International Journal of Plant & Soil Science

Volume 35, Issue 3, Page 160-169, 2023; Article no.IJPSS.96630
ISSN: 2320-7035

Influence of Tillage Systems on the Productivity of Wheat Varieties in the Conditions of Balkh Afghanistan

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Authors' contributions

This work was carried out in collaboration among all authors. Author MAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KSO, PP and MMY managed the analysis of the study, manuscript writing and literature references. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i32788

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/96630

Original Research Article

Received: 15/12/2022
Accepted: 22/02/2023
Published: 03/03/2023

ABSTRACT

In Afghanistan, the greatest challenges in agriculture system are major soil erosion, high soil moisture loss, and farming of the same crop every year leads to drop in fertility level of the soil. Conservation Agriculture defined by three principles namely minimum soil disturbance, crop rotation and permanent soil cover. A field experiment was conducted during winter and summer season of 2018 at research farm of Dehdadi, Balkh, Afghanistan. The experiment was laid out in a split plot design, comprising ten treatment combinations. The main factor was conservation agriculture and conventional agriculture with sub factor by five varieties of wheat (Moqawium, Baghlan, Chunt, Darlaman and local).The main objective of this study is to compare and determine the performance of new wheat varieties under conservation and conventional agriculture, for

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improving and identifying it's effect on wheat yield and wheat varieties under conservation agriculture.
The result indicated that different soil conservation practice could cause significant changes in term of wheat growth and yield attributes like bundle weight and yield of wheat and among wheat varieties Chunte variety significantly difference on number of tillers, bundle weight, straw yield, yield and thousand wheat kernel as compare to local wheat variety. In short time there was not any difference in soil chemical and physical of soil in term of pH, OC, N, P and K, but in long term there will be minor changes occur, so we do recommend conserving to improve the soil fertility and cultivate the chunte variety for more yield.

Keywords: Conservation agriculture; conventional tillage; soil; yield; wheat.

1. INTRODUCTION

"Nearly 80% of Afghanistan's population lives in rural areas and depends heavily on livelihoods in the agriculture sector, which, in turn, depends on agricultural production" [1].

Data obtained by researchers [2,3] demonstrate that, "wheat is the most important crop in Afghanistan, followed by rice, barley, and cotton. Most cereal crops are utilized for self-consumption. Wheat is prominent in all of the major farming systems prevailing in the country and cultivated in every province. It dominates the total cultivated cereal area estimated as 2.7 to 3 million hectares". "Despite being the dominant cereal crop in Afghanistan, the production of wheat fails to fulfill the internal demand. About 1 million tons (equivalent to 25% of internal demand) of wheat are imported annually to meet internal requirements. However, wheat production has been unstable during the last decades and the country depends on seed imports" [3].

"Reducing soil resource degradation, increasing agricultural productivity, reducing poverty, and achieving food security are major challenges of Afghanistan, As FAO [4], reported that cereals are among the oldest components of the human diet. They comprise a group of crop plants that occupy approximately one-half of the total agriculturally cultivated area globally. According to data from the Food and Agriculture Organization of the United Nations, the average annual production of cereals worldwide is about 2.5 billion tons, including approximately 750 million tons of wheat. Wheat accounts for about 30% of the total cultivation area of cereals in the world, corresponding to approximately 220 million hectares. About 60% of the total production of wheat is used for consumption purposes".

Improved wheat varieties have been introduced to the farmers as a result of the efforts of scientific institutions, such Food and Agriculture Organization [5] in Mazar-e-Sharif, and among them we have selected five varieties of wheat (Moqawium, Baghlan, Chunt, Darlaman and local) that are more common among the farmers of Balkh province, to evaluate and improve wheat yield and varieties under conservation agriculture.

"Conservation Agriculture is the best management of natural resources like soil, water, vegetation, and biodiversity for sustaining the future prospects. CA have potential to decrease the effects of changing climate by optimizing crop productivity and advantages while maintaining a coordination among agricultural, monetary, and ecological benefits" [6,7].

