure the initial soil properties prior to the field experiment. Soil samples were collected by using a soil core (5 cm in diameter) in ten locations in the experimental field at 0-10, 10-20 and 20-30 cm depths. These soil samples were oven-dried and were analyzed to determine their physical and chemical properties. At harvest, soil samples were taken to assess the effects of tillage and fertilizers on soil bulk density, pH and electrical conductivity (EC). Within each plot, three randomly chosen locations were selected to measure the previous soil parameters through the soil depth of 10 cm, then the samples were averaged for each replication. After drying for 48 hours at 105°C, the cores were analyzed to determine the bulk density [16]. In a complete block randomized design, the factorial design was used to determine the effects of tillage practices as well as fertilizers on soil bulk density, pH and EC.

Soil texture was determined using the hydrometer method developed by Bouyoucos [17]. Soil pH and electrical conductivity (EC) were measured in a 1 soil to 2.5 distilled water suspension using pH and EC electrode meters [18]. Total nitrogen was calculated using Bremner's Kjeldahl technique [19]. To measure the available N of the samples, the hot water extraction routine was used [20]. The amount of phosphorus in the soil was determined using [21] approach. The flame photometer was used to measure available potassium, according to [22]. Total carbonate was measured according to [23]. Soil organic matter was determined by the Walkley-Black method described in [24] (Table 1). Samples of farmyard and poultry manure were collected randomly, then air-dried, ground, sieved and then analyzed for total N, P, K (%), total organic carbon (%), C:N ratio and dry matter (%) [25]. The composition of organic manures is given in Table 2.

Table 1. A preliminary characterization of the experiment soil.

	Sand %	**Silt %**	**Clay %**	**Texture**	**EC dS m^{-1}**	**PH**	**Total N g kg^{-1}**	**Organic matter g kg^{-1}**	**$CaCo_3$ g kg^{-1}**	**Available mg kg^{-1}**		
										N	**P**	**K**
1st location	12.43	43.35	44.22	Silty Clay	9.27	7.24	0.53	4.13	221	39	6.05	120.17
2nd location	16.72	42.5	40.78	Silty Clay	6.19	7.83	0.41	6.01	227	32	4.32	113.24

Table 2. The organic manure's properties.

Source	**Total organic carbon (%)**	**C:N**	**Dray matter (%)**	**Total N (%)**	**Total P (%)**	**Total K (%)**
Farmyard manure	15.9	17	61.7	1.27	0.38	0.71
Poultry manure	19.7	21	72.8	1.71	0.61	1.01

2.5. Statistical Analyses

The obtained data were analyzed using GenStat 12th Edition. To determine if there are any differences between groups of variables, an analysis of variance was performed. The test of least significant difference (LSD) was used to compare the means of treatment when the p-value for the difference was less than 0.05.

3. Results and Discussion

3.1. Tillers m^{-2}

The results of Table 4 showed significant superiority of MP in achieving the highest average of tillers per square meter of 442.28 and 507.17 tillers m^{-2} at the first and second location respectively, with a 4.22%, 26.14% increase percentage compared with TC and NT respectively at the first location, and 5.57% and 32.39% compared with TC and NT respectively at the second location. The NT treatment, gave the lowest average of 350.63 and 383.09 tillers m^{-2} at the first and second locations respectively. MP and TC effectively relieved compaction beneath the surface of the soil, resulting in a reduction in bulk density (Table 9); those that encourage root development of crops. Root systems spread out over a wide area, so that they can absorb soil moisture and nutrients more efficiently. This causes more tillers to grow than no tillage treatment.

The fertilizer treatments application significantly affected wheat tillers per square meter. The results of Table 4 show that the 50% CF+PM treatment has significantly increased tillers per square meter for both locations. The treatment 50% CF+PM gave 440.41 and 497.41 tillers m^{-2} at the first and second locations respectively. While Control treatment gave an average of 359.30 and 407.07 tillers m^{-2} at the first and second locations respectively. The results also showed that there were no significant differences between 50% CF+PM and 50% CF+FYM treatments at the second location, which gave average tillers of 497.41 and 487.07 tillers m^{-2} respectively. There was an increase in tillers per square meter when synthetic fertilizer was applied. This may be due to the rapid availability of nutrients from inorganic sources [26]. Also, organic fertilizers have different chemical compositions and may have a different effect on the soil and the growth of plants. The synergistic effect of the chemical and organic fertilizers led to an increase in the nutrients available for absorption by the roots of plants, which led to the promotion of growth and an increase in the number of tillers.

In accordance with the findings in Table 4, it can be concluded that cultivars have a clear and statistically significant impact on the number of tillers per square meter. There was an increase in the tillers m^{-2} achieved by Abu Ghraib-3 cultivar by 12.36% and 19.76% compared to Al-Rasheed and IPA-99 cultivars respectively at the first location, and by 4.53% and 14.30% compared to Al-Rasheed and IPA-99 cultivars respectively at the second location. Different cultivars have different genetic makeups, which may explain this variation.

The results of Table 5 showed that there were significant differences in the characteristic of tillers per square meter when tillage practices overlapped with the fertilizers at the first location, as the highest average of tillers was 469.33 tillers m^{-2} recorded for MP×CF. Whereas NT×Control interaction treatment recorded 296.67 tillers m^{-2}. Tillage procedures and cultivars had a substantial interacted impact on the results (Table 6). The higher number of tillers at the first location was 496.00 tillers m^{-2} recorded for MP×Abu Ghraib-3 interaction treatment, while it was 340.22 tillers m^{-2} for NT×Al-Rasheed. At the second location, the maximum tiller number were 536.72 tillers m^{-2} for MP×Abu Ghraib-3, than 374.00 tillers m^{-2} for NT×IPA-99. The interaction of Fertilizers×Cultivar was also significant for tillers per square meter at the first location (Table 7). The highest number of tillers was obtained from 50% CF+PM×Abu Ghraib-3 interaction treatment of 486.56 tillers m^{-2}, while it was 316.56 tillers m^{-2} for the Control×IPA-99 interaction treatment.

3.2. SPAD (Chlorophyll Content in Flag Leaf)

Table 4 showed the results that relate to the content of wheat flag leaf chlorophyll. Based on the data, the chlorophyll content was significantly affected by the different tillage practices fertilizer and cultivars and the interaction of the three factors. According to Table 4, the chlorophyll content of wheat flag leaf was significantly affected by tillage practices. The highest values of chlorophyll content were observed in the flag leaf of wheat grown under MP and TC of 32.24 and 30.31 SPDA respectively at the first location and 34.08 and 34.04 SPDA respectively at the second location. The lowest chlorophyll content was obtained from the flag leaf of wheat grown under NT (28.34 and 30.31 SPDA respectively at the first and second locations). The SPDA values after the application of TC and NT did not differ significantly at the first location recording value of 30.31 and 28.34 SPDA respectively. The favorable effect of MP and TC tillage practices on SPDA maybe as a result of the greater accessibility of nutrient elements through the cultivated area, as a consequence of low bulk density (Table 9) and ease of flow of water and nutrients through the root zone. A soil tillage method that used conventional soil tillage (Cultivator + cage roller) tended to encourage a greater level of leaf greenness SPAD values as compared to simplified tillage (Rototiller) at silt loam soil in Poland, as the conventional tillage method significantly increased the quantity of mineral nitrogen in the 0-60 cm stratum [27].

