COMPARISON OF MECHANICAL AND CHEMICAL WEED CONTROL IN WHEAT-MAIZE CROPPING SYSTEM

Subhan Uddin[1]* and Muhammad Amin

https://doi.org/10.28941/25-4(2019)-5

ABSTRACT

Different tillage practices and herbicides application could be operated and used to optimize spatial distribution, enhance plant growth and reduce weed infestation. Therefore, the two years (2017-18 and 2018-19) experiment entitled "Comparison of mechanical and chemical weed control in wheat-maize cropping system" was conducted at New Developmental Farm, The University of Agriculture, Peshawar, Pakistan. Different tillage practices (mould board plough followed by rotavator, disc harrow, rotavator and cultivator twice followed by planking) and herbicide application (Pre-emergence, Post-emergence and control) were used. The two years experiment (2017-18 and 2018-19) was set up according to the split-plot design with 4 replications. Tillage practices were assigned to the main plots while herbicide applications were kept into the sub-plots, within the main plots. The mean data revealed that different tillage practices significantly affected weed density, fresh weed biomass, dry weed biomass, and grain yield. The maximum values of above parameters were recorded in T4 (cultivator twice) for weed density, fresh weed biomass and dry weed biomass while for grain yield in T1 (Mould board plough followed by rotavator). Almost all parameters showed a decreasing trend with increasing the level of tillage practices. Similarly herbicides application also significantly affected weed density, fresh weed biomass, dry weed biomass, and grains yield. The maximum values of above parameters were recorded in H_o (control) followed by H_1(Pre-emergence herbicides) and H_2 (Post-emergence herbicides) Interaction between different tillage practices and herbicides application (TxH) revealed significant variation between different parameters. It is concluded that integration of mechanical and chemical strategy could be useful for reducing weed growth and improving the overall farm productivity and profitability of wheat-maize cropping system.

Keywords: Herbicides, wheat, *Triticum aestivum* L., tillage, weed management.

Citation: Subhan Uddin and Muhammad Amin. 2019. Comparison of mechanical and chemical weed control in wheat-maize cropping system. Pak. J. Weed Sci. Res., 24 (4): 303-313.

[1] Department of Agricultural Mechanization, The University of Agriculture, Peshawar, Pakistan.
* Corresponding Author's E-mail:drsubhan1986@gmail.com

INTRODUCTION

The world population is increasing day by day, creating serious threats to our food security and life standards in terms of survival. This can be overcome by enhancing the production of major crops such as wheat and maize. The increase in human population has the most detrimental effect on natural resources and fuelling the acceleration of all environmental problems. The rapid increase in the human population is responsible for land, water and atmosphere pollution. The land resources are depleting at a tremendously higher rate. The land use changes in the last century were dramatic and the same is to be expected for the next century as population increases and fuels the need for new livings and drives the importance of crop land to feed the world. Increasing population results in changing land use patterns as agricultural lands are converted to housing developments and industrial parks. Shallow soil, low fertility, steep slopes, aridity and stoniness are some of the factors which render the agricultural areas unsuitable for cultivation. Population pressure is another factor responsible for soil degradation. Land scarcity is the major limiting factor for crop production. Therefore, yield increase per unit area is the only option available for improving the quantity and quality of crops (Bhatti and Khan, 1996; Hackett and O'Donvan).

