

Research Article



Response of Wheat to Tillage and Sowing Techniques under Arid Condition

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Abstract | Heavy textured soil leads to insufficiency of water in arid region. To investigate the effect of soil pulverization (P) and sowing methods (S) on Water Use Efficiency (WUE), wheat yield and economics, a field experiment was carried out at Arid Zone Research Center, Dera Ismail Khan, Khyber Pakhtunkhwa Province, Pakistan, during rabi season of 2014-15 and 2015-16. The experiment was laid in randomized complete block (RCB) design with split plot arrangement keeping pulverization viz. single tiller P₁, double tiller P₂, triple tiller P₃ and mould board plow P₄ followed by single rotavator in main plots while sowing methods i.e. Raised Bed Sowing S₁ and Flat Bed Sowing S₂ in the subplots. The results showed higher WUE in the plots receiving P₂ and S₁ in both years of experiments. Statistics revealed that P had significant effect on tillers plant⁻¹, weight of grain spike⁻¹, grain yield and harvest index % (H.I. %). While (S) had significant effect on yield of grain, straw, biomass and H.I. Maximum grain yield and BCR was recorded in treatment combination of P₂ × S₁. It is concluded that use of 2-tillers on raised bed sowing method gave significant result of WUE, economics and grain yield which may be recommended for the arid regions.

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Introduction

Tillage is an important management practice influencing soil properties and crop growth. Tillage is usually carried out to pulverize the soil, improve movement of air and water and promote plant growth. Tillage operations are used to conserve water and improve water use efficiency of the stored water (Sarkar and Singh, 2007). Similarly, Wang et al. (2002) reported that deep tillage can store up to 90% of the rainfall. Intensive and unnecessary tillage may often be harmful to the soil structure. Soil having

greater clay content requires tillage for breaking the hard pans and crust formation.

The world total area under wheat is approximately ten million hectares, which produces approximately six hundred and twenty one (621) million tons of grain thus providing on an average one fifth of the total calorific input of the world's population (Reynolds et al., 2006). It meets about 73% protein and calories of the average diet (Hossain et al., 2003).

Wheat production can be improved by using better

inputs, proper production technology and by proper tillage practices. Important factors like soil tillage and manure application affect soil physical properties and wheat yield. In crop production package soil tillage contribution is 20% (Ahmad et al., 1996). Appropriate agricultural machinery for tillage and sowing time are the two major factors for increased agricultural productivity. Shortage of proper tillage implements, planting equipment and fertilizer are some of the constraints limiting crop yield in Pakistan.

Wheat growers in the arid regions of Pakistan face problems of low rainfall, shortage of irrigation water with low soil fertility leading to low yield of wheat. Wheat crop is grown in the areas where annual precipitation ranges from 250 to 1750 mm, while area under focus of this study ranges from 180 to 305 mm. Hence water use efficiency can play a vital role in livelihood sustainability of the area. As main focus of water use efficiency is harvesting maximum yield from each drop of water. Preparation of land and sowing methods both are very important for optimum wheat production. Proper sowing methods may lead to efficient water use and also play vital role in crop yield. Normally farmers of the arid area of Dera Ismail Khan broadcast the wheat seed at sowing time with minimal land preparation due to uncertainty of rainfall (irrigation water) resulting in failure of whole crop or lower production. For efficient utilization of each drop of water for fetching more economic yield of wheat crop was the main aim of our study.

Keeping in view the above mentioned problems, a research study was designed with the objectives to reduce the cost of production of wheat crop by enhancing water use efficiency and economics of the farmers through improved management techniques and selection of appropriate agricultural machinery for tillage and sowing.