In addition, Table 4 showed that the application of fertilizer significantly affected SPAD values. The highest chlorophyll content at the first location of 32.44, 30.97 and 30.71 SPAD was obtained from flag leaf of wheat grown under 50% CF+PM, CF and 50% CF+FYM respectively, whereas the lowest chlorophyll content was receded under Control and FYM (27.98 and 29.50 SPAD respectively). It was also discovered via the process of statistically analyzing that all fertilizer treatments at the second location were superior to Control treatment following the order 50% CF+FYM, 50% CF+PM, CF, FYM and PM (34.57, 34.56, 33.24, 33.03 and 32.90 SPAD respectively), while the Control treatment recorded 28.56 SPAD. The SPAD values produced by all fertilizer treatments gradually increased compared to control, and this pattern may be linked to increased nutrient uptake in wheat. A study by [28] found no differences between corn SPAD values produced by 50 tons ha^{-1} manure and compost or by 200 kg N ha^{-1}. Moreover, they suggested that organic materials like chemical fertilizers could increase soil fertility and satisfy crops' nutritional needs. Further, they found that organic fertilizer provides crops with adequate nutrients to grow and develop. It was reported that half dose of chemical fertilizer + a half dose of poultry manure (4.87% total nitrogen) application for rice cultivars resulted in higher SPAD values than a full dose of chemical fertilizer (equivalent to N at 85 kg/hm^2 as urea), while lowest values recorded under control treatment where no nitrogen fertilizer was added [29].

The results of Table 4 showed that there were significant differences among cultivars in the chlorophyll content, as the IPA-99 cultivar outperformed by giving the highest average of chlorophyll content of 32.19 and 34.70 SPAD at the first and second location respectively, meanwhile it was 28.18 and 31.26 SPAD at the first and second location respectively for the Al-Rasheed cultivar. However, The Abu Ghraib-3 and Al-Rasheed cultivars were not statistically different from each other at the second location (32.46 and 31.26 SPAD respectively). It is possible that the variation in SPAD readings might be attributed to genotypic differences among cultivars.

At the first site, there was a significant interaction between tillage and fertilizers (Table 5). The interaction treatment MP×50% CF+PM gave the highest chlorophyll content of 35.12 SPAD compared with NT×Control that it gave the lowest value (24.21 SPAD). Similarly, the analysis of variance indicates significant triple interaction at the first location. The separated mean values by LSD test showed that the interaction treatment of MP×50% CF+PM×IPA-99 achieved the highest SPAD value of 37.13, in contrast, it was 19.03 SPAD for the NT×Control×Al-Rasheed (Table 8).

3.3. 1000-Grain Weight

From Table 4, the 1000-grain weight varied among the study treatments. More specifically, the MP treatment produced the highest winter wheat yield (30.26 and 31.20 g at the first and second location respectively), whereas the NT treatment produced the lowest (26.56 and 27.99 g at the first and second location respectively). The results of analysis of varies at the first location also showed that MP was on par with TC (30.26 and 28.57 g respectively), in addition there was no significant difference between NT and TC (26.56 and 28.57 g respectively). Moreover, NT and TC were at par with each other (27.99 and 29.38 g respectively). By applying MP and TC tillage treatments, soil bulk density was declined (Table 9). That made it easier for roots to grow horizontally and vertically. Improved conditions of the soil have resulted in a gradual enhancement of crop components since the basic elements for plant thrive have been more obtainable.

Study results showed that sources of nutrients significantly affected 1000-grain weights, which were important factors in grain yield (Table 4). At the first location, the 50% CF+PM and 50% CF+FYM fertilizer treatment recorded higher 1000-grain weight of 32.19 and 31.39 g respectively, and 32.34 and 32.29 g respectively at the second location. While it was 23.66 and 25.01 g respectively for Control treatment at the first and second location respectively. Using both organic and inorganic fertilizers enhanced the weight of a thousand grains, according to [30]. It is likely, the improved availability of plant nutrients, the extension of leaf area duration and the time it takes for photosynthates to accumulate during grain fill, the increase in soil water retention and reduction of nitrogenous fertilizer volatilization into ammonia gas, contributed to organic fertilizers in addition to inorganic fertilizers' favorable effects on weight of grain, and the individual kernel weight was finely increased [31, 32].

Data regarding the 1000-grain weight in both locations showed significant differences among wheat cultivars (Table 4). Maximum 1000-grain weight (31.81 and 30.37 at the first and second locations respectively) was for the Al-Rasheed cultivar. The control treatment resulted in the minimum 1000-grain weight (25.18 and 28.67 g at the first and second locations respectively); however, the Al-Rasheed cultivar was statistically at par with IPA-99; and Abu Ghraib-3 cultivar was statistically at par with IPA-99 at the second location. Cultivars have different genotypes, which explains the variation in the weight of a thousand grains.

In terms of 1000-grain weight, the tillage methods and fertilizer interaction was significant. The highest weight was 33.39 g at the second location respectively for MP×50% CF+PM, in return, NT×Control yielded 21.10 g (Table 5). At the first location, tillage techniques and cultivars interacted significantly (Table 6). Higher 1000-grain weight 33.16 g was for MP×Al-Rasheed than 23.12 g, which was recorded in NT×Abu Ghraib-3.

3.4. Number of Spike m^{-2}

The results in Table 4 show significant differences among tillage practices, fertilizers and cultivars for the first and second location of spike m^{-2} under different treatments. The MP achieved the heights value (334.85 and 346.11 spike m^{-2}) at the first and second location respectively followed by TC gave the value of (311.41 and 319.61 spike m^{-2} at the first and second location respectively). The lowest number of spikes at the first and second locations respectively was 265.17 and 274.56 spike m^{-2} recorded under NT. A change in the moisture content and physical properties of soil occurs during MP and TC. It decreased soil bulk density (Table 9); in addition, this mechanism of soil preparation might facilitate root penetration and encourage nutrient movement.