Wheat crop (*Triticum aestivum* L.) is a major cereal crop cultivated in the world as well as in Pakistan. It was grown on 9.224 million ha area of Pakistan with a production of 25.633 million tons with an average yield of 2779 kg ha^{-1} during 2015-16 (Pakistan Statistical Yearbook, 2016). In Khyber Pakhtunkhwa province this cereal crop recorded on average cultivated area of 0.725 million ha, which produced 1434 kg.ha^{-1} yield (CSKP, 2010-2011). It also contributes 14.4% to the value addition in agriculture and 03% to the GDP of Pakistan. Wheat crop production and its yield specifically are lower in Khyber Pakhtunkhwa as compared to national production mainly due to proportionately more cultivation on rainfed areas as compared to other provinces (Government of Pakistan, 2015). Maize (*Zea mays* L,); a cereal and forager crop of Poaceae family also plays an important role in Pakistan's economy. It is the third most grown crop worldwide and 4th largest cultivated crop in Pakistan after wheat, cotton, and rice. In Khyber Pakhtunkhwa Province, it is the second to wheat with respect to its importance (Arif *et al*., 2007). Maize was grown in Pakistan on an area of 1.191 million ha with a production 5.271 tons during 2015-16. Its average yield was 4426 kg ha^{-1}. As compared to the other countries, the yield of maize is very low due to non-adoption of modern agricultural technologies and shortage of basic resources (Govt. of Pakistan, 2015). Besides other factors, weed infestation is also one of the problems for maize crop that not only reduces its yield but also deteriorates the quality of grain. Weeds can reduce the yield of maize by up- to 25-80% or even complete destruction of crops may take place (Chikoye and Ekeleme, 2003).

Tillage practices play a key role in crop production. It improves the physical properties, and it enables the plants to present their ability to grow properly (Khattak *et al*.,2006). Soil tillage practices are used to provide better seedbed for root development and growth, weeds control, crop residue management, minimize soil erosion, level surface of the soil for proper planting, irrigation, drainage, and mixing organic matter in the soil (Temesgen *et al*., 2001). Different tillage operations have diverse effects on crop production (Usman *et al*., 2010). The un-suitable practices restrict the plant growth and development (Khattak *et al*.,2006)

The biotic factors like insects, diseases and weeds as well as the non-biotic factors including soil moisture, humidity, solar radiation and soil organic matter can affect the yield and growth of maize crop. Weed infestation is one of the serious problems which reduce the crop yields especially in Pakistan (Khan *et al.,* 2012). Weeds compete with the plants for moisture, solar radiation, light and other useful nutrients (Saeed *et al*., 2010). Yield losses in maize on average are about 40% on national level (Ali *et* *al*., 2011) while in Khyber Pakhtunkhwa,38% losses have been recorded (Hassan and Marwat, 2001). Marwat *et al*. (2011) is of the view that un-checked weeds in the field reduce the economic yield by up to 70%. The farmers in our country are mostly poor and they have very small land holding due to which, they don't consider weeds as a serious issue. They have livestock's at home so they preferably don't control the weeds in the initial stages because they are interested in the biomass of the weeds to feed their animals. As a result the farmers unknowingly increase the weed seed bank in the soil for crops other than the fodder crops.

To reduce the yield losses, various weed management techniques have been used such as chemical, mechanical, cultural and biological control. The cultural methods are still popular and useful but they are very costly, time consuming and laborious. Therefore, due to the limitations in cultural methods the judicious use of chemicals (herbicides) is one of the best way for controlling weeds that can give fast and cost effective control of many weeds infesting in maize crops (Chikoye *et al*., 2004; Khan *et al.*, 2002). The application of pre-emergence herbicides showed promising results interim of weed control at their early stages due to which crops nourish well (Sunitha *et al*., 2010). For better weed control, the current herbicides or some new herbicides like simazine, metolachlor, atrazine, acetochlor and pendimethalin can be used for better weed management (Donovan and Hackett, 2010). To overcome the food shortages the study was conducted to determine the comparison of mechanical and chemical weed control in wheat-maize cropping system in Peshawar, Pakistan. Hence, an experiment was conducted to assess the effect of different tillage methods on weed suppression and yield components of wheat-maize cropping system, to evaluate the efficacy of herbicides.

MATERIALS AND METHODS

Seedbed Preparation

All the experimental plots for the year 2017-18 and 2018-19 were irrigated one week before sowing of wheat crop. Seedbeds were ready and prepared, when these reached to the field capacity condition. Wheat variety 'Atta Habib' was planted by using a seed drill @100 kg ha^{-1}.

