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ECONOMIC EVALUATION OF WEED MANAGEMENT THROUGH TILLAGE, HERBICIDES AND HAND WEEDING IN IRRIGATED WHEAT

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ABSTRACT

Field experiment was conducted at Research Farm, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan during Rabi 2007-08 to evaluate the economic impact of different tillage depths and herbicides including hand weeding for controlling weeds in wheat. The experiment was laid out in randomized complete block design with split plot arrangement replicated four times. The treatments used were three tillage depth viz. shallow (5.5-7 cm), medium (10 cm) and deep tillage (20-25 cm) assigned to main plots, while five herbicides (2,4-D amine @ 1L ha^{-1}, Topik 15 WP @ 0.09 kg a.i ha^{-1}, 2,4-D + Topik (clodinafop), hand weeding thrice (20, 35 and 50 days after sowing) and untreated weedy check was assigned to subplots. Data were recorded on fresh weed biomass (FWB), dry weed biomass (DWB), tillers m^{-2}, wheat biomass (t ha^{-1}), harvest index (H.I %), cost of production, net benefit and benefit cost ratio (BCR). Deep tillage (DT) exhibited the best performance, with maximum tillers m^{-2} (276), maximum wheat biomass (12.2 t ha^{-1}), maximum net benefit (Rs.55526 ha^{-1}), and minimum FWB (37.1 g m^{-2}) and DWB (1.2 g m^{-2}) compared to shallow (ST) and medium tillage (MT). Hand weeding had the highest tillers m^{-2} (274), wheat biomass (12.9 t ha^{-1}), and net benefit (Rs.61563 ha^{-1}) compared to other herbicidal treatments. 2,4-D + Topik had the minimum FWB (3.8 g m^{-2}), minimum DWB (1.2 g m^{-2}), and maximum BCR (3.7:1). DT in combination with either hand weeding or mixture of 2,4-D + Topik was more economical despite higher cost of production compared to other tillage and herbicidal treatments.

Key words: Wheat, tillage, herbicides, weeds, net benefit, BCR

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the major food commodity in many nations of the world. Its demand will increase due to growing

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population of the world (Gupta *et al.* 2003). Our country has spared an area of 8.5 million ha for wheat production which needs further expansion or intensification of wheat production system (MINFAL, 2008). Despite continued efforts, wheat yield is low compared to major wheat producing countries in the world such as France, China and USA (Ozpinar, 2006). There are several factors involved in yield constraints but weed infestation is one of the important factors, which can reduce wheat yield severely if not properly attended. Weeds can reduce wheat yield by 50-80 % (Chhokar and Malik, 2002).

There are several ways to control weeds like cultural, chemical, biological and manual weeding. Each one has a significant role of its own; however, some of the control measures are out of reach of poor farmers in the developing countries. Excessive tillage and hand weeding can effectively control weeds but the recent energy crises and high labour cost in our country may affect the farmer interest and profitability of the farming in adopting physical weed control techniques. In developing countries, such as Pakistan herbicides are not widely utilized among the farming community due to small land holdings and low economic status (Khan *et al.* 2009). Use of herbicide is confined only to few crops in our country as herbicides easily control weeds and save time and energy. It is understood that farmers in the developing countries are more easily attracted towards a technology which is more productive and economical rather than its environmental consequences. The present study was therefore designed to make comparative cost and economic analysis of the different tillage methods, herbicides and hand weeding in irrigated wheat.

MATERIALS AND METHODS

Before sowing of experiment, pre-sowing irrigation was given and at proper moisture condition field was given 1 pass of cultivator (5.5-7 cm depth) followed by rotavator and seed drilling (Shallow tillage, ST). In medium tillage (MT) two passes of cultivator (10 cm depth) followed by rotavator and seeding machine while under deep tillage (DT) method 1, 2 and 2 passes of disc plough (20-25 cm depth), cultivator and rotavator were performed, respectively for field preparation. Tillage methods (ST, MT and DT) and five weed control treatments viz. 2,4-Dichlorophenoxyacetic acid (2,4-D amine) @ 1L ha^{-1}, Topik 15 WP @ 0.09 kg a.i ha^{-1}, 2,4-D + Topik, hand weeding thrice (at 20, 35 and 50 days after sowing) and untreated weedy check (control) were applied in randomized complete block design with split plots arrangement and four replications. Tillage was assigned to main plots, while herbicides were assigned to subplots. Wheat (*Triticum aestivum* L.) variety "Nasir-2k", was planted on November 4, 2007. A uniform seed rate of 120 kg ha^{-1} was used. The subplot size