Using chemical and organic fertilizer combinations significantly enhanced the number of spikes per square meter (Table 4). It can be noticed that 50% CF+PM and 50% CF+FYM treatments gave the highest values (326.67 and 316.96 spike m^{-2} respectively at the first location, and 333.96 and 325.74 spike m^{-2} respectively at the second location, while spike number under control treatment was 269.74 and 289.04 spike m^{-2} at the first and second location respectively. The results of the analysis of variance also showed that there was no significant difference between 50% CF+PM and 50% CF+FYM treatments and Control and FYM treatments at the second location. There is a significant rise in spikes for unit area when varied amounts of municipal waste compost are used (0, 30 and 60 Mg ha^{-1}) and soil incorporated and four levels of nitrogen (0, 80, 160 and 240 kg N ha^{-1}) was also reported by [33]. According to their findings, increased tillering was the cause of increased spike density at harvest due to organic and inorganic nitrogen fertilization.

Cultivars varied significantly in their spike productivity, as the IPA-99 cultivar was superior. It achieved 330.69 and 332.33 spike m^{-2} at the first and second locations respectively followed by Abu Ghraib-3, the lowest number of spikes recorded for Al-Rasheed cultivar (265.85 and 280.81 spike m^{-2} at the first and second location respectively). The results also showed no significant difference between IPA-99 and Abu Ghraib-3 cultivars at the second location (Table 4). Genetic differences among cultivars may be responsible for this variation.

The influence of Tillage×Cultivar interaction was significant (Table 6). The highest number of spike 350.56 spike m^{-2} was recorded for TC×IPA-99 respectively at the first location, while the lowest number was 216.89 spike m^{-2} recorder under NT×Al-Rasheed. At the and second location, the MP×IPA-99 recorded the higher spikes of 358.22 spike m^{-2}, while it was 231.44 spike m^{-2} for NT×Al-Rasheed interaction treatment.

3.5. Grain Yield

The results of Table 4 showed significant superiority of MP treatment in achieving the highest average of wheat grain yield of 3713.01 and 4296.01 kg ha^{-1} at the first and second location respectively,

compared with the NT treatment, which gave the lowest average of 2525.98 and 2934.96 kg ha^{-1} at the first and second location respectively. No significant difference was observed between the MP and TC treatments at the first location in regards to their test average.
The statistical analysis showed the significant effect of different fertilizer treatments on the mean grain yield at both locations (Table 4). Generally, it is clear that 50% CF+PM and 50% CF+FYM recorded an increase in grain yield values of (4189.50 and 3890.20 kg ha^{-1} respectively at the first location), and (4389.52 and 4242.35 kg ha^{-1} respectively at the second location) not showing statistically significant changes as compared to the control that recorded minimum grain yield of 2065.35 kg ha^{-1} at the first location and 2620.47 kg ha^{-1} at the second location. The reason for the increase in the grain yield is due to the role of organic and inorganic fertilizers combination in providing the plant with macronutrients (N P K) which led to an increase in the characteristics of growth such as the number of spikes and the weight of 1000 grains and the number of grains in the spike (Table 4) and this was reflected in the yield of grains as a result of the efficient transfer of carbon synthesis products and the storage of carbohydrate and protein materials in grains. According to [34], organic fertilizers (Before sowing, 40 Mg ha^{-1} yr^{-1} apply of liquid dairy cattle manure) resulted in a significantly higher grain yield and better uptake of nutrients. It is because the soil health conditions have improved, the soil fertility has increased, and the stand establishment has enhanced.
As for tested cultivars, the cultivar IPA-99 out yielded the other cultivars on the number of grain per spike and the number of spikes per square meter. That led to the increase in grain yield. The cultivar IPA-99 gave 3621.11 and 3993.56 kg ha^{-1} compared with 2942.41 kg ha^{-1} for Abu Ghraib-3 at the first location and 3320.34 kg ha^{-1} for Al-Rasheed at the second location. The findings also demonstrated that the Al-Rasheed and Abu Ghraib-3 cultivars showed indistinguishable statistical response at the first site (Table 4). A genetic variation between wheat cultivars can account for the variation in yield.

3.6. The Relationship Between Flag Leaf SPAD Values and Grain Yield
In order to verify the relationship between SPAD readings and grain yield, a correlation analysis was done. Taking both sites into consideration, the results indicated that SPAD values were positively and significantly correlated with wheat grain yield. R^2, however, was higher at the 1st location than at the 2nd. As illustrated in Figure 1, a regression analysis of the SPAD readings and yield revealed significant linear relationships at both locations, with R^2 equal to 0.9099** for the 1st location and 0.8419** for the second location.

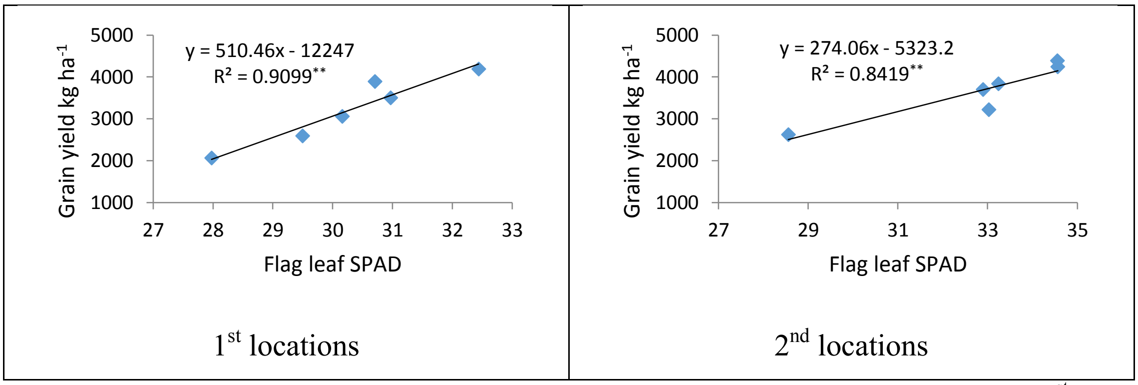

Figure 1. Relationship between grain yield and SPAD values are taken for flag leaf at the 1st and 2nd locations of the wheat plants.

Table 3. Effect of tillage practices, integrated use of organic and inorganic fertilizers and cultivars on wheat traits at both experimental locations.