Material and Methods

To investigate the effect of tillage application and sowing methods in heavy textured soils on the yield of wheat for efficient utilization of irrigation water, this study was conducted at Arid Zone Research Centre, Dera Ismail Khan lies in between 31° 53' 104" N latitude and 070° 54' 93" E longitude with mean rainfall ranging from 180 to 305 mm. Different pulverizing (tillage) equipment with two sowing methods were used in the experiment. Wheat variety Hashim 2008

was sown during 2014-15 and 2015-16, which is well adopted in the climatic condition of the area, with characteristics of high yielding and early maturing. The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement, with tillage operation (P_1 : Single tiller, P_2 : double tiller, P_3 : triple tiller and P_4 : mould board plough) was kept in main plots, while sowing methods (S_1 : raised bed and S_2 : Flatbed) were kept in sub – plots. The parameters studied in the experiment included number of grains spike⁻¹, plant height (cm), number of tiller plant⁻¹, straw yield (kg ha⁻¹), 1000- grain weight (g), grain yield (kg ha⁻¹), harvest index (%). The physico-chemical characteristics of soil before the experiment are given in Table 1.

Water Use efficiency was calculated by using the Formula:

$$\text{Water Use Efficiency (kg ha}^{-1}\text{mm}^{-1}\text{)} = \frac{\text{Grain Yield} \times 10000}{\text{Depth of Water Applied}}$$

Economics of the treatments for each year was calculated using the benefit cost ratio (BCR). Statistical analysis was carried out using the analysis of variance through the procedure given by Steel *et al.* (1997) using the computer software "Statistix 8.1". LSD was applied to compare the means of treatments in the experiment.

Table 1: Physico – chemical analysis of soil before the experiment.

| S. No. | Parameters | Value | Method |
|--------|--------------------------------------|-------|------------------------------|
| 1 | Soil Texture | Clay | Richard (1954) |
| 2 | Bulk Density (g cm ⁻³) | 1.30 | Blake and Hartage (1984) |
| 3 | pH | 7.87 | Richard (1954) |
| 4 | ECe(μSm ⁻¹) | 523 | Richard(1954) |
| 5 | Organic Matter (%) | 0.56 | Nelson and Sommer, (1982) |
| 6 | CaCO ₃ (%) | 14.45 | Richard, (1954) |
| 7 | Total N (%) | 0.035 | Bremner and Mulvaney, (1982) |
| 8 | Extractable P (mg kg ⁻¹) | 6.29 | Watanabe and Olsen,(1965) |

Results and Discussion

Water Use Efficiency (WUE)

Water use efficiency calculated during the two years of experiment showed that during the first year the double tiller on the raised bed gave the higher value

for the WUE (Figure 1). It was also observed during the initial year that raised bed sowing method was more effective than the flat bed for water utilization by the plants. The water use efficiency was found the least in the single tiller plots. In the following year of experiment the WUE plots showed greater value for the double tiller, but it was slightly higher than the triple tiller and mould board plots.

