Article

Effect of Zero and Minimum Tillage on Cotton Productivity and Soil Characteristics under Different Nitrogen Application Rates

Niamat Ullah Khan ¹, Aftab Ahmad Khan ^{2,*}, Muhammad Arif Goheer ², Izwa Shafique ³, Saddam Hussain ⁴ , Saddam Hussain ⁵ , Talha Javed ^{5,6,*}, Maliha Naz ³ , Rubab Shabbir ^{6,7}, Ali Raza ⁸ , Faisal Zulfikar ⁹ , Freddy Mora-Poblete ¹⁰ , Sunny Ahmar ¹¹ , Qasim Ali ¹², Hayssam M. Ali ¹³ and Manzer H. Siddiqui ¹³

- ¹ Cotton Research Station, Pakistan Central Cotton Committee, Dera Ismail Khan 29050, Pakistan; drkhancrs@gmail.com
- ² Global Change Impact Study Centre (GCISC), G-8/1, Islamabad 44000, Pakistan; arifgoheer@gmail.com
- ³ Department of Botany, University of Agriculture Faisalabad, Faisalabad 38000, Pakistan; izwashafique1994@gmail.com (I.S.); malihanaz099f@gmail.com (M.N.)
- ⁴ College of Agronomy, Northwest Agriculture & Forestry University, Yangling 712100, China; ch.sadam423@gmail.com
- ⁵ Department of Agronomy, University of Agriculture Faisalabad, Faisalabad 38040, Pakistan; sadamhussainuaf@gmail.com
- ⁶ College of Agriculture, Fujian Agriculture and Forestry University, Fuzhou 350002, China; rubabagronmy123@yahoo.com or rubabshabbir28@gmail.com
- ⁷ Seed Science and Technology, University of Agriculture Faisalabad, Faisalabad 38040, Pakistan
- ⁸ Center of Legume Crop Genetics and Systems Biology/College of Agriculture, Key Laboratory of Ministry of Education for Genetics, Breeding and Multiple Utilization of Crops, Oil Crops Research Institute, Fujian Agriculture and Forestry University (FAFU), Fuzhou 350002, China; aliraza6@fafu.edu.cn or alirazamughal143@gmail.com
- ⁹ Department of Horticultural Sciences, Faculty of Agriculture and Environment, The Islamia University of Bahawalpur, Bahawalpur 63100, Pakistan; ch.faisal.zulfikar@gmail.com
- ¹⁰ Institute of Biological Sciences, University of Talca, 2 Norte 685, Talca 3460000, Chile; morapoblete@gmail.com
- ¹¹ College of Plant Science and Technology, Huazhong Agricultural University, Wuhan 430070, China; sunnyahmar13@gmail.com
- ¹² Institute of Food and Agriculture Sciences, University of Florida, Gainesville, FL 32603, USA; qasimali@ufl.edu
- ¹³ Department of Botany and Microbiology, College of Science, King Saud University, Riyadh 11451, Saudi Arabia; hayhassan@ksu.edu.sa (H.M.A.); mhsiddiqui@ksu.edu.sa (M.H.S.)
- * Correspondence: aftabalam_2005@yahoo.com (A.A.K.); mtahaj@fafu.edu.cn or talhajaved54321@gmail.com (T.J.)

Citation: Khan, N.U.; Khan, A.A.; Goheer, M.A.; Shafique, I.; Hussain, S.; Hussain, S.; Javed, T.; Naz, M.; Shabbir, R.; Raza, A.; et al. Effect of Zero and Minimum Tillage on Cotton Productivity and Soil Characteristics under Different Nitrogen Application Rates. *Sustainability* **2021**, *13*, 13753. <https://doi.org/10.3390/su132413753>

Academic Editors: Sean Clark and Marc A. Rosen

Received: 16 September 2021

Accepted: 8 December 2021

Published: 13 December 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: Long-term conservation tillage and straw incorporation are reported to improve the soil health, growth, and yield traits of crops; however, little is known regarding the optimal nitrogen (N) supply under conservation tillage with straw incorporation. The present study evaluated the effects of conservation tillage practices (ZTsas: zero tillage plus wheat straw on the soil surface as such, and MTsi: minimum tillage plus wheat straw incorporated) and different N application rates (50, 100, 150, and 200 kg ha⁻¹) on the yield and quality traits of cotton and soil characteristics in a five-year field experiment. The results showed that ZTsas produced a higher number of bolls per plant, boll weight, seed cotton yield, 100-seed weight, ginning out-turn (GOT), fiber length, and strength than MTsi. Among different N application rates, the maximum number of bolls per plant, boll weight, seed cotton yield, GOT, 100-seed weight, fiber length, strength, and micronaire were recorded at 150 kg N ha⁻¹. Averaged over the years, tillage × N revealed that ZTsas had a higher boll number plant⁻¹, boll weight, 100-seed weight, GOT, fiber length, and strength with N application at 150 kg ha⁻¹, as compared to other tillage systems. Based on the statistical results, there is no significant difference in total soil N and soil organic matter among different N rates. Further, compared to MTsi, ZTsas recorded higher soil organic matter (SOM, 8%), total soil N (TSN, 29%), water-stable aggregates (WSA, 8%), and mean weight diameter (MWD, 28.5%), particularly when the N application of 150 kg ha⁻¹. The fiber fineness showed that ZTsas had no adverse impact on fiber fineness compared with MTsi. These results indicate that ZTsas with 150 kg N ha⁻¹ may

be the optimum and most sustainable approach to improve cotton yield and soil quality in the wheat–cotton system.

Keywords: cotton; productivity; soil quality; long-term conservation tillage; fertilizer; aggregate stability; soil organic matter

1. Introduction

Wheat–cotton rotation constitutes a major production system in Pakistan [1]. Farmers usually use wheat straw as animal feed, but cotton sticks are burned or used as a fuel source in rural areas [2,3]. However, burning residues can produce greenhouse gases, which are harmful to our environment and affect human health [4,5]. This burning destroys our precious natural resources (organic matter) and may adversely affect the physical, chemical, and biological properties of the soil [6,7]. In addition to these harmful effects, burning also causes nutrient loss (up to 80% N, 25% P, 21% K, and 4–60% S) and reduces soil microbial activities [8].

Residue accumulation in the soil acts as mulch, which protects the soil from soil aggregate destruction, enhances infiltration of water, and reduces soil losses by erosion [9,10]. In addition to increasing the infiltration rate, straw incorporation into the soil can also increase the water retention of the soil [11]. It is an important organic source for retaining and improving soil fertility [1]. Residue retention/incorporation into the soil is an important management method to handle crop residues [7,12]. The retention/incorporation of wheat residues may affect the soil fertility, soil physico-chemical properties, and yield of the crop [13]. The incorporation of crop residues improves the soil nutrient status and facilitates better growth and development of crops.

The adaptability of the conservation tillage system, such as the residue incorporation and minimum tillage, can increase soil organic matter (SOM), improve soil physical and biological conditions, and prevent soil degradation [14,15]. Conservation tillage, which involves multiple tillage operations, including zero and minimum tillage, has been considered as a potential measure to reduce structure degradation, minimize the loss of organic matter, and ultimately improve soil quality [16–18]. The combined effect of conservation tillage and straw retention on the accumulation of soil organic carbon (SOC) content was reported to be greater than the sole effect of conservation tillage with straw retention or incorporation into the soil [19,20]. In addition to SOC, compared with CT and residue retention (RR) alone, other traits (such as crop growth and yield attributes) were found to increase more under the combined CT system and RR [19].

