TO STUDY THE ECONOMIC ANALYSIS OF VARIOUS MECHANICAL AND CHEMICAL APPLICATIONS ON THE YIELD OF MAIZE CROP

Subhan Uddin[1*] and Mansoor Khan Khattak[1]

Department of Agricultural Mechanization and Renewable Energy Technologies, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa

ABSTRACT

The experiment on the economic analysis of mechanical and chemical applications on maize crop was conducted at the University of Agriculture, Peshawar in the year 2018 and 2019. During this experiment four levels of tillage practices (viz., mould board plough followed by rotavator, disc harrow twice, rotavator twice and cultivator twice followed by planking) and three levels of different herbicide applications (viz., pre-emergence, post emergence and control) were executed in split plot arrangement with RCB design. In this field crop experiment the tillage practices were allotted to main plots while the applications of different herbicides to sub plots within the main plots. The maximum net income of various tillage treatments and herbicide applications from maize crop was ranged from 86045.5–101008.5 Rs/ha. The highest net income of 101008.5 Rs/ha was generated from plots prepared by mould board plough while the lowest of 86045.5 Rs/ha was in control accordingly.Tillage by mould board plough and herbicide applications gave the maximum gross and net income approximately (Ranged from 26-31 % higher) as compared to shallow tillage practices. The deep tillage practices such as MB plough followed by rotavator and herbicides applications have to provide suitable soil environment, which ultimately affect the net income as compared to shallow tillage treatments. For obtaining maximum net income deep tillage implement such as mould board plough with the application of herbicides may be recommended for the farming community.

INTRODUCTION

Tillage practices particularly deep tillage affects the overall gross and net income while subsequently exert remarkable influence on maize yield. Tillage also affects the soil physical, chemical and biological properties of soil through its influence on soil properties and subsequently contributes up to 26-31% increase in net income and its production (Lal and Stewart, 2013). Different tillage practices, particularly the application of mould board plough is not an economic practice, while it also affecting the yield of major crops. The farming community of Khyber Pakhtunkhwa repeatedly every year adopting the conventional practices for crop yield and weed suppression which drastically reducing the yield by Khattak et al. *(*2006). Overall the application of tillage has been observed to improve the physical properties of soil by proving suitable condition for plants to grow and produce maximum net income (Khattak *et al*., 2006). These practices significantly affected the

weed growth, biomass and break the hard fan of soil as created from conventional tillage practices. Soil tillage practices provides, better seed environment, growth, development while reduces the number of weeds in all crops (Temesgen *et al*., 2001). During tillage practices deep tillage, was used for soil inversion, mixing up the crop residues and eradicates the weeds. The deep tillage practices such as mould board plough with the application rotavator , disc plough and chisel plough affects the soil physical properties (Khattak *et al*., 2006). Usman *et al*. (2010) evaluated that deep tillage practices have been noted significantly for boosting the crop production. However, the impact of various tillage tools changes the characteristics of the pores network in soil including the number, size, and distribution of pores which in turn control the ability of soil to store and diffuse air, water, and agricultural chemicals and, hence regulate erosion, runoff, and crop performance (Khan et al., 2001). Better to use the judicious applications of tillage practices for maximum revenue generation (Lal, 1993; Khattak *et al*., 2006). Extra ordinary uses of tillage and herbicides give rise to phenomena that are harmful to soil and crop yield. Yalcin *et al.* (2005) suggested that appropriate combination of tillage and herbicide application with recommended doses should be adopted to increase the crop production and net income of the farmer. Amin *et al*. (2014) reported that deep tillage gave substantially higher net income per hectare than shallow application of tillage. Best option of tillage application will be greater impact than normal tillage practices Khattak et al.(2006). This additional operation results in greater labor, fuel, repair and fixed costs. The net return was consistently greater for deep tillage than shallow tillage practices (Din et al., 2013a,b). Parsch *et al*. (2001) reported that total variable costs of production for shallow tillage practices were greater on average of (26345 Rs/ha) as compared to deep tillage practices of 24960 Rs/ha. On average, deep tillage resulted in higher net return above total cost of production than shallow tillage. Mean net return (3000 Rs/ha) was in deep tillage and more profitable than shallow tillage. In the light of above literature, the research study was conducted to study the economic analysis of mechanical and chemical application on the yield of maize crop and in order to choose the best tillage practice for land preparation of maize crop under irrigated area of clay loam soil. The most specific objectives of this study were:

1. To estimate the cost and net return of various tillage practices and herbicide applications on maize crop.
2. To determine the best and optimal tillage practices in terms of net return.
3. To find out the most effective and economical weed control measure individually for each crop.
4. To determine the economic analysis of treatments for the best optimal tillage practices and weed control method in terms of net return.
5. To draw implications and forward recommendations based on research findings.

MATERIALS & METHODS

Field experiment

The experiment was conducted to study the economic analysis of mechanical and chemical application on the yield of maize crop at the research farm of the University of Agriculture, Peshawar, Pakistan during 2018 and 2019.

Experimental design

The experiment was set up in a randomized complete block (RCB) design with split plot arrangements. Tillage practices of mechanical factor were kept in main plots while herbicide applications chemical factor in sub plots. The details of both factors were as follows:

Factor 01: Mechanical factor

T1 = Mould Board (MB) plough followed by rotavator

T2 = Disc Harrow 2 times

T3 = Rotavator 2 times

T4 = Cultivator twice followed by planking (as control)

Factor 02: Chemical factor

H1 = Pre-emergence

H2 = Post-emergence

Ho = Control plot

Experimental procedure

Seedbed was prepared prior to sowing, where mould board plough was applied one month before sowing, while the remaining tillage practices such as disc harrow, rotavator and cultivator were applied just before sowing. Herbicides were applied after sowing the crop. The field was irrigated prior to sowing the maize crop. After achieving the field capacity, maize variety Azam was planted.The plot size for individual treatment was kept, as 90 m x 3.5 m, and the recommended doses of fertilizers (Urea 250 kg/ha and DAP 125 kg/ha), irrigation and other inputs were applied uniformly to all the treatments.

Economic

For economic study, all production inputs within each year were recorded for different tillage practices and herbicide applications. Estimates of cost and returns were developed for each year experiment. During each year total specified expenses were calculated by using actual inputs for each

treatment of the experiment while included direct cost but excluded fixed such as land, farm overhead cost and other management cost. In this experiment the direct expenses included cost for seeds, fertilizer, labor, harvesting and threshing etc while fixed expenses included cost of lands, tractor implements, fertilizer broadcaster, seed drill, thresher, management and general farm overhead charges etc.

Different inputs and machinery cost were based on prices paid by the local farmer in each year such as renting of tractor, machinery, seed drill, purchase seeds and fertilizer. Prices for these inputs are given in Table 1. Expenses and income of each year experiment was calculated based on the average local market price (Table 1). Almost the yearly prices were used instead of average long-term prices, to reflect the effect of market forces on these prices. The net return of specified expenses was determined of each experiment on yearly basis. For economic study of different tillage practices and herbicides application the times taken to cover the area for all the practices were determined during the experiment. Each time more than three observations were made and their average were recorded. The variables cost per hectare for each tillage treatment was estimated and the results on the following aspects were calculated.

(a). Time required per hectare for each tillage treatment.

(b). Total cost of tillage practices for each treatment.