Field Experiments

The experiments were conducted to best compare the mechanical and chemical weed control in wheat-maize cropping system for two consecutive years (2017-18 and 2018-19 successively. Seedbeds were prepared when it is reached to its field capacity condition. Wheat variety 'Atta Habib' was planted by using seed drill at a R-R distance of 25cm as per standard.

Experimental Design

The experiments were set up according to the split-plot design with the following factors. Factor tillage practices were applied on main plots while herbicides were kept into the sub-plots.

Factor "A" Mechanical factor

1) T_1 = Mould board plough followed by rotavator
2) T_2 = Disc Harrow 2 times
3) T_3 = Rotavator 2 times
4) T4 = Cultivator 2 times followed by planking (As Control)

Factor "B" Chemical factor

1) H_1 = Pre-emergence herbicide
2) H_2 = Post-emergence herbicide
3) H_o = Control

Data Collection Procedures

The data were recorded on the following parameters.

Weed Density (No. m^{-2})

Weed density was calculated with help of 50cm×50 cm quadrate. Three times randomly the quadrate was thrown in each sub-plot and the weeds inside were counted, identified and recorded.

Fresh Weed Biomass (kg ha^{-1})

To determine the fresh biomass of weeds, all the existing weeds from the individual treatments were pulled out, weighed on an electronic balance in fresh condition. The reading taken was converted to kg ha^{-1} through the following formula:

$$\text{Fresh weed biomass (kg ha}^{-1}\text{)} = \frac{\text{Fresh weight of weeds (kg) in the plot}}{\text{Size of the plot (m}^2\text{)}} \times 10000$$

Dry Weed Biomass (kg ha^{-1})

For the above ground fresh weed biomass, completely dried biomass was weighed on an electric balance in dry condition. The readings obtained were divided by treatment size to get dry weed biomass in kg ha^{-1}.

Grain yield (kg ha^{-1})

The grain yield was recorded and calculated by threshing the grains from randomly selected cobs of the plants. The random selection was from the three central rows of the experimental plots. The grain collected was dried, weighted by using digital or electric and converted to kg ha^{-1} on the following formula:

$$\text{Grain yield in (kg ha}^{-1}) = \frac{\text{Grain yield in harvested area (kg)} \times 10{,}000}{\text{Harvested area (m}^2)}$$

RESULTS AND DISCUSSION

Weeds density (m^{-2})

Mean data of two consecutive years (2017-18 and 2018-19) revealed that different tillage practices and herbicides application had significant effect on weed density during wheat growing season. Maximum weed density (33.8) was recorded in plots receiving the application of cultivator twice, while minimum weed density (24.7) was observed in mould board plough followed by rotavator (Table-1 and Fig.1). Weeds compete for light, water; nutrients while tillage practices have significantly reduced weed density (Zorita, 2000). For the herbicides, maximum weed density (45.4) was recorded in control plots, while minimum (20.9%) in plots treated with post-emergence herbicide. The interactive effect of TxH, YxT and YxTxH showed a non-significant effect while YxH indicates a significant effect on weed density during wheat growing season. The higher doses of herbicides application in tillage systems were better in reducing weeds growth by Hand *et al*. (2002).

Fresh weed biomass (kg ha^{-1})

Mean data of two years (2017-18 and 2018-19) showed significant variation for fresh weed biomass. Different tillage practices, herbicide application and their interaction also revealed significance. Maximum fresh weed biomass (9.0 kg ha^{-1}) was recorded in cultivator twice followed by planking, while minimum (5.5 kg ha^{-1}) was observed in rotavator. Tillage decreases weeds as the lowest fresh biomass was observed as reported by Mehla *et al*. (2000). Regarding herbicide application, maximum fresh weed biomass (11.8 kg ha^{-1}) was noted in control plots, while minimum (5.7 kg ha^{-1}) was observed in pre-emergence herbicide. The interactive effect between TxH,YxH and TxYxH clearly showed a significant effect on fresh weed biomass while YxT revealed a non-significant results (Fig.2). Herbicides application reduces weed infestation and enhanced yield production [Hassan *et al*., 2005; Baghestani *et al*., 2007].