Treatments			**1st Location**					**2nd Location**		
Tillage	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
NT	350.63	28.34	26.56	265.17	2525.98	383.09	30.31	27.99	274.56	2934.96
TC	424.39	30.31	28.57	311.41	3409.45	480.39	34.04	29.38	319.61	3775.35
MP	442.28	32.24	30.26	334.85	3713.01	507.17	34.08	31.20	346.11	4296.01
LSD	14.507**	2.484*	2.74*	12.07**	730.7*	22.75**	3.018*	1.72*	13.13**	351.3**
Fertilizers										
Control	359.30	27.98	23.66	269.74	2065.35	407.07	28.56	25.01	289.04	2620.47
CF	422.30	30.97	29.68	313.37	3499.64	468.30	33.24	30.36	316.67	3841.61
FYM	385.59	29.50	26.16	289.67	2590.57	427.41	33.03	27.85	296.78	3217.56
PM	398.56	30.16	27.70	306.44	3061.59	454.04	32.90	29.28	318.37	3701.14
50% CF+FYM	428.44	30.71	31.39	316.96	3890.20	487.07	34.57	32.29	325.74	4242.35
50% CF+PM	440.41	32.44	32.19	326.67	4189.50	497.41	34.56	32.34	333.96	4389.52
LSD	7.685**	1.94**	2.42**	8.91**	435**	13.95**	2.036**	1.497**	8.64**	300.4**
Cultivar										
Al-Rasheed	397.57	28.18	31.81	265.85	3084.91	463.07	31.26	30.37	280.81	3320.34
IPA-99	373.00	32.19	28.41	330.69	3621.11	423.50	34.70	29.53	332.33	3993.56
Abu Ghraib-3	446.72	30.51	25.18	314.89	2942.41	484.07	32.46	28.67	327.13	3692.42
LSD	4.712**	1.595**	0.694**	8.34**	172.4**	12.57**	2.037**	1.173*	8.37**	231.1**

TN = Tillers m^{-2}, SPAD = Chlorophyll content in flag leaf, TGW = Thousand grains weight g, NSM = Number of spikes per m^2, GY = Grain yield Kg ha^{-1}. * Significantly different at 0.05, ** Significantly different at 0.01, ns: denoting not significant according to threshold significance level.

Table 4. Effect of tillage practices and integrated use of organic and inorganic fertilizers interaction on wheat traits at both experimental locations.

			1st Location					**2nd Location**		
Tillage ×Fertilizers	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
NT×Control	296.67	24.21	19.95	233.11	1389.18	328.78	26.34	21.10	248.44	1591.76
NT×CF	361.44	27.90	26.77	273.89	2649.04	393.22	30.30	29.03	284.11	3131.80
NT×FYM	323.67	30.24	24.30	248.67	1986.19	356.33	31.78	25.41	258.00	2434.41
NT×PM	338.78	27.60	25.24	272.33	2345.85	372.67	29.62	28.57	281.22	3145.20

		1st Location					2nd Location			
Tillage ×Fertilizers	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
NT×50% CF+FYM	382.11	29.30	30.88	272.89	3165.78	415.56	32.22	32.51	280.22	3619.74
NT×50% CF+PM	401.11	30.76	32.22	290.11	3619.82	432.00	31.59	31.32	295.33	3686.84
TC×Control	382.56	28.46	25.46	270.33	2322.24	428.78	30.20	24.11	296.89	2763.91
TC×CF	436.11	30.06	30.22	329.11	3823.85	493.22	33.50	30.80	320.89	3935.56
TC×FYM	409.44	30.30	24.30	298.44	2547.68	458.11	34.32	28.22	296.33	3186.98
TC×PM	421.22	30.94	26.42	308.44	3018.35	484.33	35.82	28.38	324.11	3605.54
TC×50% CF+FYM	442.89	30.63	33.12	326.33	4307.40	507.89	35.56	32.44	337.11	4553.21
TC×50% CF+PM	454.11	31.44	31.91	335.78	4437.15	510.00	34.82	32.32	342.33	4606.91
MP×Control	398.67	31.27	25.58	305.78	2484.63	463.67	29.13	29.82	321.78	3505.73
MP×CF	469.33	34.96	32.04	337.11	4026.03	518.44	35.92	31.24	345.00	4457.48
MP×FYM	423.67	27.96	29.88	321.89	3237.84	467.78	32.99	29.94	336.00	4031.27
MP×PM	435.67	31.94	31.46	338.56	3820.58	505.11	33.27	30.90	349.78	4352.68
MP×50% CF+FYM	460.33	32.19	30.15	351.67	4197.44	537.78	35.92	31.93	359.89	4554.11
MP×50% CF+PM	466.00	35.12	32.43	354.11	4511.52	550.22	37.27	33.39	364.22	4874.80
LSD	16.69**	3.579*	ns	ns	ns	ns	ns	2.681**	ns	ns

TN = Tillers m^{-2}, SPAD = Chlorophyll content in flag leaf, TGW = Thousand grains weight g, NSM = Number of spikes per m^2, GY = Grain yield Kg ha^{-1}. * Significantly different at 0.05, ** Significantly different at 0.01, ns: denoting not significant according to threshold significance level.

Table 5. Effect of tillage practices and cultivars interaction on wheat traits at both experimental locations.

			1st Location					2nd Location		
Tillage ×Cultivar	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
NT×Al-Rasheed	340.22	25.84	29.53	216.89	2298.17	377.83	28.44	29.53	231.44	2656.67
NT×IPA-99	344.33	30.22	27.03	294.33	2934.42	374.00	31.81	27.97	300.78	3125.58
NT×Abu Ghraib-3	367.33	28.95	23.12	284.28	2345.34	397.44	30.68	26.47	291.44	3022.63
TC×Al-Rasheed	418.33	26.75	32.73	264.22	3221.10	485.78	30.83	30.46	280.11	3400.45

	1st Location					2nd Location				
Tillage ×Cultivar	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
TC×IPA-99	378.00	32.53	27.68	350.56	3897.77	437.33	36.42	29.10	338.00	4129.59
TC×Abu Ghraib-3	476.83	31.64	25.30	319.44	3109.47	518.06	34.86	28.57	340.72	3796.01
MP×Al-Rasheed	434.17	31.96	33.16	316.44	3735.45	525.61	34.52	31.12	330.89	3903.91
MP×IPA-99	396.67	33.83	30.50	347.17	4031.13	459.17	35.88	31.53	358.22	4725.50
MP×Abu Ghraib-3	496.00	30.93	27.11	340.94	3372.43	536.72	31.84	30.95	349.22	4258.63
LSD	14.345 **	ns	2.676 *	15.06 **	ns	25.47 **	ns	ns	15.69 **	ns

TN = Tillers m^{-2}, SPAD = Chlorophyll content in flag leaf, TGW = Thousand grains weight g, NSM = Number of spikes per m^2, GY = Grain yield Kg ha^{-1}. * Significantly different at 0.05, ** Significantly different at 0.01, ns: denoting not significant according to threshold significance level.

Table 6. Effect of integrated use of organic and inorganic fertilizers and cultivars interaction on wheat traits at both experimental locations.