Table 1. Average variables inputs cost information by tillage practices and herbicide applications during maize 2018 and 2019

Variables Inputs	2018		2019		Average	
	Price @ Rs	Total Rs. ha^{-1}	Price @ Rs	Total Rs. ha^{-1}	Price @ Rs	Total Rs. ha^{-1}
i. Maize seeds rate: 30 kg. ha^{-1}	50 kg^{-1}	1500	55 kg^{-1}	1650	52.50 kg^{-1}	1575
ii. Urea 1st and 2nd dose: 250 kg. ha^{-1}	36 kg^{-1}	9000	37 kg^{-1}	9250	37 kg^{-1}	9125
iii. DAP dose:125 kg. ha^{-1}	80 kg^{-1}	10000	82 kg^{-1}	10250	81 kg^{-1}	10125
iv. Herbicides (Pre and post emergence) @5 L ha^{-1}	800 L^{-1}	4000	1000 L^{-1}	5000	900 L^{-1}	4500
iv. Labor cost: 50 labors ha^{-1}	600 day^{-1}	30000	700 day^{-1}	35000	650 day^{-1}	32500
v. Rented cost of tractor with various farm machinery operation costs	---------- Rs hr^{-1} ----------					

a). Cultivator two times	900	630	1000	733	950	681
b). Disk harrow two times	900	630	1000	733	950	681
c). Rotavator two times	1300	2448	1400	2637	1350	2543
d). Moldboard plow once	1200	2420	1300	2578	1250	2500
e). Seed drill	1500	1500	1700	1700	1600	1600
f). Maize sheller	1500	7500	1600	8000	1550	7750
g). Maize grain (Yield) Rs Kg^{-1}	36	--------	40	-------	38	--------
h). Stove (Yield) Rs Kg^{-1}	05	--------	06	--------	5.5	--------

Source: Survey in Peshawar Valley

RESULTS AND DISCUSSION

Maize Season 2018-19

Total Cost Estimates of Tillage Practices, herbicides plus Variable Inputs

The total cost estimate of different tillage practices, application of herbicides as well as variable inputs during both growing years of maize (2018 and 2019) are given in table 2. Mean lowest total cost of 63942.5 Rs. ha^{-1} were recorded in cultivator twice while the mean highest total cost of 69032.2 Rs. ha^{-1} was in mould board plough with rotavator. Similarly during herbicides plots the maximum 67625.4 Rs. ha^{-1} was noted in pre-emergence herbicides while the minimum 66475.4 Rs. ha^{-1} in control. Cost related to combine deep tillage & pre-emergence herbicide or post-emergence herbicide applications reflected surely to be more than shallow tillage & no-herbicide applications. The findings was same to Khattak et al. (2006), that the moldboard plows plus rotavator/ cultivator/disk Harrow including others inputs of (12,664 Rs. ha^{-1}) as compared to shallow tillage plus others inputs (12,115 Rs. ha^{-1}). Table 2. Total Cost estimates of tillage and herbicides application plus variable inputs of various tillage treatments during wheat growing seasons 2017-18 and 2018-19.

Table 2. Total Cost estimates of tillage, herbicide plus variable inputs of various treatments during maize growing seasons 2018 and 2019

	Year		
Tillage practices	**2018**	**2019**	**Average**
Mould board plough + Rotavator (T1)	65266.0	72798.3	69032.2a
Disc Harrow 2 times (T2)	64726.7	72129.3	68428.0b

Rotavator 2 times (T3)	63999.3	71131.7	67565.5c
Cultivator 2 times + planking(T4)	60736.0	67149.0	63942.5d
LSD for Tillage	102.30	5.04	47.56
Herbicide applications			
Pre-Emergence *(Dual Gold for wheat while Primextra Gold for maize)*	64032.0	71218.8	67625.4
Post-Emergence (*Selector for wheat while Reverse for maize*)	64032.0	71218.8	67625.4
Control *(No herbicides)*	62982.0	69968.8	66475.4
LSD for Herbicide	84.87	4.373	41.39
Year			
2017-18			63682.0
2018-19			70802.1
Significance			***

Interaction	Significance	Interaction	Significance
Y x T	***	Y x H	***
T x H	***	Y x T x H	***

Means followed by different letter(s) among combined treatments of tillage & herbicides as significantly different at 5% level of probability

Popp et al. (2001), observed that the total cost of production was impressive for deep method of tillage in comparison of shallow tillage practices. Heatherley and Sperlock (2001), who also studied that total expenditure, were in the range of 17460 and 19,620 Rs ha^{-1} for for both deep and shallow tillage respectively. In contrast, Parsch et al. (2001) that the maximum cost of production for shallow tillage system were greater on average of (26,345 Rs. ha^{-1}) as compared to deep tillage system of (24,960 Rs. ha^{-1}). Zentner et al. (2002) revealed that the total cost of wheat system using shallow farming versus deep farming methods is on average 18% higher (1320 Rs. ha^{-1} or more). Total cost of production for shallow tillage consistently of 13% higher than deep tillage for wheat crop management.