was kept as 5 x 1.8 m^2 having 6 rows 5 m long and 30 cm apart. Recommended doses of fertilizers (120:60:30, NPK kg ha^{-1}) and 5 irrigations with one month interval were used. Data were recorded on fresh weed biomass (FWB) (g m^{-2}), dry weed biomass (DWB) (g m^{-2}), tillers m^{-2}, wheat biomass (kg ha^{-1}), harvest index (%), cost of production, net benefit (Rs. ha^{-1}), and benefit cost ratio (BCR). Data were analyzed using analysis of variance techniques and least significant difference test was applied when results were found significant for comparison among the treatment means (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Fresh weed biomass (g m^{-2})

The weed species infesting the experimental field were *Phalaris minor*, *Rumex dentatus*, *Chenopodium album*, *Cynodon dactylon*, *Medicago denticulata*, *Melilotus indica*, *Malva parviflora*, *Lathyrus aphaca*, *Convolvulus arvensis* and *Cyperus rotandus*. Statistical analysis of the data showed that fresh weed biomass (g m^{-2}) was significantly affected by tillage (T), herbicides (H) and T x H interaction (Table-1). Means indicated that fresh weed biomass (FWB) was highest (76.0 g m^{-2}) in shallow tillage (ST) compared to FWB in deep tillage (DT) and medium tillage (MT) i.e. 37.1 and 62.1 g m^{-2}, respectively. The lowest FWB (3.8 g m^{-2}) was recorded in 2,4-D + Topik as compared to other herbicides. DT performed better in combination with 2,4-D + Topik by reducing FWB compared to ST and MT. In a similar study Marwat *et al.* (2007) reported that tillage was effective in controlling weeds and increasing grain yield as compared to shallow tillage and weedy check.

Table-1. Effect of tillage and herbicides on fresh weed biomass (g m^{-2})

Herbicides	Tillage			Means
	Shallow tillage	Medium tillage	Deep tillage	
2, 4-D	56.9	18.0	25.1	33.3
Topik	132.8	133.2	25.2	97.0
2, 4-D + Topik	3.0	8.2	0.4	3.8
Hand weeding	4.1	4.9	15.1	8.0
Control	183.2	146.2	119.8	149.7
Means	76.0	62.1	37.1	

$LSD_{0.05}$ for T =0.15 , H = 0.2, T x H = 0.34

Means followed by common letters or no letters are not significantly different at α = 0.05 (This definition will apply to all other data tables).

Dry weed biomass (g)

Dry weed biomass (DWB) was significantly affected by tillage, herbicide and tillage x herbicide interaction (Table-2). Mean data revealed that maximum dry weed biomass (16.2 g m^{-2}) was recorded in ST, while minimum DWB (7.6 g m^{-2}) was recorded in DT. Among herbicidal treatments, maximum DWB (28.7 g m^{-2}) was recorded in control (weedy check), while minimum DWB (1.2 g m^{-2}) was recorded in 2,4-D + Topik (Khan *et al.* 2003; Om *et al.* 2004). In interaction of T x H, all herbicides were more effective under DT compared to ST and MT. However, minimum DWB (0.3 g m^{-2}) was recorded with 2,4-D + Topik in DT. Hand weeding was the next higher control measure against weeds irrespective of the tillage depth (Reddy *et al.* 2003). As weed biomass is an important factor that should be given prime importance in evaluating the weed control methods therefore the effectiveness of tillage and herbicides should be incorporated in an integrated weed management packages.

Table-2. Effect of tillage and herbicides on dry weed biomass (g m^{-2})

Herbicides	Tillage			Means
	Shallow tillage	Medium tillage	Deep tillage	
2, 4-D	15.1	5.9	6.3	9.1
Topik	26.2	23.8	9.1	19.7
2, 4-D+Topik	1.2	2.2	0.3	1.2
Hand weeding	0.9	0.9	3.8	1.8
Control	37.5	29.8	18.9	28.7
Means	16.2	12.5	7.6	

$LSD_{0.05}$ for T = 0.13 , H =0.34 , T x H = 0.6

Number of tillers m^{-2}

Statistical analysis of the data revealed that number of tillers m^{-2} was significantly affected by T, H, and T x H interaction (Table-3). Comparison of the tillage treatments reflected highest number of tillers m^{-2} (276) in DT. Minimum tillers m^{-2} (241) were recorded in control, while maximum tillers (274) were recorded in hand weeded plots followed by 2,4-D + Topik (273). T x H interaction showed higher tillers under DT almost in all weed control methods, however, maximum tillers m^{-2} (287) was achieved when 2,4-D + Topik was used. This indicates that DT in combination with 2,4-D + Topik considerably controlled weeds and diverted competition in favour of crop plants, which resulted in higher number of tillers m^{-2} (Cheema and Akhtar, 2005; Khan *et al.* 2005).