	1st Location					2nd Location				
Fertilizers×Cultivar	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
Control×Al-Rasheed	364.56	24.89	27.41	229.11	1991.01	419.00	27.67	25.89	250.00	2176.05
Control×IPA-99	316.56	30.28	23.97	299.78	2473.97	363.67	30.07	26.58	304.78	3091.65
Control×Abu Ghraib-3	396.78	28.77	19.61	280.33	1731.06	438.56	27.94	22.56	312.33	2593.69
CF×Al-Rasheed	408.00	29.18	33.05	278.22	3300.94	464.89	31.34	31.94	287.67	3464.63
CF×IPA-99	407.00	33.49	29.10	336.00	3870.32	450.78	36.97	30.62	329.78	4137.86
CF×Abu Ghraib-3	451.89	30.24	26.88	325.89	3327.65	489.22	31.41	28.51	332.56	3922.34
FYM×Al-Rasheed	376.44	27.73	29.37	247.44	2415.91	439.78	30.57	28.16	268.44	2890.44
FYM×IPA-99	346.89	32.54	26.72	329.44	3192.72	382.00	35.32	27.50	327.44	3609.49
FYM×Abu Ghraib-3	433.44	28.22	22.39	292.11	2163.08	460.44	33.20	27.90	294.44	3152.73
PM×Al-Rasheed	397.67	30.01	31.53	265.22	2998.47	457.44	32.37	29.34	281.11	3516.30
PM×IPA-99	355.78	28.22	27.29	328.78	3446.46	426.11	32.31	28.83	332.22	3982.59

	1st Location					2nd Location				
Fertilizers×Cultivar	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
PM×Abu Ghraib-3	442.22	32.26	24.29	325.33	2739.85	478.56	34.03	29.69	341.78	3604.53
50% CF+FYM×Al-Rasheed	416.00	27.94	34.03	282.67	3665.05	506.56	31.62	32.93	294.78	3756.98
50% CF+FYM×IPA-99	399.89	32.39	31.73	340.33	4315.13	439.89	38.33	32.09	348.33	4583.51
50% CF+FYM×Abu Ghraib-3	469.44	31.79	28.39	327.89	3690.43	514.78	33.74	31.87	334.11	4386.57
50% CF+PM×Al-Rasheed	422.78	29.33	35.46	292.44	4138.04	490.78	34.02	33.97	302.89	4117.65
50% CF+PM×IPA-99	411.89	36.23	31.61	349.78	4428.04	478.56	35.21	31.59	351.44	4556.24
50% CF+PM×Abu Ghraib-3	486.56	31.76	29.49	337.78	4002.41	522.89	34.44	31.47	347.56	4494.67
LSD	11.991 **	ns	ns	ns	ns	ns	ns	ns	ns	ns

TN = Tillers m^{-2}, SPAD = Chlorophyll content in flag leaf, TGW = Thousand grains weight g, NSM = Number of spikes per m^2, GY = Grain yield Kg ha^{-1}. * Significantly different at 0.05, ** Significantly different at 0.01, ns: denoting not significant according to threshold significance level.

Table 7. Effect of tillage practices, integrated use of organic and inorganic fertilizers and cultivars interaction on wheat traits at both experimental locations.

	1st Location					2nd Location				
Tillage ×Fertilizers×Cultivar	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
NT×Control×Al-Rasheed	292.00	19.03	22.83	183.33	1212.18	327.00	21.93	23.44	201.00	1244.57
NT×Control×IPA-99	279.33	26.17	19.77	259.00	1600.32	316.67	28.70	23.56	274.67	2006.35
NT×Control×Abu Ghraib-3	318.67	27.43	17.24	257.00	1355.03	342.67	28.40	16.28	269.67	1524.37
NT×CF×Al-Rasheed	345.33	27.00	29.68	225.67	2360.08	382.67	30.30	29.88	242.00	2796.63
NT×CF×IPA-99	374.00	32.33	26.96	302.00	3091.50	413.33	36.03	30.57	309.67	3375.65
NT×CF×Abu Ghraib-3	365.00	24.37	23.66	294.00	2495.53	383.67	24.57	26.65	300.67	3223.11
NT×FYM×Al-Rasheed	312.00	25.17	27.51	192.33	1731.51	354.00	27.27	27.51	204.00	2141.95
NT×FYM×IPA-99	306.67	35.93	26.40	280.67	2576.37	329.33	35.67	25.80	288.00	2432.72
NT×FYM×Abu Ghraib-3	352.33	29.63	19.00	273.00	1650.70	385.67	32.40	22.91	282.00	2728.57
NT×PM×Al-Rasheed	338.67	28.37	27.98	222.67	2097.16	371.67	31.13	28.39	241.33	3064.02

		1^{st} Location					2^{nd} Location			
Tillage ×Fertilizers×Cultivar	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
NT×PM×IPA-99	318.33	24.53	24.87	306.00	2828.51	355.33	25.23	27.73	305.00	3283.76
NT×PM×Abu Ghraib-3	359.33	29.90	22.85	288.33	2111.89	391.00	32.50	29.60	297.33	3087.81
NT×50% CF+FYM×Al-Rasheed	367.33	30.47	33.56	227.33	2875.20	407.33	26.87	33.65	242.00	3212.95
NT×50% CF+FYM×IPA-99	385.67	26.53	32.13	300.33	3611.25	409.67	36.60	31.77	308.33	3904.43
NT×50% CF+FYM×Abu Ghraib-3	393.33	30.90	26.95	291.00	3010.88	429.67	33.20	32.11	290.33	3741.84
NT×50% CF+PM×Al-Rasheed	386.00	25.00	35.59	250.00	3512.87	424.33	33.13	34.30	258.33	3479.88
NT×50% CF+PM×IPA-99	402.00	35.80	32.06	318.00	3898.60	419.67	28.60	28.37	319.00	3750.58
NT×50% CF+PM×Abu Ghraib-3	415.33	31.47	29.01	302.33	3447.99	452.00	33.03	31.29	308.67	3830.07
TC×Control×Al-Rasheed	390.33	25.53	30.91	229.00	2327.34	437.67	27.47	24.55	246.33	2343.74
TC×Control×IPA-99	326.67	29.67	25.83	318.33	2943.18	373.33	32.40	26.00	308.00	3242.12
TC×Control×Abu Ghraib-3	430.67	30.17	19.63	263.67	1696.20	475.33	30.73	21.79	336.33	2705.88
TC×CF×Al-Rasheed	430.33	25.50	33.97	280.33	3387.25	471.00	28.47	34.88	296.00	3654.55
TC×CF×IPA-99	391.67	31.27	27.52	364.33	4183.53	475.33	35.83	29.75	322.33	4185.33
TC×CF×Abu Ghraib-3	486.33	33.40	29.18	342.67	3900.77	533.33	36.20	27.77	344.33	3966.78
TC×FYM×Al-Rasheed	402.00	25.13	28.63	247.67	2400.13	488.00	30.37	26.69	283.00	2875.72
TC×FYM×IPA-99	368.00	34.23	23.92	354.00	3172.70	402.33	38.37	27.14	326.00	3694.33
TC×FYM×Abu Ghraib-3	458.33	31.53	20.34	293.67	2070.21	484.00	34.23	30.82	280.00	2990.90
TC×PM×Al-Rasheed	419.00	29.30	30.60	254.33	2884.15	507.67	34.33	29.40	266.33	3398.93
TC×PM×IPA-99	372.33	29.67	26.03	335.67	3434.49	457.67	34.33	27.61	338.33	3816.02
TC×PM×Abu Ghraib-3	472.33	33.87	22.62	335.33	2736.42	487.67	38.80	28.12	367.67	3601.66
TC×50% CF+FYM×Al-Rasheed	432.67	26.90	36.43	279.33	3973.56	536.33	32.73	33.25	291.67	4049.92