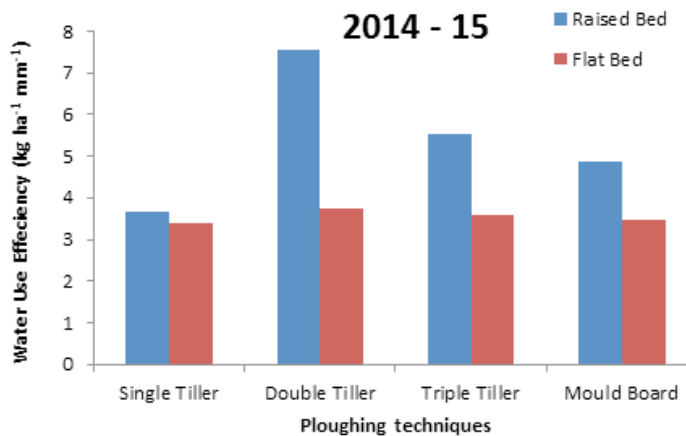


Figure 1: Water Use Efficiency of the treatments during year 2014 – 15

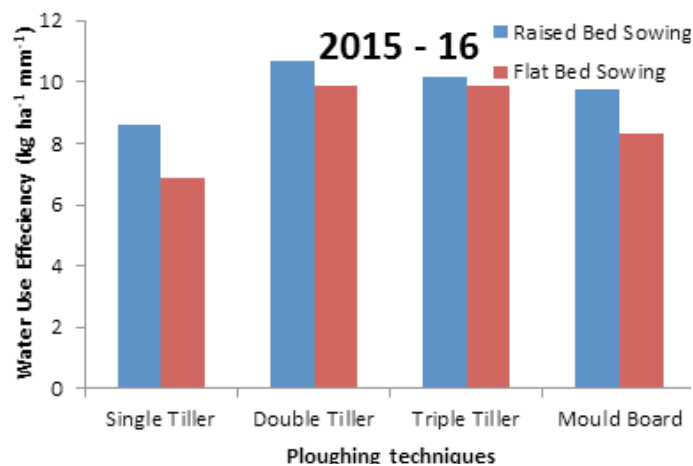


Figure 2: Water Use Efficiency of the treatments during year 2015 – 16

The least value of WUE was found in the single tiller. The raised bed confirmed better water use over the flat bed during the second year (Figure 2). Wheat crop through furrow irrigated raised bed have been reported to have greater WUE (Zhang et al., 2007; Ghane et al., 2009). Similarly, Ram et al. (2013) reported that WUE of wheat was 22.3% more on raised bed than on the flat layout. More WUE can be attributed to optimal pulverization and judicious use of water due to raised bed plantation.

Effect of sowing techniques and pulverization on the growth parameters of wheat:

Plant Height: Plant height is growth parameters

which influence the total biomass of wheat plant. The data regarding the plant height of wheat showed non-significant effect of sowing methods while the soil pulverization significantly effect at 5% level of significance. In both the years the treatment receiving double tillers (P_2) followed by single rotavator showed highest plants. The interaction between the sowing methods and tillage application showed non – significant effect on plant height in the first year of experiment, but was significantly different in second year (Table 2). Islam et al., (2011) reported significant effect of tillage operation on plant height of wheat, significantly higher plants were recorded where three passing tillers were used. Noorka et al. (2011) studied the effects of different tillage operation on yield and yield contributing parameters, two types of tillage regimes namely conservation tillage and conventional tillage were observed. Nine traits including plant height were affected significantly by tillage operation. Memon et al. (2007) performed a study in order to assess the effect of tillage on physical properties of soil, growth and yield of maize. Three different sowing methods viz. ridging, drilling and broadcasting were used under RCBD. They also observed that among agronomic observations, plant height was highest in ridge sowing method; the second best was seed drilling, while broadcast sowing was found to be less effective.

Amin et al. (2013) studied effect of tillage practices and sowing methods on emergence, number of tillers, plant height, spike length and harvest index% of wheat. Five tillage practices consisted of Tine Cultivator twice (TC-2), Chisel plow followed by rotavator (CR), Mould board plow followed by rotavator (MR), Disc plow followed by rotavator (DR) and Tine Cultivator followed by rotavator (TCR), while two sowing methods included broadcasting and drilling. Statistical analysis of the two year data revealed that tillage practices had significant effect on number of tillers and non – significant effect on plant height. The contradictory results may be due to different combination of tillage operation than ours.

Number of Tiller plant⁻¹: Number of tillersplant⁻¹ were non – significantly changed in both the years of experiments by using different sowing methods, however the use of tillage practices have significantly changed the number of tillers per plant in the first year of experiment but in the second year it was non significantly changed. The maximum number of tillers plant⁻¹ was recorded 6.75 in P_3 (Applied with triple