Table-3. Effect of tillage and herbicides on wheat tillers m^{-2}

Herbicides	Tillage			Means
	Shallow tillage	Medium tillage	Deep tillage	
2, 4-D	242	247	282	257
Topik	252	262	282	265
2, 4-D+Topik	262	272	287	273
Hand weeding	267	272	284	274
Control	232	244	248	241
Means	251	259	276	

$LSD_{0.05}$ for T =0.101, H =0.11, T x H =0.2

Wheat biomass (t ha^{-1})

Statistical analysis of the data showed that wheat biomass (t ha^{-1}) was significantly affected by T and H, while T x H interaction was non-significant (Table-4). Maximum wheat biomass (12.2 t ha^{-1}) was obtained from DT, while minimum wheat biomass (10.7 t ha^{-1}) was obtained from ST. Hand weeding and 2,4-D + Topik gave statistically similar biomass, while control showed lowest wheat biomass (9.0 t ha^{-1}). Khan *et al.* (2005) obtained similar findings and reported that hand weeding and broad spectrum herbicide produced maximum wheat biomass. The highest wheat biomass under DT, hand weeding and 2,4-D + Topik treated plots may be attributed to highest weed control efficiency and allocation of resources to wheat which ultimately enhanced wheat biomass (Singh *et al.* 2001).

Table-4. Effect of tillage and herbicides on wheat biomass (t ha^{-1})

Herbicides	Tillage			Means
	Shallow tillage	Medium tillage	Deep tillage	
2, 4-D	10.7	11.2	12.1	11.3
Topik	10.2	10.7	11.7	10.8
2, 4-D+Topik	12.2	12.7	13.7	12.8
Hand weeding	12.1	12.7	14.0	12.9
Control	8.3	9.1	9.7	9.0
Means	10.7	11.3	12.2	

$LSD_{0.05}$ for T = 0.22 , H = 0.2, T x H = NS

Harvest index

Harvest index (H.I %) was significantly affected by H and T x H interaction, while T did not influence it significantly (Table-5). Maximum H.I (28.3 %) was recorded in plots treated with Topik followed by hand weeding plots (27.6 %). In T x H interaction,

maximum H.I was recorded in MT x Topik followed by MT x hand weeding. The higher H.I with Topik treated plots may be due to effective killing of grassy weeds like *Phalaris minor*, with high density in the experimental field. However, DT was superior regarding H.I % than either of tillage when no herbicide was applied. The higher H.I in plots treated with Topik or hand weeding may be attributed to higher grain yield in these plots as reported by Tunio *et al.* (2004).

Table-5. Effect of tillage and herbicides on wheat H.I %

Herbicides	Tillage			Means
	Shallow tillage	Medium tillage	Deep tillage	
2, 4-D	24.1	24.0	24.4	24.2
Topik	28.2	29.3	27.4	28.3
2, 4-D+Topik	25.3	25.0	25.4	25.2
Hand weeding	27.1	28.5	27.0	27.6
Control	26.8	26.0	28.2	27.0
Means	26.3	26.6	26.5	

$LSD_{0.05}$ for T =NS, H =0.3, T x H = 0.5

Cost of production

The data in Table-6 shows detail of cost of production calculated for each treatment. It includes cost of seed, land preparation/cultivation, fertilizer, labor for hand weeding, herbicides, harvesting and threshing charges. The data clearly indicate higher cost of production for deep tillage and hand weeding over all other treatments used in the study. However, higher economic return from DT x hand weeding compensated for higher cost of production incurred over it (Table-7). Hand weeding is practically labour intensive and impossible for the farmers having large areas. Therefore hand weeding might be of interest and economical for the farmers having small farms.