		1st Location					2nd Location			
Tillage ×Fertilizers×Cultivar	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
TC×50% CF+FYM×IPA-99	397.33	34.57	31.97	361.67	4820.68	423.00	39.37	31.36	368.00	4884.50
TC×50% CF+FYM×Abu Ghraib-3	498.67	30.43	30.96	338.00	4127.96	564.33	34.57	32.73	351.67	4725.20
TC×50% CF+PM×Al-Rasheed	435.67	28.13	35.86	294.67	4354.16	474.00	31.63	34.03	297.33	4079.82
TC×50% CF+PM×IPA-99	412.00	35.77	30.82	369.33	4832.06	492.33	38.20	32.75	365.33	4955.26
TC×50% CF+PM×Abu Ghraib-3	514.67	30.43	29.06	343.33	4125.24	563.67	34.63	30.20	364.33	4785.67
MP×Control×Al-Rasheed	411.33	30.10	28.48	275.00	2433.51	492.33	33.60	29.69	302.67	2939.84
MP×Control×IPA-99	343.67	35.00	26.31	322.00	2878.41	401.00	29.10	30.17	331.67	4026.49
MP×Control×Abu Ghraib-3	441.00	28.70	21.95	320.33	2141.96	497.67	24.70	29.60	331.00	3550.84
MP×CF×Al-Rasheed	448.33	35.03	35.50	328.67	4155.49	541.00	35.27	31.05	325.00	3942.71
MP×CF×IPA-99	455.33	36.87	32.84	341.67	4335.94	463.67	39.03	31.55	357.33	4852.60
MP×CF×Abu Ghraib-3	504.33	32.97	27.79	341.00	3586.65	550.67	33.47	31.11	352.67	4577.14
MP×FYM×Al-Rasheed	415.33	32.90	31.97	302.33	3116.10	477.33	34.07	30.29	318.33	3653.65
MP×FYM×IPA-99	366.00	27.47	29.84	353.67	3829.09	414.33	31.93	29.56	368.33	4701.44
MP×FYM×Abu Ghraib-3	489.67	23.50	27.83	309.67	2768.33	511.67	32.97	29.97	321.33	3738.73
MP×PM×Al-Rasheed	435.33	32.37	36.02	318.67	4014.12	493.00	31.63	30.23	335.67	4085.95
MP×PM×IPA-99	376.67	30.47	30.95	344.67	4076.38	465.33	37.37	31.14	353.33	4847.99
MP×PM×Abu Ghraib-3	495.00	33.00	27.41	352.33	3371.25	557.00	30.80	31.34	360.33	4124.12
MP×50% CF+FYM×Al-Rasheed	448.00	26.47	32.09	341.33	4146.40	576.00	35.27	31.89	350.67	4008.06
MP×50% CF+FYM×IPA-99	416.67	36.07	31.10	359.00	4513.48	487.00	39.03	33.14	368.67	4961.60
MP×50% CF+FYM×Abu Ghraib-3	516.33	34.03	27.27	354.67	3932.43	550.33	33.47	30.77	360.33	4692.68
MP×50% CF+PM×Al-Rasheed	446.67	34.87	34.92	332.67	4547.11	574.00	37.30	33.59	353.00	4793.24

	1st Location					2nd Location				
Tillage ×Fertilizers×Cultivar	**TN**	**SPAD**	**TGW**	**NSM**	**GY**	**TN**	**SPAD**	**TGW**	**NSM**	**GY**
MP×50% CF+PM×IPA-99	421.67	37.13	31.96	362.00	4553.47	523.67	38.83	33.64	370.00	4962.88
MP×50% CF+PM×Abu Ghraib-3	529.67	33.37	30.41	367.67	4433.99	553.00	35.67	32.93	369.67	4868.28
LSD	ns	6.501*	ns	ns	ns	ns	ns	ns	ns	ns

TN = Tillers m^{-2}, SPAD = Chlorophyll content in flag leaf, TGW = Thousand grains weight g, NSM = Number of spikes per m^2, GY = Grain yield Kg ha^{-1}. * Significantly different at 0.05, ** Significantly different at 0.01, ns: denoting not significant according to threshold significance level.

3.7. Soil Bulk Density

Soil hardness may be gauged by its bulk density, a soil compaction indication. There was a significant impact of soil tillage on bulk density (Table 9). CT and TC recorded the lowest values at the 1st and 2nd location in the absence of any notable differences between them (1.416 and 1.426 g cm^{-3} at the 1st location respectively in addition to 1.318 and 1.343 g cm^{-3} at the 2nd location respectively). The highest values (1.466 and 1.419 g cm^{-3}) were recorded for no tillage at the 1st and 2nd locations respectively. It is likely that the lower density at greater tillage depth is a consequence of increased soil disturbance, along with the plough's shape, leading to the disturbance variance in soil that result. The findings are in line with [35], which indicates that tillage significantly affected soil bulk density, being respectively 1,48, 1,44, and 1.38 mg m^{-3} for zero tillage, conventional tillage and deep tillage.

The addition of chemical and organic manure had a statistically significant effect on bulk density at both locations (Table 9). Bulk density increased progressively at the 1st location in the order of CF> 50% CF+FYM> Control> 50% CF+PM> FYM> PM. The highest bulk density mean values were observed at CF while all other treatments shared the same significant level. Meanwhile, CF and Control were on a par with each other by recording the highest bulk density of 1.386 and 1.383 g cm^{-3} at the 2nd location, while the lowest density was recorded for PM (1.329 g cm^{-3}). Reduced bulk density could be a consequence of the low-density fibers derived from organic manures [36], increased soil pores and aeration, and better soil aggregation from organic manure [37].