Grain yield (kg.ha^{-1})

Mean data obtained of grain yield as influence by the application of tillage practices and herbicide applications during two consecutive years (2018 and 2019) are shown in Table 3. The mean value showed that the effect of tillage practices, herbicide uses and their interaction was significant. Maximum (3434.3 kg.ha-1) yield of grain was reported in plots received the application of mould board plough while minimum (3181.9 kg.ha-1) grain yield was in cultivator twice followed by planking. With respect to herbicides treatments, maximum (3445.7 kg.ha-1) grain yield was observed in sub plots of pre-emergence while minimum (3146.1 kg ha-1) was obtained in the control treatments. Herbicide applications reduces the population of weeds and increases nutrients uptake in

crop which results in greater grain yield of the crop (Jamil et al., 2005). Moreover, the interaction between TxH was significant, while that of YxT, YxH and YxTxH were non-significant for grain yield of maize (Fig.3). Similar data was also presented by Ramzan et al. (2016) where tillage practices increased grain yield of maize. Same was reported by Imran et al. (2013), Din et al. (2013), Amin et al. (2013) where different tillage practices such as deep tillage implements was found better for increasing the crop outcomes.

Table 3. Grain yield (kg.ha^{-1}) as affected by different tillage practices and herbicide applications during maize growing season

	Year		
Tillage practices	**2018**	**2019**	**Average**
Mould board plough + Rotavator (T1)	3460.9	3407.7	3434.3a
Disc Harrow 2 times (T2)	3305.1	3225.1	3265.1c
Rotavator 2 times (T3)	3407.3	3327.3	3367.3b
Cultivator 2 times + planking(T4)	3190.0	3173.9	3181.9d
LSD for Tillage	64.09	70.66	44.30
Herbicide applications			
Pre-Emergence *(Dual Gold for wheat while Primextra Gold for maize)*	3471.2	3420.1	3445.7a
Post-Emergence (*Selector for wheat while Reverse for maize*)	3376.7	3312.6	3344.7b
Control *(No herbicides)*	3174.5	3117.6	3146.1c
LSD for Herbicide	23.9	36.6	21.2
Year			
2018			3340.8
2019			3283.5
Significance			***
Interaction	Significance	Interaction	Significance
Y x T	NS	Y x H	NS
T x H	***	Y x T x H	NS

Means in last column followed by different letter(s) within each category (i.e., tillage, herbicides, year) are significantly different at 5% level of of probability; * = Significant at 5% level of probability