Table 2: *Effect of sowing techniques and ploughing methods on the growth and yield contributing parameters of wheat.*

| Treatments | Plant height (cm) | | No. of Tiller per plant | | No. of grains per spike | |
|-----------------------------|-------------------|----------------------|-------------------------|---------------------|-------------------------|---------------------|
| | 2014 – 15 | 2015 -16 | 2014 – 15 | 2015 -16 | 2014 – 15 | 2015 -16 |
| Ploughing Techniques | | | | | | |
| P ₁ | 83.75 b | 99.13 b | 5.75 b | 10.5 ^{NS} | 41.50 | 44.87 |
| P ₂ | 90.00 a | 104.38 a | 5.87 ab | 11.25 | 36.50 | 44.25 |
| P ₃ | 90.25 a | 101.62 ab | 6.75 a | 11.25 | 38.12 | 44.00 |
| P ₄ | 89.37 ab | 100.13 b | 5.87 ab | 8.75 | 36.75 | 41.62 |
| Sowing methods | | | | | | |
| S ₁ | 89.813 | 102.38 ^{NS} | 5.9375 | 9.875 ^{NS} | 36.813 ^{NS} | 44.50 ^{NS} |
| S ₂ | 86.875 | 100.25 | 6.1875 | 11.00 ^{NS} | 39.625 | 42.87 ^{NS} |
| LSD _{Plo*} | 6.2358 | 3.5343 | 0.9629 | NS | NS | NS |
| LSD _{Sow**} | NS | NS | NS | NS | NS | NS |
| LSD _{Int***} | NS | 6.0574 | NS | 5.8413 | NS | NS |

*Means in a column followed by similar letter(s) did not differ significantly at 5 % level of significance; *: plo. Stands for ploughing/tillage; **: sow. Stands for sowing; ***: Int. Stands for Interaction*

tiller) (Table 2). The interaction between the sowing methods and tillage operation was found non – significant in the first year but was significantly variable in the second year of experiment. Moeen-ud-din et al., (2015) have reported that number of tillers m⁻² was significantly higher in the plots receiving four passes of cultivator, while the lowest were recorded in the plots where chisel + rotavator was used. Results of current study are also in agreement with Leghari et al.,(2015) whom reported improved number of tillers with optimal tillage. Comparatively more number of tillers in plots tilled with more passes of tiller may be due to more pulverized soil that produced favorable environment in root zone, resulting in more tillers as compared to the treatment having application of chisel+Rotavator, where the root zone soil may not be so much soft thereby couldn't produce conducive environment for emergence of more number of tillers. Amin et al., (2013) also reported that statistical analysis of the two year data revealed that tillage practices had significant effect on number of tillers.

Number of grains per spike: The number of grains spike⁻¹ is a yield contributing parameter. The data on number of grains spike⁻¹ revealed a non – significant effect on sowing techniques, tillage operations and also in their interaction for both the experimental years (Table 2). Jug et al. (2011) reported similar results for number of grains per spike while comparing the conventional tillage operations with deep ploughs and no tills. Kahloon et al. (2012) studied the conservation technologies and traditional techniques .The

sowing techniques under the study were broadcasting, Rotary Tillage Drill, Zero Tillage Drill and Rabi Drill. Rotary Tillage Drill showed significantly higher number of grains spike⁻¹ as compared to Rabi Drill, Zero Tillage Drill and broadcasting. Though these results deviate from our results but this deviation may be attributed to different tillage implements used in experiment.

Effect of pulverization and sowing techniques on the yield parameters of wheat

Grain Yield (kg ha⁻¹): The grain yield is the economic parameter of wheat crop. In the present study the result on grain yield showed significant (P ≤ 0.05) effect of raised bed and flatbed sowing in the first year, however it was non– significant in the following year. The grain yield was also significantly changed by the tillage operations. The treatment of ploughing with double tiller gave the maximum yield 2343.5 kg ha⁻¹; it was confirmed in the second year. The interaction between the main and sub – plots yielded significant difference for grain yield (LSD_{Int} of (Table 3). Iqbal et al. (2007) also found greater yield from plots ploughed with one pass of rotavator followed by three pass of cultivator. The grain yield was statistically lower in the deep plough during the first year of experiment may be due to effect on soil structure and water movement. However it was statistically at par with the highest grain yield in the following year of experiment. Similar results have been reported by Machado et al. (2008) and Leghari et al. (2015). Remero (2010) tested effect of tillage on root development of wheat in rainfed areas.