3.8. Soil pH

Significant differences in soil pH were observed at both locations owing to tillage practices (Table 9). Soil pH were 7.354 and 7.616 for CT at the 1st and 2nd location respectively, whereas it was the lowest for NT treatment (7.19 and 7.447 at the 1st and 2nd location respectively). [38] assert that the lowest pH rate occurs in no-till systems, while the highest level occurs in conventional systems in northern parts of Khorasan Razavi province. With no-till, the soil in the upper soil layers is likely to be more acidic, as organic matter is mineralized and surface applied nitrogen fertilizer is nitrified [39].

Analyzing the data, soil pH was significantly influenced by the addition of the chemical and organic manures (Table 9). The highest soil pH was recorded for CF treatment, which was 7.537 at the 1st location and 7.73 at the 2nd location. Minimum values of soil pH were 7.061 at the 1st location and 7.383 at the 2nd location for PM treatment. Adding organic material decreased soil pH significantly. The decrease is probably a result of increased soil microbial activity caused by increased soil N levels. In addition, roots release hydrogen ions to absorb nitrogen as ammonium, which results in decreased soil pH [40].

3.9. Soil Electrical Conductivity (EC)

According to the one-way ANOVA, EC was influenced by different tillage methods at both experimental locations (Table 9). At the 1st location, the data pertaining to EC as affected by tillage practices was significant, where NT recorded the highest mean values of 9.997 dS m^{-1} compared to other tillage practices, while the lowest values were recorded for MP 7.771 dS m^{-1}. The highest values of soil EC at the 2nd location were found under NT (7.119 dS m^{-1}) followed by TC (6.953 dS m^{-1}) as there are no notable statistical distinctions between them, in contrast, the EC value of 6.434 dS m^{-1} was recorded under MP. Lower soil electrical conductivity under MP might be attributed to the enhanced water movement in the soil as a consequence to lower bulk density. [41] reported in their experiment, that electrical conductivity was higher for no-till than for deep conservation tillage, shallow conservation tillage and moldboard ploughing in silty loam soil in eastern Austria. In the current study, the organic and inorganic amendments showed a significant effect on soil EC through soil tested profiles at both experimental locations; in general, adding organic and inorganic amendments increased soil EC (Table 9). Soil EC was found greater (7.375 and 10.53 dS m^{-1} at the 1st and 2nd location respectively) in the plots receiving FYM, while it was the lowest over the control treatment (6.132 and 7.473 dS m^{-1} at the 1st and 2nd location respectively). In sandy clay loam at Pretoria, South Africa, [42] showed that poultry, cattle, and goat manures significantly increased soil electrical conductivity. [43] observed that the application of manure increased the EC compared to that of inorganic fertilizer and control treatment without fertilization for 0- to 10-cm depth, in silty loam soil in South Dakota.The EC in all treatments at the 1st location showed no significant defenses, however, there was a significant tillage×fertilizer interaction for the electrical conductivity (EC) at the 2nd location (Table 9). The EC was higher (13.397 dS m^{-1}) with NT×FYM, compared to CT×Control (6.178 dS m^{-1}). By comparing NT to MP and CT at a soil depth of 0-20 cm, [44] found that NT showed a higher EC.

Table 8. Effects of tillage practices, fertilizers treatments and their interaction soil bulk density, pH and EC at both experimental locations.

	1st location	**2nd location**	**1st location**	**2nd location**	**1st location**	**2nd location**
	Bulk density g cm^{-3}	**Bulk density g cm^{-3}**	**pH**	**pH**	**EC dS m^{-1}**	**EC dS m^{-1}**
Tillage						
NT	1.466	1.419	7.191	7.447	9.997	7.119
TC	1.426	1.343	7.233	7.530	9.038	6.953
MP	1.416	1.318	7.354	7.616	7.771	6.434
LSD	0.01865**	0.02798**	0.1344*	0.1313*	0.502**	0.514*
Fertilizers						
Control	1.432	1.386	7.298	7.570	7.473	6.132
CF	1.467	1.383	7.537	7.730	9.321	7.041
FYM	1.426	1.341	7.193	7.494	10.530	7.375
PM	1.424	1.329	7.061	7.383	8.324	6.612
50% CF+FYM	1.437	1.351	7.254	7.534	9.141	6.953
50% CF+PM	1.429	1.370	7.212	7.476	8.824	6.900
LSD	0.02637*	0.03958*	0.1901**	0.1856*	0.710**	0.727*
Tillage ×Fertilizers						
NT×Control	1.459	1.469	7.131	7.404	8.896	6.459
NT×CF	1.493	1.417	7.407	7.592	10.462	7.142
NT×FYM	1.453	1.397	7.130	7.388	13.397	8.155
NT×PM	1.451	1.392	7.008	7.289	8.324	6.611

	1st location	2nd location	1st location	2nd location	1st location	2nd location
	Bulk density g cm^{-3}	**Bulk density g cm^{-3}**	**pH**	**pH**	**EC dS m^{-1}**	**EC dS m^{-1}**
NT×50% CF+FYM	1.483	1.411	7.256	7.534	10.080	7.446
NT×50% CF+PM	1.457	1.426	7.212	7.476	8.824	6.900
TC×Control	1.429	1.342	7.256	7.601	7.345	6.661
TC×CF	1.433	1.364	7.578	7.657	9.877	7.072
TC×FYM	1.423	1.353	7.065	7.502	10.143	7.480
TC×PM	1.421	1.313	7.032	7.409	8.324	6.612
TC×50% CF+FYM	1.424	1.348	7.253	7.534	9.717	6.994
TC×50% CF+PM	1.426	1.340	7.212	7.475	8.824	6.900
MP×Control	1.409	1.348	7.507	7.703	6.178	5.276
MP×CF	1.473	1.367	7.627	7.941	7.624	6.908
MP×FYM	1.403	1.274	7.383	7.592	8.049	6.490
MP×PM	1.401	1.282	7.142	7.451	8.325	6.612
MP×50% CF+FYM	1.404	1.294	7.254	7.534	7.626	6.419
MP×50% CF+PM	1.404	1.343	7.212	7.476	8.824	6.900
LSD	ns	ns	ns	ns	1.230**	ns

Conclusion

Field experiment results, at two different locations, indicated that under southern Iraqi environmental conditions, the significantly highest values of growth parameters, yield components, wheat yield and some soil properties at both experimental locations were recorded under MP and TC tillage practices compared to NT treatment. In addition, the application of MP and TC can enhance soil bulk density and reduce electrical conductivity while increasing soil pH. Organic and inorganic fertilizer combination is essential to maintaining the soil's nutrient balance and contributing to wheat production. Application of organic manures in conjunction with mineral fertilizers can improve soil properties, wheat growth and production. It can be concluded from the results of this study that the application of 50% CF+PM and 50% CF+FYM were the best among fertilizer combinations treatments, followed by CF alone. Furthermore, the application of organic and inorganic fertilizer combination significantly affected soil bulk density, pH and electrical conductivity. It was observed that the IPA-99 cultivar exerted the highest number of spikes number, grain yield, chlorophyll content SPAD at both experimental locations. Also, the flag leaf chlorophyll content was significantly correlated with the grain yield under experimental conditions. It seems that MP and TC with organic and inorganic fertilizer combination application help to enhance some of the physico-chemical properties of the soil and provide enough nutrients for sustainable environments to increase productivity; however, the conditions of the experiment must be taken into account when re-applied in different environmental conditions.

