Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 1109 - 1120

Received 08 November 2021; Accepted 15 December 2021.

Identifying the Suitable Crop Management Practices for the Higher Crop Productivity in Indus Basin

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Abstract: Wheat is an important cereal crop of Pakistan but its per acre yield is low as compared to world average due to traditional sowing methods, late planting, excessive tillage practices and weeds infestation. Therefore, optimum tillage practices and modern sowing methods are need of the hour for the better yield of wheat. In this scenario, a field trial was conducted at the Agronomic Research Area of University of Agriculture Faisalabad during Rabi season 2018-19 to assess the agronomic response of wheat to different tillage and sowing practices. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications of spilt plot arrangement. The research trial was consist of three tillage regimes i.e.zero tillage (ZT), reduced tillage(RT) and conventional tillage(CT) and three sowing methods i.e. flat sowing (FS), ridge sowing (RS) and bed sowing (BS) was kept in subplots. The results demonstrated that all the treatments have significant impact on growth and production but the cost benefit ratio of zero tillage (3.23) was highest followed by reduce tillage (3.12) and conventional tillage (2.94) respectively. Correspondingly, cost benefit ratio of sowing method was found maximum in bed sowing (3.20) followed by ridge (3.08) and flat sowing (3) respectively.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 1109 - 1120

Received 08 November 2021; Accepted 15 December 2021.

Keywords: sowing methods, tillage practices, benefit cost ratio

Introduction:

Wheat (Triticum aestivum L.) is second highly cultivated cereal crop worldwide after maize with an area of one sixth of the total arable land in world (Houshyar et al., 2010). It is major staple food of about 35% of the world population including Pakistan.Wheat contributes 1.6% in GDP of Pakistan and about 8.9% in value addition. Area of Pakistan under wheat cultivation during the year 2018-19 was 8.74 million hectare which produced 25.08 million tones (GOP, 2019).

Most of the farmers of South East Asia apply intensive tillage operation for wheat cultivation. The tillage operations are energy intensive and cause delay in seeding, because land preparations require time (Bhushan et al., 2008; Jat et al., 2009). Tillage has major impact on benefit cost ratio as it contributes about 25-30% of the total cost of production in wheat (Saharawat et al., 2011).

It's a challenging job for the researcher to develop such crop production technologies which require low energy and reduce input cost and also have positive effects on soil and environmental health (Gathala et al., 2011b). Most of the farmers in India are now widely practicing zero tillage (ZT) in wheat grown after rice and Pakistan is lacking behind in this regard. ZT allows the farmer to sow wheat on proper time which would not be possible in conventional tillage method in rice-wheat cropping system, moreover it helps to enhance microbial activity within the soil, protects soil from erosion, reduce energy use and input cost (Erenstein and Laxmi, 2008; Ali *et al.,* 2016). Conventional tillage (CT) is widely under practice in Pakistan as it helps in moisture conservation which is considered an important factor influencing yield, it also decrease soil heat, increase root penetration and enhance nutrient availability (Qamar*et al*., 2012). On the contrary, heavy tillage practices cause soil compaction, increase soil bulk density and enhance CO_2 emission from soil by increasing microbial respiration (Miransari*et al.,* 2007).

Sowing method contributes greatly in the seed placement at appropriate depth and consequently influences the crop establishment. It is important to choose the most appropriate sowing method for wheat which depends upon the sowing time, moisture availability in soil at the time of sowing, residual quantity in the field and accessibility to planting machinery(Sikander*et al.,* 2003; Alam, 2012). In Pakistan broadcasting is very common method of wheat sowing and it is a difficult task to control weeds in this method as compared to bed and ridge planting methods. Moreover it is observed that weed infestation is less in bed planting method than flat planting method (Hassan *et al*., 2005; Ram *et al*., 2005). Bed sowing provides better mechanical weed management, enhance the water and fertilizer use efficiency and also help to regulate soil erosion (Sayri, 2003; Yadav*et al.,* 2012). The objective of this study was to evaluate the best tillage and sowing method for wheat crop in Faisalabad conditions.

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Received 08 November 2021; Accepted 15 December 2021.

Material and method:

1.1 Experimental site and soil properties

The experiment was carried outat Agronomic Research Area of University of Agriculture Faisalabad (73°06' East Longitude and 31°26' North latitude) during Rabiseason 2018-19.The study area was situated at 184.4 m above sea level with annual rainfall of 250-500mm.The more comprehensive metrological data of the experimental area exhibited below inthe Table 1.1. Furthermore, a composite soil sample was taken at the depth of 6 and 12 inches from the experimental field. The sample was examined for the soil health parameters.