Table-1. Weed density m^{-2} as affected by different tillage practices and herbicides application during wheat growing season.

	Year		
Tillage	**2017-18**	**2018-19**	**2-years Mean**
MB Plough (T1)	27.2	22.2	24.7d
Disc Harrow (T2)	30.2	25.2	27.7c
Rotavator (T3)	33.3	28.3	30.8b
Cultivator(T4)	36.3	31.3	33.8a
LSD for Tillage	1.51	1.51	0.99
Herbicide			
Pre-Emergence (H1)	20.7	22.1	21.4b
Post-Emergence (H2)	26.6	15.2	20.9b
Control (H_o)	47.9	42.9	45.4a
LSD for Herbicide	2.417	1.880	1.491
Year			
2017-18			31.7
2018-19			26.7
Significance			***
Interaction	Significance	Interaction	Significance
Y x T	NS	Y x H	***
T x H	NS	Y x T x H	NS

Means followed by different letters of the various categories are significantly different at 5% level of probability by using least significant difference (LSD) test.

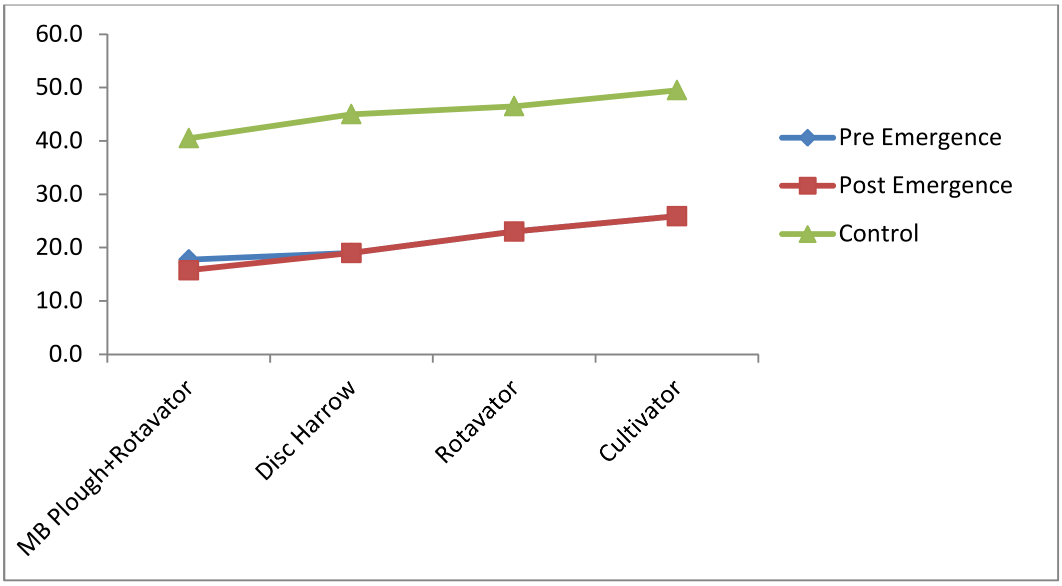

Fig.1 Weed density as affected by different tillage practices and herbicides application.

Table-2. Fresh weed biomass (kg ha^{-1}) as affected by different tillage practices and herbicide application during wheat growing season.