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References

[1] Lal R and Shukla M K 2004 *Principles of soil physics* 1st Editio. Boca Raton: CRC Press.
[2] Balesdent J, Chenu C, and Balabane M 2000 *Soil tillage Res.* **53**215–230

[3] Cassel D K, Raczkowski C W, and Denton H P 1995 *Soil Sci. Soc. Am. J.* **59**1436–1443
[4] Hill, R L 1990 *Soil Sci. Soc. Am. J.* **54**161–166
[5] Feng Y, Ning T, Z Li, Han B, Han H, Li Y, Sun T, and Zhang X 2014 *Plant, Soil Environ.* **60**100–104
[6] Bhattacharyya P, Nayak A K, Shahid M, Tripathi R, Mohanty S, Kumar A, Raja R, Panda B B, Lal B, Gautam P, and others 2015 *Crop J.* **3**387–395
[7] Sun R, Zhang X-X, Guo X, Wang D, and Chu H 2015 *Soil Biol. Biochem.* **88**9–18
[8] Nkoa, R 2014 *Agron. Sustain. Dev.* **34**473–492
[9] Hlisnikovský L, and Kunzová E 2014 *Agriculture* **60**142
[10] Aajmi Salman M, and Kamal Al-Shibani J A 2019 *Al-Qadisiyah J. Agric. Sci.* **9**247–256
[11] Eghball B, Wienhold B J, Gilley J E, and Eigenberg R A 2002 *J. Soil Water Conserv.* **57**470–473
[12] Sharma A R, and Mittra B N 1991 *Indian J. Agron.* **36**299–303
[13] Geisseler D, and Scow K M 2014 *Soil Biol. Biochem.* **75**54–63
[14] Sradnick A, Oltmanns M, Raupp J, and Joergensen R G 2014 *Geoderma* **226**79–84
[15] Yuan Z, Cao Q, Zhang K, Ata-Ul-Karim S T, Tian Y, Zhu Y, Cao W, and Liu X 2016 *Front. Plant Sci.* **7**719
[16] Salehi Hikouei I, Kim S S, and Mishra D R 2021 *Sensors* **21**4408
[17] Bouyoucos G J 1962 *Agron. J.* **54**464–465
[18] Palojärvi A, Kellock M, Parikka P, Jauhiainen L, and Alakukku L 2021 *Front. Microbiol.* **12**1291
[19] Bremner J M 1996 *Nitrogen-total Methods of soil analysis*: Part 3 Chemical methods 5 pp1085–1121
[20] Curtin D, Wright C E, Beare M H, and McCallum F M 2006 *Soil Sci. Soc. Am. J.* **70**1512–1521
[21] Olsen S R 1982 LE: Sommers: *Phosphorus. Methods of soil analysis* (Eds.: AL Page, RH Miller and DR Keeney) p 403
[22] Black C A 1965 *Methods of Soil Analysis* Part II Mono 9. Madison, Wisconsin USA: American Society of Agronomy, Inc.
[23] Jackson M L 2005 *Soil chemical analysis: advanced course* UW-Madison Libraries Parallel Press
[24] Page A L and Keeney D R 1982 *Methods of soil analysis* American Society of Agronomy
[25] Chapman H D and Pratt P F 1961 *Methods of analysis for soils, plants and waters* University of California Agr Sci, Berkeley University of California, Division of Agricultural Sciences
[26] Hammad H M, Khaliq A, Ashfaq A, Aslam M, Malik A H, Farhad W, and Laghari K Q 2011 *Int. J. Agric. Biol.* **13**137-140
[27] Kulig B, Lepiarczyk A, Oleksy A, Kołodziejczyk M 2010 *Eur. J. Agron*. **33**43–51
[28] Naderi R, and Ghadiri H 2010 *DESERT (BIABAN)* **15**159–165
[29] Moe K, Moh S M, Htwe A Z, Kajihara Y, and Yamakawa T 2019 *Rice Sci.* **26**309–318
[30] Hossain S M A, Kamal A M A, Islam M R, and Mannan M A 2002 *J. Biol. Sci* **2**304–306
[31] Gill, H. S., and Meelu O. P.. 1982. Studies on the substitution of inorganic fertilizers with organic manure and their effect on soil fertility in rice—wheat rotation. *Fertil. Res.* **3**(4):303–314
[32] Badaruddin M, Reynolds M P, and Ageeb O A A 1999 *Agron. J.* **91**975–983
[33] Abedi T, Alemzadeh A, and Kazemeini S A 2010 *Aust. J. Crop Sci.* **4**384–389
[34] Matsi T, Lithourgidis A S, and Gagianas A A 2003 *Agron. J.* **95**592–596
[35] Hassan D F, Jafaar A A, Mohamm R J, and others 2019 *Iraqi J. Agric. Sci.* **50**42–47
[36] Abbas F, and Fares A 2009 *Soil Sci. Soc. Am. J.* **73**995–1003
[37] Gangwar K S, Singh K K, Sharma S K, and Tomar O K 2006 *Soil Tillage Res.* **88**242–252
[38] Gholami A, Asgari H R, and Saeidifar Z 2014 *Int. J. Adv. Biol. Biomed. Res.* **2**1513–1524
[39] López-Fando C, and Pardo M T 2009 *Soil Tillage Res.* **104**278–284
[40] Bezdicek D Fauci M and Schwab G 2002 *In Direct seed Conf.* Department of crop and soil sciences, WSU, Pullman, WA

[41] Neugschwandtner R W, Száková J, Pachtrog V, Tlustoš P, Čern`y J, Kulhánek M, Kaul H-P Euteneuer, P, Moitzi G, and Wagentristl H 2020 *Int. Agrophysics* **34**133–140
[42] Azeez J O, and Van Averbeke W 2012 *Communications in Soil Sci. Plant Anal.* **43**865–874
[43] Ozlu E, and Kumar S 2018 *Soil Sci. Soc. Am. J.* **82**1243–1251
[44] Perez-Brandán C, Arzeno J L, Huidobro J, Grümberg B, Conforto C, Hilton S, Bending G D, Meriles J M, and Vargas-Gil S 2012 *Crop Prot.* **40**73–82