The application of N fertilizer is considered to be an important strategy to increase cotton yield. In Pakistan, farmers tend to increase the use of N fertilizers to increase cotton production. Both wheat and cotton are exhaustive crops, and there is continual mining of nutrients from the soil. On the other hand, the extensive use of N under the minimum tillage (MT) system may be economically ineffective and may also pollute the environment [1,21,22]. Therefore, alternative tillage combined with optimal N fertilizer can be explored to optimize cotton yield and soil quality. Conservation tillage with straw returning to the field is a possible alternative, which can accumulate organic matter on the surface of the soil, increase moisture absorption, improve soil properties (physical, chemical, and biological), and may increase cotton yield in the long run [23,24]. Zero tillage and straw incorporation into the soil can increase soil organic matter and total soil N, thus causing significant changes in N management [1,2]. Studies have shown that compared with the minimum tillage with straw incorporation, soil aggregates covered by zero tillage mulch have larger aggregate size, aggregate stability, and total organic carbon [25,26]. The higher seed cotton yields obtained with ZTs as may be attributed to the positive impact of this practice on moisture accessibility for crops [2,27], hastening of organic matter decomposition, and higher nutrient availability.

Considering the importance of straw retention into the field, an appropriate tillage system should be adopted. Choosing an appropriate tillage system allows farmers to optimize soil conditions such as optimal N level to achieve better crop growth and bring multiple benefits to the environment. During the past few years, many studies have been conducted to evaluate the effects of conservation tillage and straw incorporation on soil characteristics, crop growth, and productivity. However, it is still unclear whether a higher or lower rate of N is beneficial under the straw-returning conservation tillage system. Therefore, it is vital to explore the cotton productivity promoting role of different tillage systems and N rates. Taking it into count, it may be hypothesized that ZTsas or MTsi with different N rates improves cotton productivity by modulating soil characteristics, cotton yield, and quality-related attributes. To test this hypothesis, the present study was conducted to check the impact of zero and minimum tillage on cotton yield, quality traits, and soil characteristics, and to identify the optimal N rate under these tillage systems for sustainable crop production.

2. Materials and Methods

2.1. Experimental Site

The study was conducted at Cotton Research Station, Ratta Kulach (31°49' N, 70°55' E, 165 m above sea level) in Dera Ismail (D.I.) Khan, Pakistan. The experimental soil was Hyperthermic, and Typic Torrifluvents, which is characterized by being moderately saline, less fertile, and requiring irrigation for crop production [28]. The study area is located in an arid region, and canal water is the main source of irrigation. The climate of the area is temperate with hot and dry summer, and major quantity of rainfall is received during the monsoon season (July to September). The climatic data during the study period (2011–2016) are presented in Table 1.

Table 1. Total monthly precipitation (mm) received during experimental years (2011–2012 to 2015–2016).

Month	Precipitation				
	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016
April	34	45	10	13	159
May	30	32	30	36	25
June	80	63	99	77	64
July	222	249	200	255	245
August	229	211	203	214	251
September	111	112	115	337	116
October	8	70	22	39	162
November	5	12	15	5	25
December	40	-	17	-	18
January	30	22	25	25	26
February	12	66	30	77	92
March	220	245	110	266	257
Total	1020	1127	876	1344	1440

2.2. Experimental Design and Treatments

The experiment was started in 2011 and conducted under split plot arrangement with three replications. Two tillage treatments were maintained under the main plots: (i) zero tillage plus wheat straw on the soil surface as such; (ii) and MTsi: minimum tillage plus wheat straw incorporated. The sub-plots include the following four N rates: (i) 50 kg ha⁻¹, (ii) 100 kg ha⁻¹, (iii) 150 kg ha⁻¹ and (iv) 200 kg ha⁻¹. Among tillage treatments, MTsi involved ploughing to a soil depth of 7 cm by using tractor field cultivator having 11 tines, followed by the plank for five successive years (2011–2012, 2012–2013, 2013–2014, 2014–2015, and 2015–2016) after the harvest of the previous crop (wheat, *Triticum aestivum* L.), and the straw was incorporated immediately. No-tillage was carried out for ZTsas treatment. Under the MTsi system, the cotton seeds were sown by

dibbling method, with 2 seeds per hill. In ZTsas, cotton was sown directly into standing wheat straw (hand sowing with a wooden stick). The cotton cultivar, cv. Bt. CIM-616 (a drought-tolerant cultivar), was selected for this study and sown in mid-May for five years of experiment. Each plot was 30 m², 10 m long, and 3 m wide and contained four rows. The seed was planted at a distance of 70 cm between the rows and 30 cm within the rows. Thinning was carried out 15 days after sowing (DAS). For all experimental plots, 60 kg ha⁻¹ phosphorus from triple super phosphate (TSP) and 30 kg ha⁻¹ potassium from potassium sulphate were applied as the basal dose. The N was applied in three equal splits (i.e., after thinning (15 DAS), at flowering, and boll formation stage). A post-emergence herbicide, haloxyfop-R-methyl (108 g L⁻¹) was applied to control weeds. An insecticide, Novastar 56-EC (bifenthrin + abamectin, at the rate of 1.23 L ha⁻¹) was sprayed by using of knapsack hand-sprayer at 15-day intervals, starting from the time when the population of insects reached the economic threshold level.

2.3. Soil Sampling and Analysis

Before sowing, soil samples were taken from experimental fields at a depth of 0 to 10 cm, and physico-chemical properties were analyzed. The experimental soil was silty-clay in texture (containing 150, 450, and 400 g kg⁻¹ sand, silt, and clay, respectively), calcareous in nature with slightly alkaline (pH 7.7), and low in organic matter (6.6 g kg⁻¹). The soil also contains: total N, 0.3 g kg⁻¹; extractable phosphorus, 7.7 mg kg⁻¹ soil; and available potassium, 191 mg kg⁻¹ soil. At the end of each experimental year, the soil samples were again collected from the soil managed by ZTsas and MTsi systems by use of a 50 mm diameter steel sampling tube. From each plot, five soil core samples were taken from a depth of 30 cm. The corresponding samples from all five cores in each plot were bulked to make a composite sample for ZTsas and MTsi plots. The composite soil samples were dried at 40 °C and ground to a size of <2 mm. From each composite sample, 10 g of subsample were taken and stored in polythene bags for chemical analysis. The subsamples from each plot (1 g soil) were analyzed for N content in soil. The organic matter content was determined through wet oxidation determination by using the method described by Nelson and Sommers [29]. The determination of total soil N was carried out according to the Kjeldahl method as described by Bremner and Mulvaney [30]. The phosphorus content was measured by spectrophotometry, and the potassium content was measured by using of the flame photometer. The extractable P and K in soil samples were determined by the AB-DTPA extractable method [31].

2.4. Aggregate Stability

In order to measure the aggregate stability, at the end of the fifth year of the experiment, soil samples were collected from the ZTsas and MTsi plots by using a 50 mm diameter steel sampling tube. From each plot, three samples were taken from 2 locations at a depth of 10 cm. The corresponding samples from all 3 cores were bulked, and the composite samples for each treatment were collected in polythene bags. The wet sieving method was used to determine the water stable aggregates and mean weight diameter, following the method of Kemper and Rosenau [32].