	Year		
Tillage	**2017-18**	**2018-19**	**2-years Mean**
MB Plough (T1)	6.9	7.0	7.0b
Disc Harrow (T2)	7.5	7.0	7.3b
Rotavator (T3)	5.2	5.8	5.5c
Cultivator(T4)	9.0	9.1	9.0a
LSD for Tillage	0.97	1.46	0.81
Herbicide			
Pre-Emergence (H1)	3.4	6.1	4.7b
Post-Emergence (H2)	6.4	3.7	5.1b
Control (H_o)	11.7	11.9	11.8a
LSD for Herbicide	0.555	0.679	0.427
Year			
2017-18			7.2
2018-19			7.2
Significance			NS
Interaction	Significance	Interaction	Significance
Y x T	NS	Y x H	***
T x H	***	Y x T x H	*

Means followed by different letters of the various categories are significantly different at 5% level of probability by using least significant difference (LSD) test.

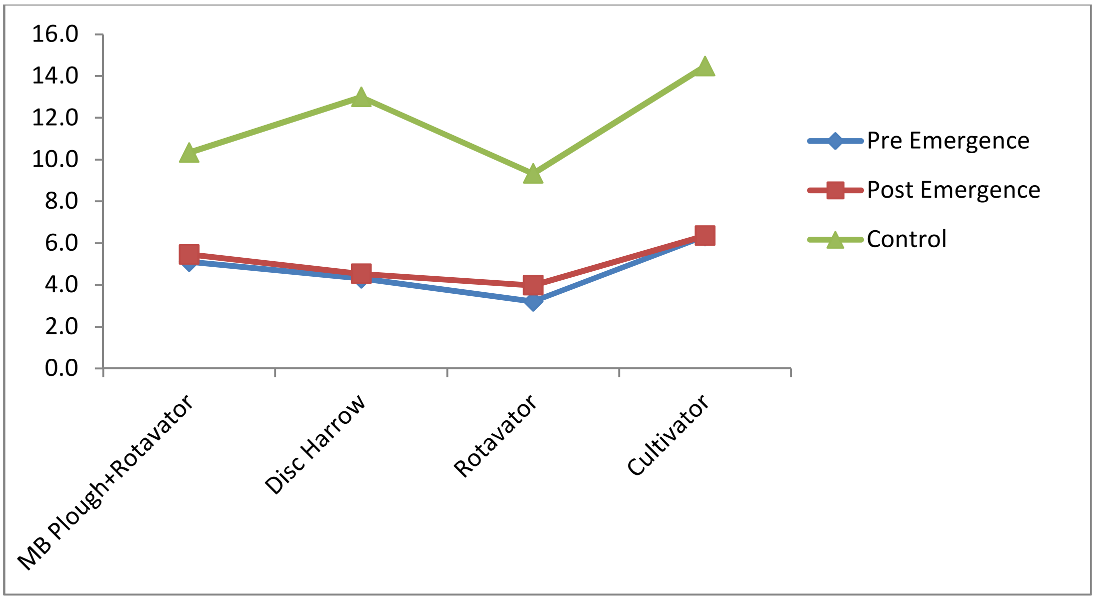

Fig.2. Fresh weed biomass as affected by different tillage practices and herbicides application

Dry weed biomass (kg ha^{-1})

Means data of two consecutive years (2017-18 and 2018-19) revealed that different tillage practices, herbicide application and interaction between TxH had significant effect on dry weed biomass (Table-3). Maximum dry weed biomass (4.4 kg ha^{-1}) was recorded in cultivator twice followed by planking while minimum (3.3kg ha^{-1}) in plot prepared by mould board plough followed by rotavator. Tillage practices used to decrease weed density as results lowest dry biomass observed (Mehla *et* *al*., 2000). Regarding herbicide application maximum dry weed biomass (5.6 kg ha^{-1}) was noted in control plots while minimum (2.2 kg ha^{-1}) in plot receiving the application of pre-emergence herbicide. The interactive effect of TxH, YxT, YxH and YxTxH clearly showed significant effect on dry weed biomass (Fig.30). Herbicides applicant can damage weeds growth and production (Hassan *et al*. 2005; Baghestani *et al.* 2007).

Table-3. Dry weed biomass (kg ha^{-1} as affected by different tillage practices and herbicide application during wheat growing season.