Table 1.1 Average monthly weather of Faisalabad (2018-19)

Month	Mean Temp (°C)	Relative Humidity (%)	Rain (mm)	Sunshine (hours)
December	14.3	81.4	0.8	6.7
January	13.4	80.6	19	5.5
February	14.5	79.1	64.1	6.6
March	19.8	68.4	55.6	8.8
April	27.7	42.3	31.3	9.1
May	31.3	46.6	39.2	10.2

Table 1.2Properties of soil

Variables	Unit	Result
pH	-	7.82
E.C	dsm^{-1}	1.32
Organic Matter (O.M)	%	1.37
Available Phosphorus (P)	Ppm	11.72
Available Potassium (K)	Ppm	272
Available Nitrogen (N)	Ppm	0.07
Saturation	%	31.34

Experimental details and management:

This trial was carried out to evaluate the agronomic response of wheat undervarious tillage and sowing practices. There were nine treatments and three replications. The tillage methods i.e. zero tillage, reduced tillage and conventional tillage was completely randomized in main units likewise sowing methods i.e. flat sowing (FS), ridge sowing (RS) and bed sowing

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(BS) was kept in subplots by using RCBD under split plot arrangements. Each plot has a size of 54 m^2 (6m*9m).

Time of sowing, plant population and fertilizer application:

Ujala-2016 cultivar of wheat was sown on 21 November, 2018 by using the recommended seed rate of 125 kg per hectare. The single row hand drill was used by keeping row spacing of 22.5 cm. Recommended dose of NPK (125, 60, 60 kg/ha) was applied to each plot. The phosphorus and potash was broadcasted completely at the time of sowing while nitrogen was applied in three split doses i.e at the time of sowing, first and second irrigation. All other factors like irrigation, plant protection and fertilization was applied uniformly to all the treatments.

Table no. 1.3

Tillage methods	**Tillage implement (number of operations)**				
	Acronym	**Harrowing**	**Cultivator**	**Planker**	**Rotovator**
Conventional tillage	**CT**	**2**	**2**	**2**	**2**
Reduce tillage	**RT**	**1**	**1**	**1**	**1**
Zero tillage	**ZT**	**0**	**0**	**0**	**0**

Results

Number of Spikelets per spike:

The date regarding influence of different tillage and sowing practices on number of spikelets per spike is illustrated in table no. 2. Results indicated that higher number of spikelets per spike was recorded in conventional tillage (23.6) followed by reduce and zero tillage (21.07 and 18.02) respectively and statistically at par. While in case of sowing methods, bed sowing gives maximum number of spikelets per spike (21.85) followed by ridge and flat sowing (20.99 and 19.85), respectively. Interaction between tillage and sowing methods was non-significant.

Table no. 1.4

Treatments	**T_1=Conventional tillage**	**T_2=Reduced tillage**	**T_3=Zero tillage**	**Means**
SM_1 Flat Sowing	22.913	19.900	116.737	19.850C
SM_2 Ridge Sowing	23.600	21.263	18.133	20.99B

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SM_3 Bed Sowing	24.300	22.073	19.193	21.856A
Means	23.604A	21.079B	18.021C	

Number of grains per spike:

The data exhibited in table no. 2 clearly demonstrated that tillage and sowing methods have remarkable impact on number of grains per spike. Maximum no of grains per spike was observed in conventional tillage (65.42) gradually decreases in reduce and zero tillage (60.53 and 57.09), respectively. Bed sowing gives higher number of grains per spike (63.85) which is followed by ridge and flat sowing (61.19 and 57.99), respectively. Interaction among tillage and sowing methods were non-significant.

Table no. 1.5

Treatments	**T_1=Conventional tillage**	**T_2=Reduced tillage**	**T_3=Zero tillage**	**Means**
SM_1 Flat Sowing	61.690	58.323	53.980	57.998C
SM_2 Ridge Sowing	64.547	61.117	57.923	61.196B
SM_3 Bed Sowing	70.037	62.163	59.373	63.858A
Means	65.424A	60.534B	57.092C	

Number of tillers (m^2):

The results indicated that the number of productive tillers per unit area was considerablyinfluenced by different tillage methods. Conventional tillage produce higher no of productive tillers per unit area (312.67) followed by reduce tillage (280.50) and zero tillage (239.29), respectively and statistically at par. As regard to sowing methods, bed sowing produce highest number of productive tillers per unit area (295.84) followed by ridge sowing (278.11) and flat sowing (258.50), respectively.