Table 3: *Effect of sowing techniques and ploughing methods on the yield attributes of wheat.*

| Treatments | Grain Yield (kg ha ⁻¹) | | Thousand grain weight (g) | | Straw Yield (kg ha ⁻¹) | | Harvest Index | |
|--------------------------|------------------------------------|--------------------|---------------------------|----------|------------------------------------|-----------|---------------|----------|
| | 2014 – 15 | 2015 -16 | 2014 – 15 | 2015 -16 | 2014 – 15 | 2015 -16 | 2014 – 15 | 2015 -16 |
| Ploughing methods | | | | | | | | |
| P ₁ | 1818.0 d | 2994 b | 37.35 a | 36.26 NS | 4512 a | 5246 b | 28.71 d | 34.25 |
| P ₂ | 2343.5 a | 3677 a | 35.81 d | 38.12 | 3610.8 d | 7105.5 a | 38.57 a | 33.5 |
| P ₃ | 2146.3 b | 3593 ab | 36.33 c | 37.11 | 3963.9 c | 6204.5 ab | 35.08 b | 36.00 |
| P ₄ | 1901.0 c | 3124 ab | 36.69 b | 35.73 | 4486.6 b | 4988.1 b | 29.70 c | 37.50 |
| Sowing techniques | | | | | | | | |
| S ₁ | 2409.5 a | 3483 ^{NS} | 36.339 b | 37.975 a | 4377.7 a | 5545.5 NS | 35.563a | 36.75 a |
| S ₂ | 1694.9 b | 3211 | 36.756 a | 35.644 b | 3909.3 b | 6226.5 | 30.475b | 33.875 b |
| LSD _{Plo} | 12.341 | 663.83 | 0.3284 | NS | 31.805 | 1247 | 1.0300 | NS |
| LSD _{Sow} | 11.036 | NS | 0.1802 | 2.2707 | 25.930 | NS | 0.8706 | 1.98 |
| LSD _{Int} | 17.452 | 828.04 | 0.4644 | 4.5414 | 37.082 | 1748.8 | 1.2214 | 3.96 |

Means in a column followed by similar letter(s) did not differ significantly at 5 % level of significance

He reported that Conventional Tillage (CT) exhibited better root development & root biomass than No Tillage (NT). Results of this study were contrary to our results. In our results greater grain yield of wheat was observed in double tiller plots than single tiller while in their findings, higher grain yield was found in non – tillage plots. He attributed this due to greater water storage in the soil profile in dry areas. The reason for difference in the results may be due to the difference of study area/environment. Our study was in irrigated area, while they performed research on wheat in dry areas. Moreover, the different results may be due to soil type on which he conducted the experiments.

Thousand grain weight (g): Thousand grain weight of wheat showed significant effect of sowing techniques during the two years of experiment, with the highest value of 36.756 g and 37.975 g for flat bed and raised bed sowing for 1st and 2nd year of experiment respectively (Table 3). The tillage operation showed significant effect during the first year of experiment with the highest thousand grain weight of 37.35 g in P₁ (single tiller), it was followed by the rest of the ploughing treatments. In the second year the treatments showed non – significant effect on the thousand grain weight. The interaction between the sowing techniques and ploughing operation was significantly changed in both the experimental years (P<0.05). Our results are supported by the findings of Farooq and Cheema (2014) that reported significantly higher 1000 grain weight on bed sowing. Shah et al. (2013) also reported heavier thousand grain weight on raised bed sowing. Similar finding have been re-

ported by Moeen-ud-din et al. (2015) in their experiment conducted on raised bed. Zamir et al. (2013) found significant effect of different tillage operations on 1000 grain weight. The highest was found in the conventional as compare with the sub- soiler.