	Year		
Tillage	**2017-18**	**2018-19**	**2-years Mean**
MB Plough (T1)	3.8	2.8	3.3b
Disc Harrow (T2)	4.4	2.8	3.6b
Rotavator (T3)	2.8	2.3	2.6c
Cultivator(T4)	5.2	3.6	4.4a
LSD for Tillage	0.54	0.58	0.37
Herbicide			
Pre-Emergence (H1)	1.9	2.4	2.2b
Post-Emergence (H2)	3.7	1.5	2.6b
Control (H_o)	6.4	4.8	5.6a
LSD for Herbicide	0.298	0.272	0.196
Year			
2017-18			4.0
2018-19			2.9
Significance			***
Interaction	Significance	Interaction	Significance
Y x T	*	Y x H	***
T x H	***	Y x T x H	***

Means followed by different letters of the various categories are significantly different at 5% level of probability by using least significant difference (LSD) test.

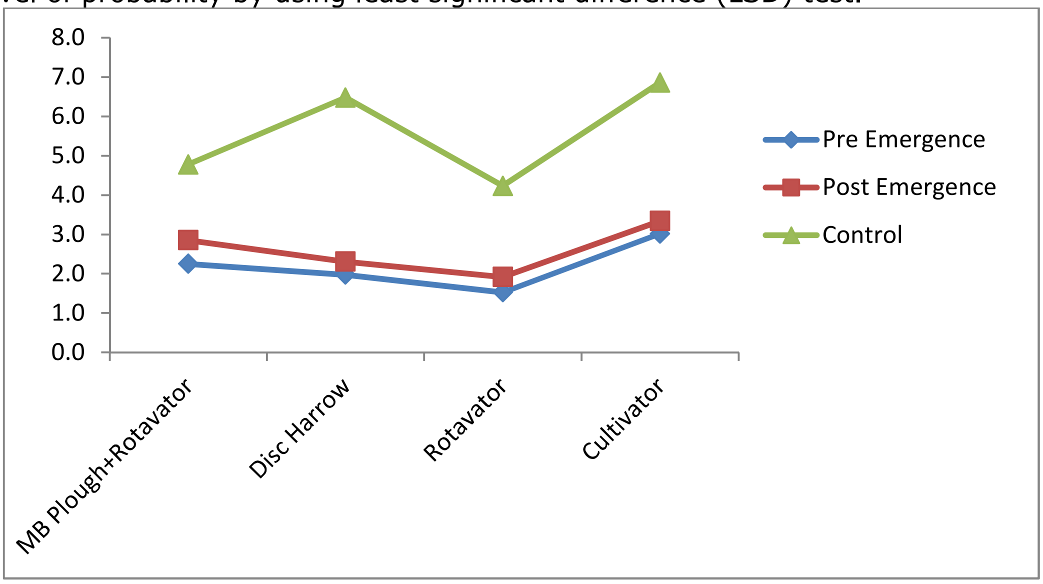

Fig.3 Dry weed biomass as affected by different tillage practices and herbicides application

Grain yield (kg ha^{-1})

The two consecutive years data (2017-18 and 2018-19) showed that different tillage implements, herbicides application and interaction between TxH had significant effect on grain yield (Table-4). Maximum grain yield (4381.4kg ha^{-1}) was harvested in the plot prepared by mould board plough followed by rotavator, while minimum (4152.5 kg ha^{-1}) yield was recorded in cultivator twice followed by planking. These results are supported by the findings of Imran *et al*.(2013), Gangwar *et al.* (2004) and Ali *et al.* (1982) who concluded that different tillage practices have increased the grain yield in their studies. Regarding herbicide applications, maximum grain yield (4434.1 kg ha^{-1}) was recorded in pre-emergence herbicide, while minimum (4064 kg ha^{-1}) was noted in control plots (Table-4). This might be due to the application of herbicide which reduced the population of weeds and enabled the crop uptake of more nutrients which enhanced the grain yield (Jamil *et al*., 2005). On the other hand, interaction effect between TxH showed a significance, while, YxT, YxH and YxTxH were non-significant statistically (Fig.4).