2.5. Measurements of Soil Moisture Content

The soil moisture content was measured in the last year of the experiment (2015–2016). First sampling was taken 30 days after sowing, and a total of six values were measured at one-month intervals (June–November). In each experimental unit, soil samples were collected from 2 points at a soil depth of 0 to 10 cm using a screw auger and transferred directly to the soil moisture cans. The samples were then dried in an oven at 100 °C to a constant weight, and the soil moisture contents were calculated by the gravimetric method.

2.6. Measurements of Yield and Yield Components

From each experimental unit, five plants were tagged, and the mature fluffy bolls of each plant were counted. In order to determine the weight of the bolls, 50 bolls were randomly selected from the tagged plants in each experimental unit. Then, the average weight of 50 bolls was used, and expressed in grams. The seed cotton was manually picked from each treatment in the last week of November and the first week of January. Seed cotton was then pooled over 2 picks, and total seed cotton yield was calculated.

2.7. Fiber Quality

Ginning out-turn (GOT) is the ratio of the weight of lint to the total weight of seed cotton. The lint of each sample was weighed, and GOT was calculated by using the following formula: $GOT (\%) = (\text{lint yield} / \text{seed cotton yield}) \times 100$ [33]. For fiber length, a representative cotton lint sample was taken from each plot, and the average length was obtained in the laboratory using a high volume instrument (HVI) system. Similarly, micronaire (indicating fiber fineness), fiber strength, and fiber uniformity were all measured in the laboratory through HVI system at the Central Cotton Research Institute, Multan, Pakistan.

2.8. Statistical Analysis

Data were processed using Microsoft Excel 2013, and then subjected to the analysis of variance (ANOVA) using the M STAT C Package [34]. When the F-values were significant for main and interaction effects, means were compared using least significant difference test at 0.05 level of probability.

3. Results

3.1. Boll Number and Weight (g)

The number of bolls and the weight per boll are the main factors for determining cotton yield. In the last year of experiment (the 5th year, 2015–2016), the number of bolls per plant and weight per boll were significantly higher than 2011–2012, 2012–2013, 2013–2014, and 2014–2015. The tillage systems had a significant influence on the boll number plant⁻¹ and bolls weight (Table 2). ZTsas resulted in higher boll number plant⁻¹ and heavier bolls than in MTsi. In 2015–2016, the boll number plant⁻¹ and bolls weight in ZTsas treatment were significantly higher than that of MTsi. The mean values for N averaged over tillage revealed that compared with other rates, the application of 150 kg N ha⁻¹ produced more bolls plant⁻¹ and heaviest weight per boll. Under the interaction of T × N, the maximum bolls plant⁻¹ and boll weight were obtained in ZTsas with the N application rate of 150 kg N ha⁻¹.

3.2. Seed Cotton Yield

The yield of seed cotton statistically differed over the years. The seed cotton yield in the last year of the experiment (2015–2016) was higher than that in 2011–2012, 2012–2013, 2013–2014, and 2014–2015 (Table 2). The seed cotton yield under ZTsas treatment was higher than MTsi. The mean values for N, averaged over the tillage system, revealed that elevated doses of N enhanced the seed cotton yield. The highest yield was recorded at N application at 150 kg ha⁻¹ compared with other rates. It is clear that ZTsas was better than MTsi systems supplemented with 150 kg ha⁻¹ under T × N interaction.

3.3. Total Soil N and Soil Organic Matter

Over the years, total soil N (TSN) and soil organic matter (SOM) have improved significantly. The highest values of TSN and SOM were obtained in 2015–2016 (Table 3). Tillage treatments significantly influence the TSN and SOM. The significantly higher values of SOM (8%) and TSN (29%) were achieved for soil managed by ZTsas system, as compared with MTsi system. The results also showed that the application of N significantly increased TSN and SOM, the highest values were recorded under the application of N at 200 kg ha⁻¹.

The highest TSN and SOM were recorded in the soil managed by the ZTsas system, with N application at 150 kg N ha⁻¹, during 2015–2016.

Table 2. Bolls number plant⁻¹, boll weight (g), and seed cotton yield (kg ha⁻¹) during five years of experimentation (2011–2012, 2012–2013, 2013–2014, 2014–2015, and 2015–2016) under different tillage and nitrogen (N) treatments.

Treatment	Boll Number (plant ⁻¹)			Boll Weight (g)			Seed Cotton Yield (kg ha ⁻¹)		
Year (Y)	ZTsas	MTsi	Mean	ZTsas	MTsi	Mean	ZTsas	MTsi	Mean
2011–2012	22.7 g	24.2 f	23.5 d	2.39 g	2.41 g	2.40 e	1616 h	1717 g	1667 e
2012–2013	26.9 d	27.9 c	27.4 b	2.88 cd	2.84 e	2.86 c	2240 d	2303 cd	2271 c
2013–2014	24.8 f	25.6 e	25.2 c	2.62 f	2.63 f	2.63 d	1801 f	1919 e	1860 d
2014–2015	28.8 b	26.8 d	27.8 b	2.91 b	2.87 d	2.89 b	2547 b	2382 c	2464 b
2015–2016	31.8 a	27.3 cd	29.6 a	2.96 a	2.90 bc	2.93 a	3085 a	2579 b	2832 a
LSD (0.05)	0.77		0.54	0.02		0.01	83.29		58.90
Tillage management (T)	26.98 a	26.35 b		2.75 a	2.73 b		2258 a	2180 b	
LSD (0.05)	0.34			0.01			37.25		
Nitrogen (kg ha ⁻¹) (N)									
50	19.9 e	19.8 e	19.9 d	2.64 f	2.59 g	2.62 c	1804	1743	1773 d
100	24.4 d	24.1 d	24.2 c	2.77 d	2.75 e	2.76 b	2290	2143	2217 c
150	34.8 a	34.2 a	34.5 a	2.82 a	2.78 cd	2.80 a	2607	2593	2600 a
200	28.9 b	27.3 c	28.1 b	2.78 bc	2.80 b	2.79 a	2330	2241	2285 b
LSD (0.05)	0.69		0.49	0.02		0.01	Ns		52.68
Interactions (<i>p</i> -values)									
Y × N		0.0000			0.0000			0.0000	
Y × T × N		0.6775			0.0022			0.6285	

Note: Means in their respective group sharing no common letter(s) are significant ($p < 0.05$). Abbreviations: Ns, non-significant; ZTsas, zero tillage with straw retention; MTsi, minimum tillage with straw incorporation.

Table 3. Total soil N and soil organic matter as influenced by tillage systems and N rates.