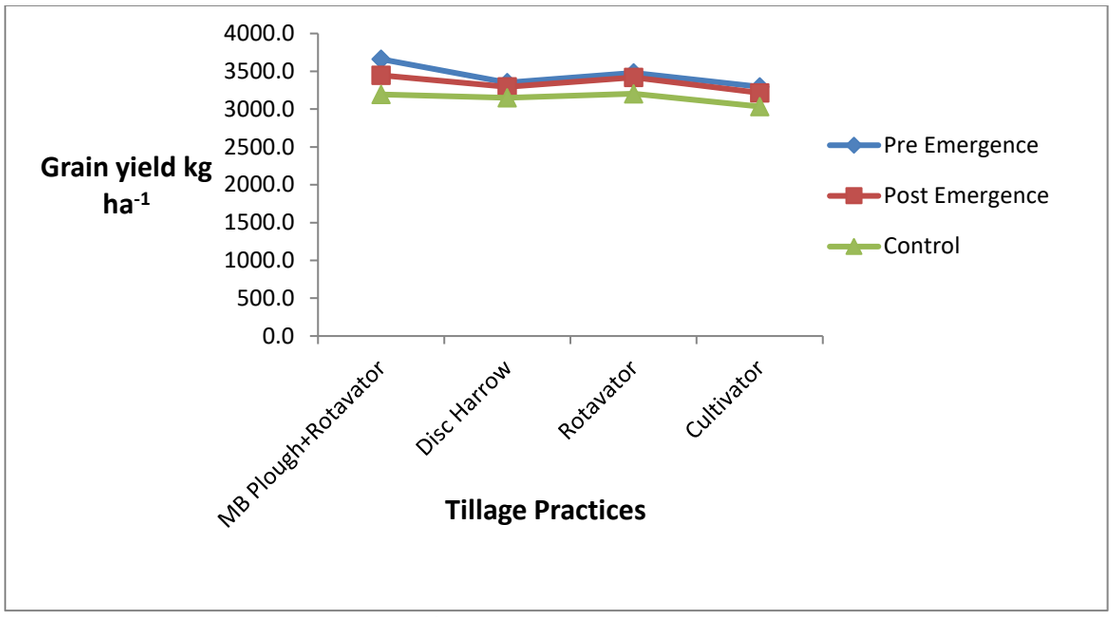

Figure 3. Grain yield (kg.ha^{-1}) of maize as affected by different tillage practices and herbicide applications

Total Gross Revenue of Tillage plus Herbicide Applications from maize yield and Straw Yield

The total gross revenue is shown in Table 4. Mean highest gross revenue of 170040.7 Rs ha^{-1} was found in those plots which were prepared by mould board plough while the lowest gross revenue of 153670.4 Rs ha^{-1} in cultivator twice respectively. Similarly during herbicides application the maximum 169961.0 Rs ha^{-1} gross revenue was reported in pre-emergence herbicide while the minimum in control.These results shown that tillage with applications of herbicide such as pre and post could increase the gross income of wheat crop. While in case of tillage with no application of herbicide either pre-emergence or post-emergence could not increase the gross income of wheat crop. It seems that both the applications i.e. tillage and herbicide could effectively control the weeds and ultimately it can provided sufficient moisture content and nutrients for the growth of wheat crop. Lucas et al.(2001) evaluated that deep tillage resulted in higher average revenue than shallow tillage for all cropping systems, with the exception of irrigated continuous cotton crop. Parsch et al. (2001), also reported on average, deep tillage system resulted in higher revenue above total cost of production than shallow tillage system. Popp et al. (2001), who found that the judicious uses of tillage reduced the financial risk while increase the gross revenue as compared to shallow tillage practices.

Table 4. Total gross revenue of tillage plus herbicides applications of various treatments from straw & yield of maize during growing season 2018 and 2019

	Year		
Tillage practices	**2018**	**2019**	**Average**
Mould board plough + Rotavator (T1)	160111.7	179969.7	170040.7a
Disc Harrow 2 times (T2)	151168.8	168826.4	159997.6c
Rotavator 2 times (T3)	156572.3	174983.4	165777.9b

Cultivator 2 times + planking(T4)	144262.1	163078.8	153670.4d
LSD for Tillage	2102.69	2273.80	1438.14
Herbicide applications			
Pre-Emergence *(Dual Gold for wheat while Primextra Gold for maize)*	160021.6	179900.5	169961.0a
Post-Emergence (*Selector for wheat while Reverse for maize*)	155240.4	174025.7	164633.0a
Control *(No herbicides)*	143824.2	161217.6	152520.9b
LSD for Herbicide	995.35	1435.67	850.94
Year			
2017-18			153028.7
2018-19			171714.6
Significance			***

Interaction	Significance	Interaction	Significance
Y x T	NS	Y x H	*
T x H	***	Y x T x H	NS

Means followed by different letter(s) among combined treatments of tillage & herbicides are significantly different at 5% level of probability.