Table no. 1.6

Treatments	**T_1=Conventional tillage**	**T_2=Reduced tillage**	**T_3=Zero tillage**	**Means**

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SM_1 Flat Sowing	296.00	272.67	206.84	258.50C
SM_2 Ridge Sowing	310.33	278.50	245.50	278.11B
SM_3 Bed Sowing	331.67	290.33	265.53	295.84A
Means	312.67A	280.50B	239.29C	

Thousand grain weight:

The data pertaining thousand grain weights expressed in the table 4. Rigorous analysis of variance demonstrated that tillage and sowing methods had statistically greater effect on thousand grain weight. On the other hand, the interaction between tillage and sowing method was non-significant. Results showed that maximum 1000-grain weight was observed in conventional tillage which is 44.906 gm followed by reduced and zero tillage with an average grain weight of 41.329 and 37.101 gm respectively. maximum 1000-grain weight was observed in bed sowing method which is 42.514 gm followed by ridge and flat sowing with an average grain weight of 41.358 gm& 39.463 gm, respectively.

Table no. 1.7

Treatments	**T_1=Conventional tillage**	**T_2=Reduced tillage**	**T_3=Zero tillage**	**Means**
SM_1 Flat Sowing	43.300	40.253	34.337	39.463C
SM_2 Ridge Sowing	45.120	41.493	37.460	41.358B
SM_3 Bed Sowing	46.297	42.240	39.007	42.514A
Means	44.906A	41.329B	37.101C	

Grain yield:

Experimental data study for grain-output revealed that different tillage and sowing methods had a highly significant result taking place on grain output of wheat whereas the interactions between tillage and sowing method was non-significant as presented in table no. (4). The study also revealed that conventional tillage have higher grain output 5434 kg/ha followed by reduced and zero tillage with an average output of 5005.6 and 4415.9 kg/ha respectively.

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The additional aspect assessment of experimental data disclosed that the higher output was observed in Bed sowing that produced higher grain output 5137.4 kg/ha which is higher than ridge and flat sowing methods with an average output of 4944.5 and 4773.7 kg/ha, respectively.

Table no. 1.8

Treatments	**T_1=Conventional tillage**	**T_2=Reduced tillage**	**T_3=Zero tillage**	**Means**
SM_1 Flat Sowing	5308.9	4952.9	4159.2	4773.7C
SM_2 Ridge Sowing	5448.4	4967.1	4417.9	4944.5B
SM_3 Bed Sowing	5544.6	5196.9	4670.6	5137.4A
Means	5434.0A	5005.6B	4415.9C	

Biological yield

Results indicated that higher biological yield (14594 kg ha^{-1}) was found in conventional tillage whereas zero tillage exhibited the minimum yield (12116 kg ha^{-1}) as shown in (Table 4.16).

At the same time, bed sowing showed greater output (13773 kg ha^{-1}) in comparison to ridge and flat sowing, respectively. The results also illustrated that the minimum biological yield was recorded in flat sowing (12778 kg ha^{-1}). On the contrary, Interaction between tillage and sowing methods was non-significant.

Table no. 1.9

Treatments	**T_1=Conventional tillage**	**T_2=Reduced tillage**	**T_3=Zero tillage**	**Means**
SM_1 Flat Sowing	13753	12787	11794	12116C
SM_2 Ridge Sowing	14592	13100	12095	13262B
SM_3 Bed Sowing	15437	13420	12461	13773A
Means	14594A	13102B	12116C	

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Economic analysis:

According to the statistics of Punjab Government, the average cost of wheat production is fixed (74542 PKR ha^{-1}) for all the treatment which includes seed, fertilizers, water charges, labor and land rent. Variable cost that includes tillage operations and seedbed preparation is different for each treatment and listed below in table number. The gross income was calculated based on wheat grain and straw yield per hectare according to present market value. Benefit cost ratio is calculated by dividing gross income to total cost.

$$\text{BCR} = \frac{Gross\ income}{Total\ cost}$$

The data in table 4.19 illustrated a higher benefit cost ratio under the zero tillage. Moreover, results indicated that higher BCR was observed under zero tillage (3.23) followed by reduce (3.12) and conventional tillage (2.94), respectively. While in case of sowing methods maximum value of BCR was observed in bed sowing (3.20) followed by ridge (3.08) and flat sowing (3), respectively. These results in agreement with those of Chhokar*et al*. (2007) who found that the reduced expenditure on tillage provided additional profit of about Rs. 9516 ha^{-1} for zero tillage over other tillage practices.