Treatment	Total Soil N (g kg ⁻¹)			Soil Organic Matter (g kg ⁻¹)		
Year (Y)	ZTsas	MTsi	Mean	ZTsas	MTsi	Mean
2011–2012	0.18 f	0.18 f	0.18 e	3.60 e	4.18 d	3.89 d
2012–2013	0.20 e	0.19 ef	0.20 d	3.72 e	4.30 d	4.00 d
2013–2014	0.31 c	0.26 d	0.29 c	4.38 d	4.38 d	4.38 c
2014–2015	0.38 b	0.26 d	0.32 b	5.84 b	5.39 c	5.61 b
2015–2016	0.46 a	0.28 d	0.37 a	8.41 a	5.71 b	7.06 a
LSD (0.05)	0.02		0.014	0.26		0.18
Tillage management (T)	0.31 a	0.24 b		5.19 a	4.79 a	
LSD (0.05)	0.03			0.12		
Nitrogen (kg ha ⁻¹) (N)						
50	0.25	0.19	0.22 c	4.35	3.92	4.13 d
100	0.29	0.23	0.26 b	5.01	4.70	4.85 c
150	0.33	0.25	0.29 a	5.43	4.95	5.18 b
200	0.34	0.27	0.31 a	5.98	5.60	5.79 a
LSD (0.05)	Ns		0.01	Ns		0.16
Interactions (<i>p</i> -values)						
Y × N		0.6137			0.4416	
Y × T × N		0.9960			0.0003	

Note: Means in their respective group sharing no common letter(s) are significant ($p < 0.05$). Abbreviations: Ns, non-significant; ZTsas, zero tillage with straw retention; MTsi, minimum tillage with straw incorporation.

3.4. Quality Characteristics

The average data of 100-cotton seed weight (g), ginning out-turns, and quality traits (fiber length, fiber strength, and micronaire values) are presented in Table 4. The values were varied significantly over the years. Seed weight, fiber length and strength were recorded higher in 2015–2016, compared with other experimental years. The results also showed that N and tillage treatments had a significant impact on the quality traits of cotton crop. The seed weight, fiber length, and strength in ZTsas treatment were significantly

higher than that of MTsi treatment. Compared with ZTsas treatment, the micronaire values in MTsi treatment were higher, indicating the lesser fitness of fiber under MTsi system. Under N application, the heaviest seeds and fine fiber were obtained from N application at 150 kg ha⁻¹. However, there were no significant year $\times$ tillage $\times$ nitrogen interactions for these traits.

Table 4. Fiber properties as influenced by tillage treatments and N rates, averaged over the years.

Treatment		100-Seed Weight (g)	Ginning Out-Turn (%)	Fiber Length (mm)	Fiber Strength (g tex ⁻¹)	Micronaire
Year (Y)						
2011–2012		7.23 e	39.2	28.5 c	26.5 b	4.4
2012–2013		7.74 d	39.2	28.5 c	26.5 b	4.4
2013–2014		8.24 c	39.2	28.5 c	26.6 b	4.4
2014–2015		8.43 b	38.9	28.6 b	28.5 a	4.4
2015–2016		8.70 a	38.9	28.7 a	28.5 a	4.4
LSD (0.05)		0.13	Ns	0.06	0.06	Ns
Tillage management (T)	ZTsas	8.11 a	39.1	28.6 a	27.4 a	4.4 b
	MTsi	8.03 b	39.1	28.5 b	27.3 b	4.5 a
LSD (0.05)		0.08	Ns	0.04	0.04	0.04
Nitrogen (kg ha ⁻¹) (N)						
50		7.60 c	38.2 b	28.5 b	27.2 b	3.9 d
100		8.16 b	39.2 a	28.6 a	27.4 a	4.2 c
150		8.40 a	39.3 a	28.6 a	27.4 a	4.7 b
200		8.11 b	39.5 a	28.6 a	27.4 a	4.9 a
LSD (0.05)		0.12	0.51	0.05	0.05	0.05
Interactions (<i>p</i> -values)						
Y $\times$ T		0.4956	0.9967	1.0000	1.0000	0.9738
Y $\times$ N		0.1054	1.0000	1.0000	1.0000	0.9862
T $\times$ N		0.1367	0.7991	0.1549	0.1523	0.0346
Y $\times$ T $\times$ N		0.9905	0.9894	1.0000	1.0000	1.0000

Note: Means in their respective group sharing no common letter(s) are significant ($p < 0.05$). Abbreviations: Ns, non-significant; ZTsas, zero tillage with straw retention; MTsi, minimum tillage with straw incorporation.

3.5. Aggregate Stability and Soil Moisture Content

As shown in Table 5, the tillage and N treatments significantly affected the water stable aggregates (WSA, %) and the mean weight diameter (MWD). The significantly higher WSA and MWD were recorded for ZTsas treatment. Under N treatments, N application at 150–200 kg ha⁻¹ can get the highest values of WSA and MWD at a depth of 0–10 cm. Similarly, in the last year of the experiment, MTsi had higher moisture content than ZTsas (Figure 1).

Table 5. Water stable aggregates (%) and mean weight diameter (mm) as influenced by different tillage treatments and nitrogen rates.

Treatments	Water Stable Aggregates (%)	Mean Weight Diameter (mm)
Tillage management		
ZTsas	61.28 a	0.45 a
MTsi	56.78 b	0.34 b
LSD (0.05)	0.61	0.011
Nitrogen (kg ha ⁻¹)		
50	58.77	0.33 c
100	59.12	0.39 b
150	59.12	0.43 a
200	59.12	0.44 a
LSD (0.05)	Ns	0.016
Tillage $\times$ nitrogen	Ns	Ns

Note: Means in their respective group sharing no common letter(s) are significant ($p < 0.05$). Abbreviations: Ns, non-significant; ZTsas, zero tillage with straw retention; MTsi, minimum tillage with straw incorporation.

Figure 1. Effect of tillage treatments (ZTsas, zero tillage with straw retention; MTsi, minimum tillage with straw incorporation) on soil moisture content during the last year of experiment (2015–2016).

4. Discussion

The rainfall is a major source of irrigation for cotton cultivation in the study area. There was a significant variation in the amount and the distribution of rainfall during the experimental years. The highest amount of rainfall was received during the year of 2015–2016; however, the lowest amount of rainfall was received during 2013–2014, followed by 2011–2012 (Table 1). In this study, a greater number of fruiting sites was recorded for ZTsas system compared with the MTsi system. A higher number of bolls and weight of boll were reported under ZTsas than that of MTsi. Similarly, a higher seed cotton yield was also obtained under the ZTsas treatment, compared with the MTsi treatment (Table 2). The enhanced boll retention and weight of boll in the ZTsas system were due to the improved soil N, soil organic matter, and conserved soil moisture. Under the ZTsas treatment, the cotton seed yield was higher, because of the greater number of bolls and boll weight under the same treatment. Similar findings were reported by [22,35,36], which found that zero tillage significantly improved the cotton yield. In a recent study, Nouri et al. [37] also reported that conservation tillage practices are markedly increased the cotton yield. However, these findings are inconsistent with Lewis [38] and Ajayi [39], who reported that tillage practices did not influence the lint yield of cotton. Additionally, according to Usman et al. [40], higher lint yield could not be achieved with conservational tillage practices under the condition of poor drainage of the soil. The higher yield of cotton under the zero tillage system was mainly due to reduced evaporation and greater infiltration under residue retention [36]. More values of yield contributing factors under zero tillage cultivation are attributed to the improved physical properties and organic content of soil [41]. The improved soil moisture content under straw mulching may also help to improve the yield and yield components [42]. However, these findings are inconsistent with the results of Song et al. [19], who found that zero tillage negatively influences the yield-contributing factors of rice crop. Fertilizers are an important factor in today agriculture. They are responsible for substantial increase in crops yields, and allow crops to be planted in soil that would otherwise be nutrient deficient. Fertilizers are also used in agriculture to maintain soil fertility. It is well established that each of the nutrient elements plays an essential role in growth and development of the plants, and when present in deficient quantities can reduce growth and yields. Inorganic fertilizer, especially N, P,

and K, not only serve to maintain, but their application directly or indirectly causes changes in the chemical, physical, and biological properties of the soil. These changes, in the long term, are believed to have significant influences on the quality and productive capacity of soils [43]. Plant growth and yield production are affected by different parameters including soil, plant, and climate properties. Altering soil properties, including physical, chemical, and biological ones can influence plant growth and yield production [44]. In the current study, increased values of yield and yield parameters with increasing N were reported, and the higher cotton seed yield was reported when N was applied at 150 kg ha^{-1} . These findings are consistent with [22,45], which suggest that the increasing level of N are resulted in a significant increase in number of bolls per plant and boll weight, and the application of N at 150 kg ha^{-1} gave the maximum values of these traits. The highest cotton seed yield under ZTsas and N application at 150 kg ha^{-1} may be due to increased N supply and improved decomposition of wheat straw, which enhances the biological activities in the soil, and better root growth because of the improved soil structure and soil moisture content.