"Soil organic matter not only provides nutrients for the crop, but it is also, above all else, a crucial element for the stabilization of soil structure" [8].

"CA is the best management of natural resources like soil, water, vegetation, and biodiversity for sustaining the future prospects. CA have potential to decrease the effects of changing climate by optimizing crop productivity and advantages while maintaining a coordination among agricultural, monetary, and ecological benefits" [6,7].

Peigne et al., [9] found "conservation tillage includes a shal-low working depth without soil inversion, i.e. no tillage or reduced or shallow tillage with tines or discs".

Aune JB, [10] noted that "conservation agriculture is furthermore more efficient in building soil organic matter than organic agriculture and conventional agriculture. Conservation agriculture has been found to sequester between 0.1 and 1 t C ha^{-1} $year^{-1}$. Building soil organic matter content can be

considered as a cornerstone in adaption to climate as this will increase soil water holding capacity and reduce soil temperature. System studies have shown that nitrogen and greenhouse gas emission are less in conservation agriculture as compared to conventional and organic agriculture. The non-use of pesticides is the major environmental advantages of organic agriculture".

"Data obtained by other researchers [11-14] demonstrate the beneficial effects of conservation tillage on the yields of cereal crops in conventional farming". "The success of conservation tillage in organic farming hinges on the choice of crop rotation to ensure weed and disease control and nitrogen availability" [15].

"Understanding the effects of conservation tillage practices on soil structure is critical for suitable soil management" [16]. "Conservation tillage (no-tillage and minimum tillage) systems generally improve soil organic C, plant-available water capacity, aggregation, and soil water transmission" [11].

Conventional agriculture is increasingly based on highly specialized, highly productive farms. Abson et al., [17] noted that "this specialization results in farms that lack resilience to changing market and environmental conditions, and that by decreasing agricultural diversity the resilience of the farming system also decreases".

1.1 Objectives

1. To determine the performance of new wheat varieties under conservation agriculture.
2. To evaluate the improved wheat varieties under conservation agriculture.
3. To identify soil crop management and its effect on wheat yield

2. MATERIALS AND METHODS

An experiment was conducted during the year 2018-2019 at Balkh, Afghanistan ARIA research farm of Dehdadi, in order to study the "Performance of wheat varieties under different tillage system (conservation and conventional agriculture)". The details of material and methods was adopted during the investigation are described in this section.

Dehdadi district is located in western Balkh province. Latitude and longitude of the study area expands from 36˚ 39' 32.105'' to 66˚ 57' 29.459''. Average annual rainfall measures less than 500 mm. It is located 16 km far away from central of Balkh. The climate is arid or semi-arid based on climate classification method. Most of the crops are grown as irrigated. Conventional tillage is commonly practiced for seedbed preparation, but we want to implement modern methods of tillage (conservation tillage) in the region.

In this study, two factors, main factor is conservation agriculture (zero tillage), (C1) and conventional agriculture (deep plowing), (C2). Sub factor is the 5 wheat varieties.

Each treatment will replicate three times in 1000 m^2, the plot size was 5 to 4 m and the total plot size was 20 m^2.

Fertilizers urea and Di-ammonium phosphate (DAP) was used uniform to all treatments at same time, just urea will used one part as basal and rest of that was used at tillering and heading stages of growing wheat under the soil. The crop was irrigated by the channel water it is safe for wheat crop. Weeds and crop residues were removing manually from the experimental field. Planking has been done in both the direction to prepare leveled and fine seed bed. Layout of the experimental field is carried out. Bunds were prepared manually to separate the experimental units and replications. Furrows were opened at 60 cm x 15 cm distance with the help of shovel.

2.1 Cultivation

The wheat cultivated on 29 November 2018 and Dehdadi research farm.

2.2 Harvesting and Threshing

The crop harvested at physical maturity. The ear heads and straw harvested from the net plot of each treatment separately and weight it.