Straw Yield: The straw yield is an important yield component. In the study it was found that straw yield was significantly higher by sowing in raised bed (S₁) over the flat bed (S₂) in first year of sowing, while in the second year it was non – significantly different (Table 3). The ploughing treatments showed significant effect on the straw yield of wheat. The highest straw yield of 4512 kg ha⁻¹ was found in P₁ (single tiller) during the first year of experiment, while it was greater in the double tiller in the following year of experiment. The ploughing operation with mould board plough (P₄) yielded the least in both the years of experiment. The interaction was found significant for both the years. It was found that increase in tillage reduced the straw yield of wheat. Similarly, Ali et al. (2016) recorded greater straw yield with zero tillage over the conventional tillage methods. Sowing methods with different bed size have been reported to have significant effect on the straw yield of wheat (Mollah et al., 2009). Alam et al. (2013) found that straw yield of wheat was significantly enhanced by the conventional tillage over zero tillage.

Harvest Index %: Harvest Index % showed significant higher value of 35.56 and 36.75 % for the raised bed plots (S₁) during the 1st and 2nd years respectively (Table 3). The effect of ploughing operation on the HI has shown significant effect during the first year, but it was

Table 4: Economics of the treatments used during year 2014 – 15 and 2015 – 16.

| Treatments | Gross income | | Total Cost | | Net Income | | BCR | |
|----------------|--------------|-----------|------------|-----------|------------|-----------|-----------|-----------|
| | 2014 -15 | 2015 – 16 | 2014 – 15 | 2015 – 16 | 2014 – 15 | 2015 – 16 | 2014 – 15 | 2015 – 16 |
| P ₁ | 31289.47 | 48768.2 | 27050 | 27050 | 4239.47 | 21718.2 | 1.15 | 1.802 |
| P ₂ | 47171.05 | 55627.1 | 27850 | 27050 | 19321.05 | 28577.1 | 1.69 | 2.05 |
| P ₃ | 38092.1 | 48498.4 | 28650 | 28650 | 9442.1 | 19848.4 | 1.32 | 1.69 |
| P ₄ | 32263.15 | 43955.1 | 28650 | 28650 | 3613.15 | 15305.1 | 1.12 | 1.53 |
| P ₁ | 27552.63 | 37391.1 | 26250 | 26250 | 1302.63 | 11141.1 | 1.04 | 1.42 |
| P ₂ | 32078.94 | 47670 | 27050 | 27850 | 5028.94 | 19820 | 1.18 | 1.71 |
| P ₃ | 29381.57 | 52690.3 | 27850 | 27850 | 1531.57 | 24840.3 | 1.05 | 1.89 |
| P ₄ | 28763.15 | 45461.1 | 27850 | 27850 | 913.15 | 17611.1 | 1.032 | 1.63 |

non – significantly different amongst the treatments during second year. The double tiller (P₂) was found to give higher HI (38.57), while the rest followed during the initial year of experiment. The interaction between the main and sub – plots was found significantly different for HI% during the two experimental years. Mollah et al. (2009) reported similar results for Harvest index of wheat by using different sowing methods. Gholami et al. (2014) recorded the lowest value for no and reduce tillage and were higher for the conventional tillage methods. Amin et al. (2013) reported that HI was significantly affected by the sowing methods and tillage operation showed non – significant influence on the Harvest Index.

Economics of various treatments during two years of experiment

The economics of different treatments showed that during the two years of experiment the benefit cost ratio (BCR) was found greater in the raised plots with double tiller having the value of 1.69 and 2.05 respectively (Table 4). The least value for BCR was found in the mould board plough plots, which was 1.03 with the sowing technique of flat bed, while in the second year it was found least in the single tiller having the value of 1.42.

Conclusion and Recommendations

It was concluded from the result of the study that tillage operations and sowing techniques carried out for two consecutive years showed a greater influence on the growth and yield of wheat and water use efficiency under agro-climatic conditions of Dera Ismail Khan, KP, Pakistan. Comparing the treatments showed that double tiller sown on the raised bed gave better result in terms of yield, water use efficiency and also the economics of the farmer. On the basis of the

current study it may be recommended for the heavy textured soil to use double tillers on the raised bed for receiving improved results.

Authors Contribution

AS, QK and MM conceived the idea of the study. AS wrote the manuscript and QK, MM, MJK and AU helped him. QK, MM and MK provided technical input. MJA and MK did overall Management of the article.

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