Over the years, the highest yield was attained in 2015–2016, which may be due to the more precipitation during this experimental year (Table 1). A lower number of bolls per plant and lower cotton seed yield in 2011–2012 and 2013–2014 was also due to less amount of rainfall received during this period. Variable yields of crops under changing patterns of rainfall were also reported elsewhere [46]. Furthermore, less rainfall was received in September and October, during the period of boll formation. Therefore, crops may suffer from water stress due to the uneven distribution of rainfall. Water scarcity limits the supply of photosynthates to developing organs, and leads to the shedding of fruiting forms [41], which ultimately reduces crop yields.

There were non-significant tillage $\times$ nitrogen, year $\times$ tillage $\times$ nitrogen interactions for quality traits. Generally, tillage practices and N rates significantly affected the quality traits, such as fiber length, fiber strength, and micronaire. These findings are inconsistent with the results of previous studies [47–49], where the authors have found that tillage practices did not influence the fiber quality traits. However, these findings are consistent with Khan et al. [50], who reported that tillage practices significantly affected the fiber quality traits. Similarly, McDonald et al. [51] also reported that zero tillage with cover crop positively influenced the quality traits of cotton as it increased the cotton fiber strength. Under different tillage practices, increasing N rates significantly increased the number of bolls per plant [38,52]. However, opposite findings were reported by Afzal [53], N application under different planting densities did not influence the lint weight and fiber quality.

Compared with un-disturbed soils (ZTsas), disturbed soils (MTsi) showed larger destruction of soil, resulting in smaller aggregates and lower WSA [54–56]. Zero tillage with wheat straw had a higher proportion of WSA and MWD than MTsi (Table 5). Significant improvements in WSA and MWD were reported under ZTsas than tilled treatments [54,56]. Water stable aggregates and MWD were improved in zero tillage with wheat straw as such on the soil surface than those minimum tillage plus straw incorporated into the soil [57]. In another study, Li et al. [58] reported that zero tillage practice effectively improved the soil structure, thereby increasing the water storage compared with conventional tillage. Similar findings were also reported by Wilkes et al. [59], where the authors have reported that zero tillage practice significantly improved the WSA than the conventional tillage system. An improvement in WSA under residue incorporation was also reported elsewhere [60]. According to Abbas et al. [61], under zero tillage, more availability of plant residue and minimum soil disturbance significantly improved the aggregate stability in the soil layers. Similarly, tillage practices also significantly influence the soil moisture content (Figure 1). Under zero tillage (no soil disturbance), a large amount of plant residues on the soil surface reduces the water and energy exchange between the soil surface and the atmosphere, and ultimately lead to an increase in soil water content [58,62,63]. The ZTsas provides straw mulch to protect moisture from evaporation losses.

Conservation tillage practices, including reduced tillage, rotary tillage, and zero tillage, had a positive effect on total soil N (TSN) and soil organic matter (SOM) accumulation [64,65].

However, this study showed that not all the conservation tillage practices are effective in improving the TSN and SOM. The results revealed that among tillage systems, the higher TSN and SOM were found under the ZTsas system compared with MTsi system. This may be due to reduced damage to soil aggregates, and increased stability of organic carbon under zero tillage practices [19]. Similar findings were reported by Dou and Hons, [66], who found that zero tillage practice significantly improved the soil organic carbon, compared with conventional tillage. In a recent review-based study, Mondal et al. [67] also reported that zero tillage significantly improved the soil organic carbon content than conventional tillage practice. Under zero tillage, an abundance of plant residue on the soil surface reduces the exchange of water and energy between the atmosphere and soil surface, and leads to a decrease in soil temperature and increase soil water content, thereby favoring more organic matter in the soil [68]. Our results also showed that increasing the rate of N significantly increased the TSN and SOM. Similar findings were reported by Dou and Hons [66], who proposed that N application under zero tillage significantly improved the TSN. In general, TSN and SOM also varied among experimental years. Additionally, the highest TSN and SOM were recorded during the final year of the experiment. In the long run, the earthworms and burrowing insects cut the wheat straw and gradually incorporate organic matter, as well as increasing soil fertility in zero tillage plus straw as such on the soil surface. Thus, the maximum values of these traits were found during the last growing seasons [1]. Overall, modern seed and biotechnological approaches in combination to tillage practices may play a crucial role in sustainable crop production under harsh environmental conditions [69–74].

5. Conclusions

Our results demonstrated that ZTsas and N application at 150 kg ha^{-1} increased the boll number plant^{-1} , boll weight, seed cotton yield, GOT, 100-seed weight, fiber length, strength, and micronaire, compared with MTsi and other N treatments. Significant improvements in soil physical properties were shown in ZTsas compared to MTsi. Furthermore, compared with MTsi, ZTsas also had a constructive impact on soil fertility in terms of higher organic matter and TSN. In comparison with MTsi, the ZTsas treatment had higher amounts of WSA and MWD. In addition, the higher WSA and MWD were obtained with N application at $150\text{--}200 \text{ kg ha}^{-1}$. Therefore, ZTsas with N application at 150 kg ha^{-1} can improve cotton yield, fiber quality, and soil fertility under rain-fed conditions.