2.3 Experimental Data Collection

Observations on growth and yield parameters were recorded on five randomly selected plants from the net plot area. Following are the observations recorded at days after cultivation and at the harvest stage.

Table 1. Details of treatment which was included in the experiment

Treatment combinations	
1	conservation agriculture + Moqawium-06 (C1V1)
2	conservation agriculture + Baghlan-09(C1V2)
3	conservation agriculture + Chunt(C1V3)
4	conservation agriculture + Darlaman-06 (C1V4)
5	conservation agriculture + local (C1V5)
6	conventional agriculture + Moqawium-06 (C2V1)
7	conventional agriculture + Baghlan-09 (C2V2)
8	conventional agriculture + Chunt (C2V3)
9	conventional agriculture + Darlaman-06 (C2V4)
10	conventional agriculture + local (C2V5)

Table 2. The experiment layout

1	**Design**		Split Randomized Block Design
2	**Number of replications**		3
3	**Total number of treatments**		2 x 5 =10
4	**Total number of experimental units**		30
5	**Plot size**	(a) Gross	5.0 m x 4.0 m
		(b) Net	4.5 m x3.5 m
6	**Total experimental area**		1000 m2
7	**Seed rate**		125 (kg/ha)
8	**Crop and variety**		-
9	**Spacing**		20 cm row to row

2.3.1 Growth

Stand fall/spring %
Plant height (cm)
Spike height (cm)

2.3.2 Yield and yield attributing

No. of tillers/ m^2
No. of grains/spike
Grain yield (kg/ha)
Straw yield/ha

The treatment wise spike and fodder samples were withdrawn and pre weighted. The fodder samples were air dried first in open space of field than again dry in hot air oven at $65^oC \pm 1^oC$ while samples will cut into small pieces and directly dry in oven at $65^oC \pm 1^oC$ till constant weight. These dry samples were again weight, and these weights were used for calculation of dry matter yield.

To study the effect of conservation and conventional on soil physio-chemical properties, treatment wise soil samples were collected before and after the harvest of the wheat from 0-22.5 cm depths (Initial and at harvest), air dried at room temperature and ground using wooden mortar-pestle and retained for further analysis. The retained soil samples were analyzed for pH, EC, Organic carbon, available N, P_2O_5, K_2O, deploying the standard methods. The data pertaining to growth and yield contributing characters and yield, as well as soil analysis were statistically analyzed as per the methods described by Steel and Torrie [18].

3. RESULTS

Data pertaining to growth and yield attributes of wheat *viz*., yield, straw yield, thousand kernel weight, tillers per square meter, number of seed per spike, plant height and bundle weight recorded during growth and harvest as influenced by conservation agriculture and conventional agriculture and their interaction, tillage with wheat varieties are presented in Table 3.

The wheat yield and bundle weight were significantly influenced by application of conservation agriculture. Among the different tillage systems, treatment conservation agriculture significantly higher as compared to conventional agriculture.

The wheat yield and bundle weight were also significantly affected by application of conservation agriculture on among different

wheat varieties. Among the wheat varieties significant higher yield obtain by Chunte variety, at par with Baghlan and the lowest yield achieved by local variety.

The thousand kernel weight and number of seed per spike, straw yield, plant height and number of tillers/m^2 was found non-significant both factors tillage systems and wheat varieties.

The yield of wheat indicated that significantly higher yield enhanced by the application of conservation agriculture among different wheat varieties. Chunte wheat variety received significantly higher yield as to compare with local variety. There is not any significant difference on interactions.

The interaction was failed to show any significant effect on growth and yield attributes of wheat under different tillage systems.

No significant effect of different tillage's and wheat varieties, and their interactions were observed on soil chemical content (pH, EC, N, P, K and organic carbon of soil) (Tables 3 and 4). However, in case of conservation agriculture, slightly higher OC, N, P and K content in soil was noted.