Net income from maize Crop

Data pertaining to the net income of combine various tillage and herbicides applications treatments shown statistically significantly different on the net income of maize growing seasons (2018 and 2019) as depicted in Table 5. Mean highest net income of 101008.5 Rs ha^{-1} was found in mould board plough followed by rotavator while the lowest net income was 89727.9 Rs ha^{-1} in cultivator twice followed by planking.Similarly during herbicide applications the highest net income 102335.7 Rs ha^{-1} was reported in pre-emergence herbicides while the lowest 86045.5 Rs ha^{-1}in control (Table 5). These results shown that tillage with applications of pre-emergence or post-emergence herbicides could increase the net income of wheat crop. In case of tillage with no application of herbicide either pre-emergence or post-emergence could not increase the net income of wheat crop. It seems that by the combine applications of tillage and herbicides could effectively work for the control the weeds during wheat growing seasons. Consequently, it could provide save moisture content and nutrients availability wheat crop. These findings are in agreements of Lucas et al (2001), that deep tillage increase higher than shallow method. Parsch et al. (2001) also reported, that deep tillage system on average resulted higher net income above total cost of production than shallow tillage system. Popp et al. (2001), who found that in tillage implements the deep tillage was significant in increasing the net income. The finding of this research is fully in agreement with the Khattak et al. (2006), Zentner et al. (2002) and Leghari et al. (2017) that conventional tillage generally provided the highest net return than conservation tillage on all soil, however, the finding of Lafond, *et al.,* (1993) in contrast of the present study.

Table 5. Total net income of tillage plus herbicide applications of various treatments during maize growing season 2018 and 2019

	Year		
Tillage practices	**2018**	**2019**	**Average**
Mould board plough + Rotavator (T1)	94845.7	107171.3	101008.5a
Disc Harrow 2 times (T2)	86442.1	96697.1	91569.6c
Rotavator 2 times (T3)	92572.9	103851.8	98212.4b
Cultivator 2 times + planking(T4)	83526.1	95929.8	89727.9c
LSD for Tillage	2064.73	2270.78	1425.19
Herbicide applications			
Pre-Emergence *(Dual Gold for wheat while Primextra Gold for maize)*	95989.6	108681.7	102335.7a
Post-Emergence (*Selector for wheat while Reverse for maize*)	91208.4	102806.9	97007.6b
Control *(No herbicides)*	80842.2	91248.8	86045.5c
LSD for Herbicide	1002.6	1435.4	852.85
Year			
2017-18			89346.7
2018-19			100912.5
Significance			***
Interaction	Significance	Interaction	Significance
Y x T	NS	Y x H	*
T x H	***	Y x T x H	NS

Means followed by different letter(s) among combined treatments of tillage & herbicides are significantly different at 5% level of probability.

CONCLUSION AND RECOMMENDATIONS

Following conclusion are derived from the study:

- It is concluded that tillage practices particularly, the application of mould board plough followed by rotavator was found better in weed suppression and yield production.
- Herbicides uses at pre-emergence and post-emergence stages were found better in controlling the weed growth and improve the yield and yield components.
- The maximum net revenue of both wheat and maize crop were obtained from plots prepared by mould board plough followed by rotavator as well as treated with pre-emergence herbicide.
- Over all for maize crop the maximum of Rs. 101008.5 ha^{-1} net revenue was reported from plots of mould board plough followed by rotavator twice, and disc harrow with an amount of Rs.91569.6 ha^{-1}, rotavator twice Rs. 98212.4 ha^{-1} while minimum net return of Rs. 89727.9 ha^{-1} was noted from cultivator twice followed by planking.

- Tillage by mould board plough and herbicides application gave the maximum gross and net income approximately (Ranged from 26-31 % higher) as compared to shallow tillage practices.
- For obtaining maximum net come deep tillage implements such as mouldboard plough with the combination of rotavator should be used.
- For obtaining maximum net income deep tillage implement such as mould board plough with the application of herbicides may be recommended for the farming community.

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