Author Contributions: Conceptualization, N.U.K. and A.A.K.; methodology, A.A.K.; software, N.U.K.; validation, M.A.G.; formal analysis, N.U.K.; investigation, N.U.K. and A.A.K.; resources, N.U.K.; data curation, N.U.K.; writing—original draft preparation, N.U.K., A.A.K., F.M.-P. and H.M.A.; writing—review and editing, T.J., R.S., A.R., S.A., Q.A., S.H. (Sadam Hussain), S.H. (Saddam Hussain), H.M.A., M.N., F.M.-P., F.Z., M.H.S., I.S. and M.N.; visualization, T.J.; supervision, S.H. (Saddam Hussain); project administration, S.H. (Saddam Hussain); funding acquisition, H.M.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research was financially supported by the Researchers Supporting Project number (RSP-2021/123), King Saud University, Riyadh, Saudi Arabia.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to extend their sincere appreciation to the Researchers Supporting Project number (RSP-2021/123), King Saud University, Riyadh, Saudi Arabia.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Usman, K.; Khan, N.; Khan, M.U.; Saleem, F.Y.; Rashid, A. Impact of tillage and nitrogen on cotton yield and quality in a wheat-cotton system, Pakistan. *Arch. Agron. Soil Sci.* **2013**, *60*, 519–530. [\[CrossRef\]](#)
- Nehra, O.; Yadav, A. Evaluation of zero-till sown wheat (*Triticum aestivum* L.) in sequence with basmati rice (*Oryza sativa* L.) under shallow ground water table conditions. *Haryana J. Agron.* **2011**, *27*, 52–53.
- Shahryari, Z.; Fazelipour, M.H.; Setoodeh, P.; Nair, R.B.; Taherzadeh, M.; Ghasemi, Y. Utilization of wheat straw for fungal phytase production. *Int. J. Recycl. Org. Waste Agric.* **2018**, *7*, 345–355. [\[CrossRef\]](#)
- Ravindra, K.; Singh, T.; Mor, S. Emissions of air pollutants from primary crop residue burning in India and their mitigation strategies for cleaner emissions. *J. Clean. Prod.* **2019**, *208*, 261–273. [\[CrossRef\]](#)
- Oanh, N.T.K.; Permadi, D.A.; Dong, N.P.; Nguyet, D.A. Emission of Toxic Air Pollutants and Greenhouse Gases from Crop Residue Open Burning in Southeast Asia. In *Remote Sensing for Archaeology and Cultural Landscapes*; Springer: Berlin/Heidelberg, Germany, 2018; pp. 47–66.
- Fernández-García, V.; Marcos, E.; Fernández-Guisuraga, J.M.; Taboada, A.; Suárez-Seoane, S.; Calvo, L. Impact of burn severity on soil properties in a *Pinus pinaster* ecosystem immediately after fire. *Int. J. Wildland Fire* **2019**, *28*, 354. [\[CrossRef\]](#)
- Kumar, P.; Singh, R.K. Selection of sustainable solutions for crop residue burning: An environmental issue in northwestern states of India. *Environ. Dev. Sustain.* **2021**, *23*, 3696–3730. [\[CrossRef\]](#)
- Carr, P.M.; Gramig, G.G.; Liebig, M.A. Impacts of Organic Zero Tillage Systems on Crops, Weeds, and Soil Quality. *Sustainability* **2013**, *5*, 3172–3201. [\[CrossRef\]](#)
- Gürsoy, S.; Sessiz, A.; Malhi, S. Short-term effects of tillage and residue management following cotton on grain yield and quality of wheat. *Field Crop. Res.* **2010**, *119*, 260–268. [\[CrossRef\]](#)
- Bogunovic, I.; Pereira, P.; Kisic, I.; Sajko, K.; Sraka, M. Tillage management impacts on soil compaction, erosion and crop yield in Stagnosols (Croatia). *Catena* **2018**, *160*, 376–384. [\[CrossRef\]](#)
- Zhang, X.; Xin, X.; Zhu, A.; Zhang, J.; Yang, W. Effects of tillage and residue managements on organic C accumulation and soil aggregation in a sandy loam soil of the North China Plain. *Catena* **2017**, *156*, 176–183. [\[CrossRef\]](#)
- Halde, C.; Entz, M.H. Plant species and mulch application rate affected decomposition of cover crop mulches used in organic rotational no-till systems. *Can. J. Plant Sci.* **2016**, *96*, 59–71. [\[CrossRef\]](#)
- Halde, C.; Gulden, R.H.; Entz, M.H. Selecting Cover Crop Mulches for Organic Rotational No-Till Systems in Manitoba, Canada. *Agron. J.* **2014**, *106*, 1193–1204. [\[CrossRef\]](#)
- Li, Y.; Li, Z.; Chang, S.X.; Cui, S.; Jagadamma, S.; Zhang, Q.; Cai, Y. Residue retention promotes soil carbon accumulation in minimum tillage systems: Implications for conservation agriculture. *Sci. Total Environ.* **2020**, *740*, 140147. [\[CrossRef\]](#)
- Rahmati, M.; Eskandari, I.; Kouselou, M.; Feiziasl, V.; Mahdavinia, G.R.; Aliasgharzad, N.; McKenzie, B.M. Changes in soil organic carbon fractions and residence time five years after implementing conventional and conservation tillage practices. *Soil Tillage Res.* **2020**, *200*, 104632. [\[CrossRef\]](#)
- Hussain, S.; Hussain, S.; Guo, R.; Sarwar, M.; Ren, X.; Krstic, D.; Aslam, Z.; Zulifqar, U.; Rauf, A.; Hano, C.; et al. Carbon Sequestration to Avoid Soil Degradation: A Review on the Role of Conservation Tillage. *Plants* **2021**, *10*, 2001. [\[CrossRef\]](#)
- Hazarika, S.; Parkinson, R.; Bol, R.; Dixon, L.; Russell, P.; Donovan, S.; Allen, D. Effect of tillage system and straw management on organic matter dynamics. *Agron. Sustain. Dev.* **2009**, *29*, 525–533. [\[CrossRef\]](#)
- He, J.; Kuhn, N.; Zhang, X.M.; Li, H.W. Effects of 10 years of conservation tillage on soil properties and productivity in the farming-pastoral ecotone of Inner Mongolia, China. *Soil Use Manag.* **2009**, *25*, 201–209. [\[CrossRef\]](#)
- Song, K.; Yang, J.; Xue, Y.; Lv, W.; Zheng, X.; Pan, J. Influence of tillage practices and straw incorporation on soil aggregates, organic carbon, and crop yields in a rice-wheat rotation system. *Sci. Rep.* **2016**, *6*, 36602. [\[CrossRef\]](#)
- Liu, Z.; Gao, T.; Tian, S.; Hu, H.; Li, G.; Ning, T. Soil organic carbon increment sources and crop yields under long-term conservation tillage practices in wheat-maize systems. *Land Degrad. Dev.* **2020**, *31*, 1138–1150. [\[CrossRef\]](#)
- Mahmood, T.; Wang, X.; Ahmar, S.; Abdullah, M.; Iqbal, M.S.; Rana, R.M.; Yasir, M.; Khalid, S.; Javed, T.; Mora-Poblete, F.; et al. Genetic potential and inheritance pattern of phenological growth and drought tolerance in cotton (*Gossypium Hirsutum* L.). *Front. Plant Sci.* **2021**, *12*, 705392. [\[CrossRef\]](#)
- Khan, N.; Khalid, U.; Fazal, Y.; Abdus, S.; Hayatullah, K.; Saleem, D.; Sadia, G. No-Till with Optimum N Fertilization Produces High Cotton Lint Yield and Improves N Efficiency in Wheat-Cotton Cropping System. *Philipp. Agric. Sci.* **2014**, *97*, 257–265.
- Nyakatawa, E.; Reddy, K.; Lemunyon, J. Predicting soil erosion in conservation tillage cotton production systems using the revised universal soil loss equation (RUSLE). *Soil Tillage Res.* **2001**, *57*, 213–224. [\[CrossRef\]](#)
- Boquet, D.J.; Hutchinson, R.L.; Breitenbeck, G.A. Long-Term Tillage, Cover Crop, and Nitrogen Rate Effects on Cotton: Yield and Fiber Properties. *Agron. J.* **2004**, *96*, 1436–1442. [\[CrossRef\]](#)
- Nafi, E.; Webber, H.; Danso, I.; Naab, J.B.; Frei, M.; Gaiser, T. Interactive effects of conservation tillage, residue management, and nitrogen fertilizer application on soil properties under maize-cotton rotation system on highly weathered soils of West Africa. *Soil Tillage Res.* **2020**, *196*, 104473. [\[CrossRef\]](#)
- Frame, W.H.; Herbert, D.A.; Mehl, H.; Cahoon, C.; Reiter, M.S.; Flessner, M. *Virginia Cotton Production Guide*; Publication AREC-124NP; Office of Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University: Blacksburg, VA, USA, 2016; pp. 5–7.