Net benefit (Rs ha^{-1})

Net benefit was significantly affected by T, H and T x H interaction (Table-7). Maximum net benefit (Rs.55,526 ha^{-1}) was recorded in DT, while minimum net benefit (Rs.49,401 ha^{-1}) was recorded in ST. The increase in net benefit was in accordance to the tillage depth. The higher the tillage, the higher the net benefit and *vice versa*. Mean values for herbicides showed that highest net benefit (Rs.61,563 ha^{-1}) was obtained from hand weeding plots followed by 2,4-D + Topik treated plots (Rs.58,950 ha^{-1}).

Table-6. Break-up of total cost of production (Rs/ha) for crop season 2007-08.

Treatments		Cost (Rs. ha^{-1})							
Tillage	**Herbicides**	**Seed**	**Ploughings**	**Irrigation water**	**Fertilizer**	**Herbicides**	**Harvesting**	**Threshing**	**Total cost ha^{-1}**
ST	H1*	2400	1000	1000	9911.9	405	3000	2000	19716.9
	H2	2400	1000	1000	9911.9	875	3000	2000	20186.9
	H3	2400	1000	1000	9911.9	1280	3000	2000	20591.9
	H4	2400	1000	1000	9911.9	4500	3000	2000	23811.9
	H5	2400	1000	1000	9911.9	-	3000	2000	19311.9
MT	H1	2400	2000	1000	9911.9	405	3000	2000	20716.9
	H2	2400	2000	1000	9911.9	875	3000	2000	21186.9
	H3	2400	2000	1000	9911.9	1280	3000	2000	21591.9
	H4	2400	2000	1000	9911.9	4500	3000	2000	24811.9
	H5	2400	2000	1000	9911.9	-	3000	2000	20311.9
DT	H1	2400	4500	1000	9911.9	405	3000	2000	23216.9
	H2	2400	4500	1000	9911.9	875	3000	2000	23686.9
	H3	2400	4500	1000	9911.9	1280	3000	2000	24091.9
	H4	2400	4500	1000	9911.9	4500	3000	2000	27311.9
	H5	2400	4500	1000	9911.9	-	3000	2000	22811.9

*H1= 2,4-D, H2= Topik, H3=2,4-D + Topik, H4= hand weeding, H5= control

Net benefit was the lowest in control plot (Rs.41,480 ha^{-1}) compared to other treatments. In T x H interaction, DT was almost superior to ST and MT at all weed control treatments, however, with hand weeding it showed highest net benefit of Rs.61,563 ha^{-1} followed by Rs. 58,950 ha^{-1} with 2,4-D + Topik. Cheema *et al.* (2006) communicated similar findings and reported that plots treated with herbicides recorded higher net benefit over weedy check due to effective weed control and ultimately higher yield.

Table-7. Effect of tillage and herbicides on wheat net benefit (Rs.).

Herbicides	Tillage			Means
	Shallow tillage	Medium tillage	Deep tillage	
2, 4-D	44658	46158	51158	47325
Topik	49188	53188	52563	51646
2, 4-D+Topik	56283	57783	62783	58950
Hand weeding	58063	62063	64563	61563
Control	38813	39063	46563	41480
Means	49401	51651	55526	

$LSD_{0.05}$ for T =720.9 , H=859, T x H= 1488

Benefit cost ratio (BCR)

Statistical analysis of the data revealed that BCR was significantly affected by T, H, and T x H interaction (Table-8). Maximum BCR (3.4:1) was recorded in ST, which was statistically at par with MT (3.4:1), while minimum BCR (3.3:1) was recorded in DT. The lower BCR under DT could be due to higher cost of cultivation compared to ST and MT. Mean values for herbicides showed highest BCR (3.7:1) with 2,4-D + Topik treated plots, while minimum BCR (3.0:1) was recorded in control (Cheema *et al.* 2006; Reddy *et al.* 2003). In T x H interaction, maximum BCR (3.7:1) was recorded with 2,4-D + Topik in ST, which was statistically similar to MT (3.7:1). ST and MT were almost superior to DT regarding higher BCR at each level of weed control treatments, however, DT gave higher BCR in control plots. In a study Waheedullah *et al.* (2008) reported that herbicide application was economical as compared to hand weeding.

Table-8. Effect of tillage and herbicides on wheat BCR.