4. DISCUSSION

Plant yield attributes of wheat *viz*., yield, and bundle weight of wheat were significantly affected by conservation agriculture. (Table 3). The reasons are due to (i) steady and higher availability of N, P_2O_5, K_2O, and cationic micronutrients (Table 4) during the crop growth period which have enhanced the growth and yield attributes and finally augmented to better yield (ii) addition of crop residue, enhanced the level of soil enzymes activity and promoted the recycling of soil nutrients in the ecosystem, improve the absorptive power of cations and anions present on soil particle and that may be released slowly during the crop growth and improvement in soil structure which reduced the soil crusting and also serves as a source of energy for soil micro flora which resulted in better root and (iii) no disturbance of soil physical properties of soil.

"Evidence of some short- to medium-term studies on wheat- based systems, showed that conservation tillage practices (no and reduced tillage) either with partial crop residue or removed, increased soil bulk density on surface soil compared with conventional tillage practices" [19,20].

Suchowilska et al. [21] observed that "the contents of minerals (especially microelements), vitamins,and organic compounds necessary for correct development of the organism decrease in wheat along with increases in the productivity and yields of its genotypes, which can lead to highly unfavourable consequences". "Data obtained by other researchers [13,22-27] clearly demonstrated the beneficial effects of conservation tillage (NT and MT) on soil structure and fertility". Daraghmeh et al. [16] found that "compared to conventional tillage, reduced tillage improved soil structure through a combination of increased soil organic matter, reduced soil bulk density and increased proportion of larger aggregates".

Table 3. Effect of tillage and wheat varieties on growth and yield attributes of wheat

Treatments	Bundle weight/9.2 m2	Straw yield kg/ha	Plant height/cm
Tillage's			
Conservation	11.461	7498.186	96.44
Conventional	11.06	7646.395	96.92
S. Em. +	0.052	96.956	1.389
CD @ 5 %	0.31	NS	NS
CV %	1.79	4.96	5.56
Wheat varieties			
Local	9.378	6159.036	97.55
Chunte	12.257	8243.942	98.617
Darlaman	11.648	8071.262	97.267
Baghlan	11.612	7764.455	96.033
Moqawium	11.408	7622.757	93.933
S. Em. +	0.213	236.776	1.392
CD @ 5 %	0.63	709.8862	NS

Treatments	Bundle weight/9.2 m2	Straw yield kg/ha	Plant height/cm
Interaction			
S. Em. +	0.302	334.852	1.969
CD @ 5 %	NS	NS	NS
CV %	60.64	7.66	3.53

Table 4. Effect of tillage and wheat varieties on No. of tillers per square meter of wheat

Treatments	No. of tillers/m2	Yield kg/ha
Tillages		
Conservation	397.867	4959.785
Conventional	368.733	4375.344
S. Em. +	8.297	77.87
CD @ 5 %	NS	473.917
CV %	8.38	6.44
Wheat varieties		
Local	265.167	4034.804
Chunte	442.833	5078.522
Darlaman	396.167	4589.97
Baghlan	414.833	4856.922
Moqawium	397.5	4777.605
S. Em. +	10.61	193.18
CD @ 5 %	31.8093	580.97
Interaction		
S. Em. +	15.004	274.046
CD @ 5 %	NS	NS
CV %	6.78	10.17

Table 5. Effect of tillage and wheat varieties on soil chemical properties after harvest of wheat

Treatments	pH	EC dS/m	OC%
Tillage			
Conservation	8.183	0.393	1.113
Conventional	8.157	0.387	1.08
S. Em. +	0.096	0.027	0.045
CD @ 5 %	NS	NS	NS
CV %	4.56	26.5	15.88
Wheat varieties			
Local	8.108	0.398	1.033
Chunte	8.277	0.385	1.117
Darlaman	8.007	0.405	1.15
Baghlan	8.128	0.387	1.117
Moqawium	8.332	0.375	1.067
S. Em. +	0.11	0.021	0.032
CD @ 5 %	NS	NS	NS
Interaction			
S. Em. +	0.156	0.03	0.045
CD @ 5 %	NS	NS	NS
CV %	3.3	13.36	7.11
Initial	8.47	0.29	0.9

“This could be also ascribed due to existence of favorable nutritional environment under the influence of conservation agriculture which had a positive effect on vegetative and reproductive growth which ultimately led to realization of higher values for growth attributes leading to higher yield of crop, the results of [28-32] (khosravani et al., 2008), are similar to the results of this study and confirmed our results in the field of product yield wheat”.