27. Dalton, T.J.; Yahaya, I.; Naab, J. Perceptions and performance of conservation agriculture practices in northwestern Ghana. *Agric. Ecosyst. Environ.* **2014**, *187*, 65–71. [\[CrossRef\]](#)
28. Soil Survey Staff. Keys to soil of NWFP, FATA and northern areas. Lahore: National Institute of research in soils and geomatics; pp 76. *Commun. Soil Sci. Plant Anal.* **2009**, *16*, 322–338.
29. Nelson, D.; Sommers, L.E. Total carbon, organic carbon, and organic matter. In *Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties*; Soil Science Society of America: Madison, WI, USA, 1983; pp. 539–579.
30. Bremner, J.; Mulvaney, C. Nitrogen-total. In *Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties*; Page, A.L., Miller, R.H., Keeney, D.R., Eds.; Soil Science Society of America: Madison, WI, USA, 1982; pp. 595–624.
31. Soltanpour, P.N. Use of ammonium bicarbonate DTPA soil test to evaluate elemental availability and toxicity. *Commun. Soil Sci. Plant Anal.* **1985**, *16*, 323–338. [\[CrossRef\]](#)
32. Kemper, W.D.; Rosenau, R.C. Aggregate stability and size distribution. In *Methods of Soil Analysis. Physical and Mineralogical Properties. Part I*, 2nd ed.; Klute, A., Ed.; ASA-SSSA: Madison, WI, USA, 1986; Volume 9, pp. 425–442.
33. Guo, X.; Ma, J.; Guo, Y.; Sun, M.; Zhou, J.; Yuan, Y.; Zhang, T.; Sun, X.; Song, X. The relationship between fiber initiation and lint percentage in cotton. *Pak. J. Bot.* **2014**, *46*, 2227–2238.
34. Steel, R.; Torrie, J. *Principles and Procedures of Statistics: A Biometrical Approach*, 2nd ed.; McGraw-Hill Book Company: New York, NY, USA, 1980; p. 481.
35. Nouri, A.; Lee, J.; Yin, X.; Tyler, D.D.; Saxton, A.M. Thirty-four years of no-tillage and cover crops improve soil quality and increase cotton yield in Alfisols, Southeastern USA. *Geoderma* **2019**, *337*, 998–1008. [\[CrossRef\]](#)
36. DeLaune, P.; Mubvumba, P.; Ale, S.; Kimura, E. Impact of no-till, cover crop, and irrigation on Cotton yield. *Agric. Water Manag.* **2020**, *232*, 106038. [\[CrossRef\]](#)
37. Nouri, A.; Lee, J.; Yoder, D.C.; Jagadamma, S.; Walker, F.R.; Yin, X.; Arelli, P. Management duration controls the synergistic effect of tillage, cover crop, and nitrogen rate on cotton yield and yield stability. *Agric. Ecosyst. Environ.* **2020**, *301*, 107007. [\[CrossRef\]](#)
38. Lewis, K.L.; Burke, J.A.; Keeling, W.S.; McCallister, D.M.; DeLaune, P.B.; Keeling, J.W. Soil Benefits and Yield Limitations of Cover Crop Use in Texas High Plains Cotton. *Agron. J.* **2018**, *110*, 1616–1623. [\[CrossRef\]](#)
39. Ajayi, A. The effects of tillage methods and intercropping on soil water characteristics, growth and grain yield of maize (*Zea mays* L.) and groundnut (*Arachis hypogaea* L.) on an alfisol in South West, Nigeria. *Afr. J. Agric. Res.* **2015**, *10*, 2866–2874. [\[CrossRef\]](#)
40. Usman, K.; Khalid, U.; Malik, M.W.I.; Hamza, A.; Saad, M.; Riaz, M.; Ghulam, S. Response of Bt cotton (*Gossypium hirsutum* L.) to irrigation and potassium fertilization under two tillage systems in a silty clay soil. *Arch. Agron. Soil Sci.* **2020**, *67*, 1–16. [\[CrossRef\]](#)
41. Xie, T.; Shan, L. Water stress and appropriate N management achieves profitable yields and less N loss on sandy soils. *Arid. Land Res. Manag.* **2021**, *35*, 358–373. [\[CrossRef\]](#)
42. Conaty, W.C.; Johnston, D.B.; Thompson, A.J.; Liu, S.; Stiller, W.N.; Constable, G.A. Use of a managed stress environment in breeding cotton for a variable rainfall environment. *Field Crop. Res.* **2018**, *221*, 265–276. [\[CrossRef\]](#)
43. Samuel, A.D.; Bungau, S.; Tit, D.M.; Melinte, C.E.; Purza, L.; Badea, G.E. Effects of Long Term Application of Organic and Mineral Fertilizers on Soil Enzymes. *Rev. Chim.* **2018**, *69*, 2608–2612. [\[CrossRef\]](#)
44. Miransari, M. Soil microbes and plant fertilization. *Appl. Microbiol. Biotechnol.* **2011**, *92*, 875–885. [\[CrossRef\]](#)
45. Blaise, D. Effect of tillage systems on weed control, yield and fibre quality of upland (*Gossypium hirsutum* L.) and Asiatic tree cotton (*G. arboreum* L.). *Soil Tillage Res.* **2006**, *91*, 207–216. [\[CrossRef\]](#)
46. Watts, D.B.; Runion, G.B.; Balkcom, K.S. Nitrogen fertilizer sources and tillage effects on cotton growth, yield, and fiber quality in a coastal plain soil. *Field Crop. Res.* **2017**, *201*, 184–191. [\[CrossRef\]](#)
47. Wang, X.; Qi, J.-Y.; Zhang, X.-Z.; Li, S.-S.; Virk, A.L.; Zhao, X.; Xiao, X.-P.; Zhang, H.-L. Effects of tillage and residue management on soil aggregates and associated carbon storage in a double paddy cropping system. *Soil Tillage Res.* **2019**, *194*, 104339. [\[CrossRef\]](#)
48. Khan, N.; Usman, K.; Yazdan, F.; Din, S.U.; Gull, S.; Khan, S. Impact of tillage and intra-row spacing on cotton yield and quality in wheat–cotton system. *Arch. Agron. Soil Sci.* **2015**, *61*, 581–597. [\[CrossRef\]](#)
49. Khan, N.U.; Khan, F.; Kashan, M.; Ullah, Q.; Rauf, A. Nitrogen Use Impact on Nitrogen Use Efficiency and Lint Yield in Zero Tillage Cotton. *Pak. J. Agric. Res.* **2018**, *31*, 45–54. [\[CrossRef\]](#)
50. Afzal, M.N.; Tariq, M.; Ahmad, M.; Mubeen, K.; Khan, M.A.; Afzal, M.U.; Ahmad, S. Dry Matter, Lint Mass and Fiber Properties of Cotton in Response to Nitrogen Application and Planting Densities. *Pak. J. Agric. Res.* **2019**, *32*, 229. [\[CrossRef\]](#)
51. McDonald, M.D.; Lewis, K.L.; Ritchie, G.L. Short Term Cotton Lint Yield Improvement with Cover Crop and No-Tillage Implementation. *Agronomy* **2020**, *10*, 994. [\[CrossRef\]](#)
52. Ngwira, A.R.; Thierfelder, C.; Lambert, D.M. Conservation agriculture systems for Malawian smallholder farmers: Long-term effects on crop productivity, profitability and soil quality. *Renew. Agric. Food Syst.* **2013**, *28*, 350–363. [\[CrossRef\]](#)
53. Da Silva, M.F.; Fernandes, M.M.H.; Fernandes, C.; da Silva, A.M.R.; Ferraud, A.S.; Coelho, A.P. Contribution of tillage systems and crop succession to soil structuring. *Soil Tillage Res.* **2021**, *209*, 104924. [\[CrossRef\]](#)
54. Li, Y.; Li, Z.; Cui, S.; Jagadamma, S.; Zhang, Q.P. Residue retention and minimum tillage improve physical environment of the soil in croplands: A global meta-analysis. *Soil Tillage Res.* **2019**, *194*, 104292. [\[CrossRef\]](#)
55. Guo, Y.; Fan, R.; Zhang, X.; Zhang, Y.; Wu, D.; McLaughlin, N.; Zhang, S.; Chen, X.; Jia, S.; Liang, A. Tillage-induced effects on SOC through changes in aggregate stability and soil pore structure. *Sci. Total Environ.* **2020**, *703*, 134617. [\[CrossRef\]](#)