Herbicides	Tillage			Means
	Shallow tillage	Medium tillage	Deep tillage	
2, 4-D	3.3	3.2	3.2	3.2
Topik	3.4	3.5	3.3	3.4
2, 4-D+Topik	3.7	3.7	3.6	3.7
Hand weeding	3.5	3.5	3.4	3.4
Control	3.0	2.9	3.1	3.0
Means	3.4	3.4	3.3	

$LSD_{0.05}$ for T = 0.1, H=0.1, T x H= 0.1

CONCLUSION

Deep tillage performed better possessing maximum tillers m^{-2} (276), maximum wheat biomass (12.2 t ha^{-1}), maximum net benefit (Rs.55526 ha^{-1}), and minimum FWB (37.1 g m^{-2}) and DWB (1.2 g m^{-2}) compared to shallow (ST) and medium tillage (MT). Hand weeding had the highest tillers m^{-2} (274), wheat biomass (12.9 t ha^{-1}), and net benefit (Rs.61563 ha^{-1}) compared to other herbicidal treatments. 2,4-D + Topik had the minimum FWB (3.8 g m^{-2}), minimum DWB (1.2 g m^{-2}), and maximum BCR (3.7:1). DT in conjunction with either hand weeding or mixture of 2,4-D + Topik was more economical compared to other tillage and herbicidal treatments.

REFERENCES CITED

Cheema, M. S. and M. Akhtar. 2005. Efficacy of different post emergence herbicides and their application methods in controlling weeds in wheat. Pak. J. Weed Sci. Res. 11(1-2): 23-30.

Cheema, M. S., M. Akhtar and M.S. Iqbal. 2006. Performance of different herbicides in wheat under irrigated conditions of southern Punjab, Pakistan. Pak. J Weed Sci. Res. 12(1-2): 53-59.

Chhokar, R.S. and R.K Malik. 2002. Isoproturon resistant *Phalaris minor* and its response to alternate herbicides. Weed Tech. 16: 116–123.

Gupta, R.K., R.K. Naresh, P.R. Hobbs, J. Jiaguo and J.K. Ladha. 2003. Sustainability of post-green revolution agriculture: the rice–wheat cropping systems of the Indo-Gangetic Plains and China. *In* J.K., Ladha, J. Hill, R.K. Gupta, J. Duxbury and R.J. Buresh

(Eds.), Improving the productivity and sustainability of rice–wheat systems: Issues and Impact. ASA Special Publication 65. ASA, Madison, WI, USA. 1: 1–25.

Khan, M.A., R.E. Blackshaw and K.B. Marwat. 2009. Biology of Milk thistle and management options for growers in northwest Pakistan. Weed Biol. Manag. 9(2): 99-105.

Khan, A., M. Ilyas and T. Hussain. 2005. Response of wheat to herbicides application and hand weeding under irrigated and non-irrigated conditions. Pak. J Weed Sci. Res. 11(1-2): 1-9.

Khan, M.H., G. Hassan, N. Khan and M.A. Khan. 2003. Efficacy of different herbicides for controlling broadleaf weeds in wheat. Asian J. Plant Sci. 2(3): 254-256.

Marwat, K.B., M. Arif and M. A. Khan. 2007. Effect of tillage and Zn application methods on weeds and yield of maize. Pak. J. Bot. 39(5): 1583-1591.

MINFAL. 2008. Agricultural Statistics of Pakistan. Govt. of Pakistan, Ministry of Food, Agriculture and Livestock, Economic Wing, Islamabad.

Om, H., S. Kumar and S.D. Dhiman. 2004. Biology and management of *Phalaris minor* in rice–wheat system. Crop Prot. 23: 1157–1168.

Ozpinar, S. 2006. Effects of tillage systems on weed population and economics for winter wheat production under the Mediterranean dry land conditions. Soil Till. Res. 87: 1–8.

Reddy, B.V.S., P. S. Reddy, F. Bidinger and M. Blummel. 2003. Crop management factors influencing yield and quality of crop residues. Field Crops Res. 84: 57–77.

Singh, S., S.N. Sharma and R. Prasad. 2001. The effect of seeding and tillage methods on productivity of rice–wheat cropping system. Soil Till. Res. 61: 125–131.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw Hill Book Co. Inc., New York.

Tunio, S.D., S.N. Kaka and A.D. Jawar. 2004. Effect of integrated weed management practices on wheat yield. Pak. J. Agric. Engg. Vet. Sci. 20(1): 5-10.

Waheedullah, M. A. Khan, S. Arifullah and M. Sadiq. 2008. Evaluation of Integrated weed management practices for maize (*Zea mays* L.). Pak. J. Weed Sci. Res. 14(1-2): 19-32.