Table 6. Effect of tillage and wheat varieties on soil chemical properties after harvest of wheat

Treatments	N (PPM)	P (PPM)	K (PPM)
Tillage			
Conservation	24.14	34.287	112.933
Conventional	20.28	31.067	89
S. Em. +	2.248	0.618	8.073
CD @ 5 %	NS	NS	NS
CV %	39.2	7.32	30.97
Wheat varieties			
Local	22.283	33.617	105.333
Chunte	20	34.433	106
Darlaman	19.933	32.783	98
Baghlan	22.65	29.433	86.667
Moqawium	26.183	33.117	108.833
S. Em. +	2.038	5.599	11.704
CD @ 5 %	NS	NS	NS
Interaction			
S. Em. +	2.882	7.918	16.551
CD @ 5 %	NS	NS	NS
CV %	22.47	41.56	28.39
Initial	33.9	15.5	70

"Farmers should operationalize or adapt these principles to suit their specific circumstances. This approach has given rise to debates about what should 'count' as conservation agriculture or SRI and whether all principles need to be followed. Thierfelder et al., [33] for example, compare a 'conventional control treatment' with two 'manual systems of conservation agriculture' (i.e., two manual seeding methods), but the description of the conservation agriculture treatments makes no mention of soil cover or residue management. Some have gone so far as to suggest that what really matters is not the specific practices, but whether the farmer thinks s/he is practicing conservation agriculture or SRI" [34].

"Soils under conservation agriculture (CA) have high water infiltration capacities reducing significantly surface runoff and thus soil erosion. This improves the quality of surface water, reduces pollution from soil erosion, and enhances groundwater resources. CA is characterized by three interlinked principles, namely continuous minimum mechanical soil disturbance, permanent organic soil cover and diversification of crop species grown in sequence or associations. Soil aggregate stability was used as an indicator of soil susceptibility to water erosion" [35,36].

The growth and yield attributes (thousand kernel weight and no. of seed per spike, straw yield, plant height and no of tillers/m^2 were not significantly affected by tillage systems (Table 3). Similar non-significant results of tillage systems were reported by Mohammadi et al. [37] and Boloor et al. [38].

No significant changes were observed for chemical parameters *viz*. (pH, EC, N, P, K and organic carbon of soil) (Tables 5 and 6). Under the influence of applied different tillage systems. Applying of no tillage on soil will improves the soil chemical properties is a well-documented and scientifically proven fact but here such non-significant effect was quite acceptable as chemical properties of soil remain unchanged in short course of time, hence non-significant result was anticipated. Similar results were reported by Veeresh, [39], Laxminarayana [40], Kannan et al. [41], Nandapure et al. [42], Khalid et al. [43] & Nwite et al. [44].

5. CONCLUSION

Conservation agriculture compared with conventional led to higher performance based on yield of wheat, but it seems in this treatment long-lasting product performance with short-term results may vary. Therefore, we propose such studies for longer timescales and for different environmental and climatic conditions.

Among the wheat varieties. Chunt-01 got higher yield as compared to others and recommended for our Afghan farmers.

FUNDING

This work supported by GRAIN project, USAID, Michigan University.

ACKNOWLEDGEMENTS

We gratefully acknowledge Mrs. Carmen Benson GRAIN Project chief of Party, Michigan University, and Mr. Masoud Karimi capacity building manager of GRAIN Project for good assistance in completion of the research and thank Professor Mohammad Yousuf Fakoor Head of Agronomy Department of Agriculture Faculty, Balkh University for huge help to us. This work supported by GRAIN project, USAID, Michigan University.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/96630