56. Fonte, S.J.; Quintero, D.C.; Velásquez, E.; Lavelle, P. Interactive effects of plants and earthworms on the physical stabilization of soil organic matter in aggregates. *Plant Soil* **2012**, *359*, 205–214. [\[CrossRef\]](#)
57. Acar, M.; Çelik, İ.; Günel, H. Effects of long-term tillage systems on soil water content and wheat yield under Mediterranean conditions. *J. New Theory* **2017**, *17*, 98–108.
58. Li, J.; Wang, Y.-K.; Guo, Z.; Li, J.-B.; Tian, C.; Hua, D.-W.; Shi, C.-D.; Wang, H.-Y.; Han, J.-C.; Xu, Y. Effects of Conservation Tillage on Soil Physicochemical Properties and Crop Yield in an Arid Loess Plateau, China. *Sci. Rep.* **2020**, *10*, 4716. [\[CrossRef\]](#)
59. Wilkes, T.I.; Warner, D.J.; Edmonds-Brown, V.; Davies, K.G.; Denholm, I. Zero Tillage Systems Conserve Arbuscular Mycorrhizal Fungi, Enhancing Soil Glomalin and Water Stable Aggregates with Implications for Soil Stability. *Soil Syst.* **2021**, *5*, 4. [\[CrossRef\]](#)
60. Gao, Q.; Ma, L.; Fang, Y.; Zhang, A.; Li, G.; Wang, J.; Wu, D.; Wu, W.; Du, Z. Conservation tillage for 17 years alters the molecular composition of organic matter in soil profile. *Sci. Total Environ.* **2021**, *762*, 143116. [\[CrossRef\]](#)
61. Abbas, H.G.; Mahmood, A.; Ali, Q. Zero tillage: A potential technology to improve cotton yield. *Genetika* **2016**, *48*, 761–776. [\[CrossRef\]](#)
62. Hossain, M.M.; Begum, M.; Hashem, A.; Rahman, M.; Ahmed, S.; Hassan, M.M.; Javed, T.; Shabbir, R.; Hadifa, A.; Sabagh, A.E.; et al. Strip tillage and crop residue retention decrease the size but increase the diversity of the weed seed bank under intensive rice-based crop rotations in Bangladesh. *Agronomy* **2021**, *11*, 1164. [\[CrossRef\]](#)
63. Gao, L.; Wang, B.; Li, S.; Han, Y.; Zhang, X.; Gong, D.; Ma, M.; Liang, G.; Wu, H.; Wu, X.; et al. Effects of different long-term tillage systems on the composition of organic matter by ¹³C CP/TOSS NMR in physical fractions in the Loess Plateau of China. *Soil Tillage Res.* **2019**, *194*, 104321. [\[CrossRef\]](#)
64. Blaise, D.; Ravindran, C. Influence of tillage and residue management on growth and yield of cotton grown on a vertisol over 5 years in a semi-arid region of India. *Soil Tillage Res.* **2003**, *70*, 163–173. [\[CrossRef\]](#)
65. Awad, M.; El-Desoky, M.A.; Ghallab, A.; Kubes, J.; Mawly, S.E.A.; Danish, S.; Ratnasakera, D.; Islam, M.S.; Skalicky, M.; Brestic, M.; et al. Ornamental plant efficiency for heavy metals phytoextraction from contaminated soils amended with organic materials. *Molecules* **2021**, *26*, 3360. [\[CrossRef\]](#)
66. Dou, F.; Hons, F.M. Tillage and nitrogen effects on soil organic matter fractions in wheat-based systems. *Soil Sci. Soc. Am. J.* **2006**, *70*, 1896–1905. [\[CrossRef\]](#)
67. Mondal, S.; Chakraborty, D.; Bandyopadhyay, K.; Aggarwal, P.; Rana, D.S. A global analysis of the impact of zero-tillage on soil physical condition, organic carbon content, and plant root response. *Land Degrad. Dev.* **2019**, *31*, 557–567. [\[CrossRef\]](#)
68. Zhang, X.; Zhu, A.; Yang, W.; Zhang, J. Accumulation of organic components and its association with macroaggregation in a sandy loam soil following conservation tillage. *Plant Soil* **2017**, *416*, 1–15. [\[CrossRef\]](#)
69. Afzal, I.; Javed, T.; Amirkhani, M.; Taylor, A.G. Modern seed technology: Seed coating delivery systems for enhancing seed and crop performance. *Agriculture* **2020**, *10*, 526. [\[CrossRef\]](#)
70. Afzal, I.; Saleem, S.; Skalicky, M.; Javed, T.; Bakhtavar, M.A.; Kamran, M.; Shahid, M.; Sohail Saddiq, M.; Afzal, A.; Shafqat, N.; et al. Magnetic field treatments improves sunflower yield by inducing physiological and biochemical modulations in seeds. *Molecules* **2021**, *26*, 2022. [\[CrossRef\]](#)
71. Javed, T.; Afzal, I. Impact of seed pelleting on germination potential, seedling growth and storage of tomato seed. *Acta Hortic.* **2020**, 417–424. [\[CrossRef\]](#)
72. Javed, T.; Afzal, I.; Mauro, R.P. Seed coating in direct seeded rice: An innovative and sustainable approach to enhance grain yield and weed management under submerged conditions. *Sustainability* **2021**, *13*, 2190. [\[CrossRef\]](#)
73. Shabbir, R.; Javed, T.; Afzal, I.; Sabagh, A.E.; Ali, A.; Vicente, O.; Chen, P. Modern biotechnologies: Innovative and sustainable approaches for the improvement of sugarcane tolerance to environmental stresses. *Agronomy* **2021**, *11*, 1042. [\[CrossRef\]](#)
74. Javed, T.; Shabbir, R.; Ali, A.; Afzal, I.; Zaheer, U.; Gao, S.J. Transcription factors in plant stress responses: Challenges and potential for sugarcane improvement. *Plants* **2020**, *9*, 491. [\[CrossRef\]](#) [\[PubMed\]](#)