Table-4. Grain yield (kg ha^{-1}) as affected by different tillage practices and herbicide application during wheat growing season.

	Year		
Tillage	**2017-18**	**2018-19**	**2-years Mean**
MB Plough (T1)	4356.4	4406.4	4381.4a
Disc Harrow (T2)	4187.6	4237.6	4212.6b
Rotavator (T3)	4340.9	4390.9	4365.9a
Cultivator (T4)	4127.5	4177.5	4152.5b
LSD for Tillage	86.42	86.42	56.75
Herbicide			
Pre-Emergence (H1)	4409.1	4459.1	4434.1a
Post-Emergence (H2)	4311.3	4361.3	4336.3b
Control (H_o)	4039.0	4089.0	4064.0c
LSD for Herbicide	45.026707	45.026707	31.01701685
Year			
2017-18			4253.1
2018-19			4303.1
Significance			*
Interaction	Significance	Interaction	Significance
Y x T	NS	Y x H	NS
T x H	*	Y x T x H	NS

Means followed by different letters of the various categories are significantly different at 5% level of probability for herbicides by using least significant difference (LSD) test

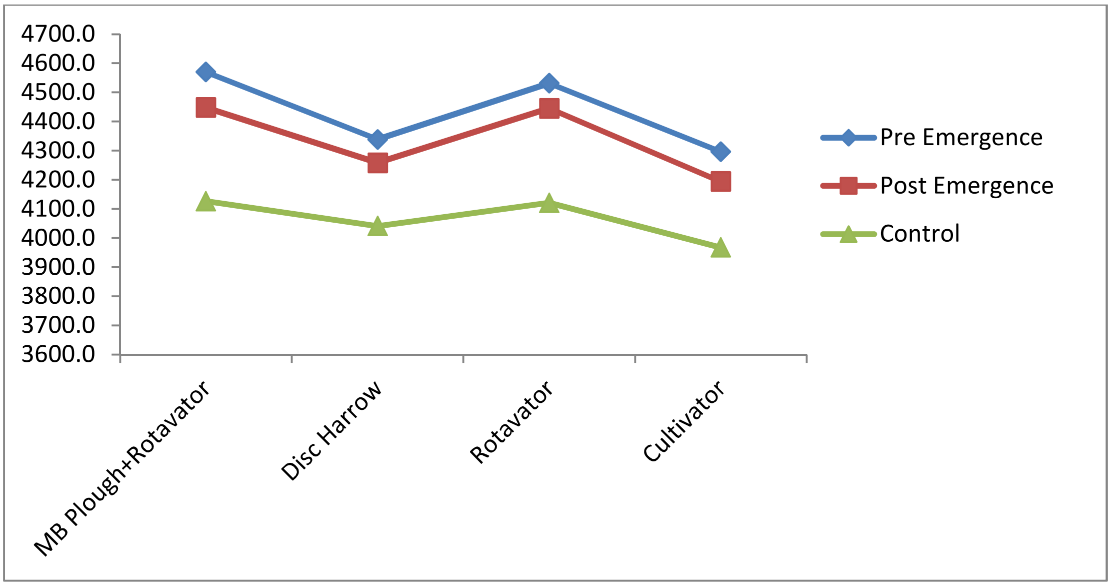

Fig.4. Grain yield as affected by different tillage practices and herbicide applications.

CONCLUSIONS

- It is concluded that mould board plough followed by rotavator have performed better in weed suppression and yield outcomes.
- Tillage practices had performed better in reducing the weeds and consequently enhanced grain yield and its components.
- Pre-emergence and post-emergence herbicides were found better in controlling the weed growth and improve the yield and yield components.

RECOMMENDATIONS

On the basis of conclusions it is recommended that:

- Mould board plough followed by rotavator with the application of pre and post-emergence herbicides could be recommended for optimum yield and yield components of wheat.

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