Table no. 2 Economic analysis (Benefit cost ratio)

Treatments	**T_1=Conventional tillage**	**T_2=Reduced tillage**	**T_3=Zero tillage**	**Means**
SM_1 Flat Sowing	2.85	3.06	3.09	3
SM_2 Ridge Sowing	2.93	3.09	3.23	3.08
SM_3 Bed Sowing	3.03	3.20	3.38	3.20
Means	2.94	3.12	3.23	

Table No.2.1 Variable cost per hectare PKR

Treatments	**T_1=Conventional tillage**	**T_2=Reduced tillage**	**T_3=Zero tillage**
SM_1 Flat Sowing	**8304**	**4152**	**0**
SM_2 Ridge Sowing	**9539**	**4769**	**0**
SM_3 Bed Sowing	**9539**	**4769**	**0**

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Discussion:

The planting methods have significant impact on yield parameters of wheat including number of tillers, Number of spikelets per spike, number of grains per spike, thousand grain weight, grain yield and biological yield. The higher growth and yield was observed under bed sowing as a consequence of better soil health and lower weed density. A popular explanation of lower weed density in bed sowing is that the maximum weed seeds are present in upper layer of soil which could be buried to deeper depth during bed sowing consequently hampered the germination of weeds. The corresponding results were demonstrated by Mollah, et al. (2009) who has concluded that bed sowing of wheat has 30-40% lower weed infestation in comparison with the traditional flat sowing. Likewise, higher grain yield of wheat was recorded by Aggarwal&Gosswami, (2003) under bed sowing in comparison with flat and ridge sowing. Their results indicated that better crop establishment in bed sowing was due to the lower weed population and higher number of tillers.

On the other hand, grain yield under conventional tillage was found maximum due to the fact that conventional tillage loosen the soil and increase the porosity which has positive effect on root growth, water infiltration and air exchange. Moreover, soils under conventional tillage warm faster in comparison with the reduced or zero tillage. These findings were consistent with Machado, *et al*. (2008) who has indicated the greater potential of conventional tillage for better crop yield as compare to the other tillage practices. Furthermore, Sainju*et al.* (2006) obtained higher number of tillers, grain yield, thousand grain weight and biological yield in wheat under conventional tillage. These findings were also well documented by the Busscher*et al.* (2005).

On the contrary, Sharma, et al. (2002) reported the lower yield of wheat under conventional tillage resulting from less productive tillers and lower thousand grain weight. The results were in conformity with Beldar, et al. (2002) who has assessed the moisture stress, iron deficiency and rise in soil pH followed by conventional tillage system. The moisture stress at early establishment of crop may hampered the wheat yield. Additionally, deterioration of soil properties and salt accumulation was also observed by Yadvinder-Singh, et al. (2008) followed by lower yield of wheat.

The cost benefit ratio is important parameter in crop production system which determine the feasibility of input. Our results demonstrated the highest benefit cost ratio of zero tillage followed by reduce and conventional tillage. The results suggested that zero tillage practice in wheat not only save the input cost and turnaround around but also reduce the energy consumption and environmental pollution which leads to enhance farmer income. The similar conclusions were reached by Saharawat, et al. (2010) and Gathala, et al. (2011a,b). Furthermore, Sharma, et al. (2002) assessed that zero tillage practice not only saved that 59 liter of fuel per hectare but also conserve the time of approximately 8 hours per hectare by minimizing the tillage operations from seven to one.

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Conclusion:

It can be concluded that marginal return of wheat under zero tillage was higher in comparison to other tillage methods. Although, conventional tillage indicatedthe positive impact on grain yield of wheat but the overall profitability was lower due to the higher consumption of fuel and energy. The study also revealed that bed sowing of wheat has more advantage of better crop yield as compared to flat and ridge sowing. While interaction of sowing methods and tillage practices indicated no significant effect on crop yield. Hence a more systematic analysis is required to evaluate the influence of different tillage and sowing methods in to determine the most suitable method in accordance to the agro-ecological zone, crop production system and farmers circumstances.

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