Relative Influence of Tillage, Fertilizer, and Weed Management on Weed Associations in Wheat Cropping Systems of Ethiopian Highlands

Kassahun Zewdie[1] and Rungsit Suwanketnikom[2]

ABSTRACT

Field experiment was conducted at Ambo Plant Protection Research Center of western Ethiopia during 2002 and 2003 to determine the combined effects of tillage, fertilizer and weed management on weed population dynamics in bread wheat (*Triticum aestivum* L.) field. The results indicated that tillage, fertilizer and weed management systems had a significant effect on weed population dynamics. The total amount of weed density tended to increase in no tillage than conventional tillage or moldboard plow in both years. The magnitude change was ranged from two to four folds when comparing densities in no tillage with others. Among the dominant weeds *Polygonum nepalense, Sonchus arvensis, Galinsoga parviflora, Plantago lanceolata, Setaria* spp., *Echinocloa colona*. and *Phalaris paradoxa*, were significantly reduced in density by moldboard plowing relative to other tillage systems. Tillage had a significant effect on yield in both 2002 and 2003 cropping season. Tank mixture of fenoxaprop-P-ethyl and fluroxypyr +MCPA resulted in a significant reduction of total weed number and increased wheat yield by 40% followed by hand weeding twice. Application of fertilizer increased total broad leaf and grass weed biomass significantly. Fertilizer is more important than tillage in affecting yields and yield components. It improved grain yield up to 48% over the untreated control in both years. Weeding without fertilizer did not affect grain yield. Weeding and fertilizer significantly increased grain yield. The interactions between tillage and fertilizer for total broad leaf weed biomass, grass and broad leaf weed densities were significant. Fertilizer and weed management interaction affects total broad leaf weed density. As far as plant height, grain yield and 1000-kernel weight of wheat are concerned tillage by fertilizer interaction was significant.

Key words: tillage, weed management, fertilizer, wheat, *Triticum aestivum* L.

INTRODUCTION

Weeds are a significant threat to wheat (*Triticum aestivum* L.) production in Ethiopia, causing a tremendous yield loss of up to 70% in some wheat growing areas (Kassahun and Tanner, 1998). Globally, under heavy weed competition, wheat yields can be reduced by 50% and sometimes depressed to zero (Hanson *et al*., 1982).

Currently weed control is one of the basic production problems faced by wheat producers in the western parts of the country. Farmers in the major wheat producing agro-ecologies of Ethiopia recognize weed competition as one of the principal constraints to bread wheat production both in the peasant and state farm sectors (Kassahun and

[1] Ethiopian Agriculture Research Organization, Holetta Agriculture Research Center, P.O. Box 2003, Addis Abeba, Ethiopia.
[2] Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

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Tanner, 1998). Responses by the farmers to weed infestation cover different approaches, including hand weeding, although it is highly demanding for time and labor. Some researchers have mentioned the use of herbicides also influence on seed number and species composition of the seed bank such that depending on the herbicide under use while certain species in the seed bank decrease others may increase (Robert and Neilson, 1981).

Changes in tillage practices can affect weed population dynamics, including weed seed distribution and abundance in the soil (Mulugeta and Stoltenberg, 1997). Concerns about specific weed shifts and associated crop yield losses, however, have restricted the wide spread adoption of this technology (Buhler *et al*., 1994). Shifts toward grass, perennial, wind disseminated weeds, and volunteer crops have been observed in conservation tillage systems. Conservation tillage practices that reduce soil disturbance affect weed community dynamics and crop weed interference.

Several experiments have revealed that nitrogen fertilizer has a positive influence on weed emergence and growth (Fawcett and Slife, 1978; Amanuel and Tanner, 1991; Peterson and Nalewaja, 1992). Other than tillage, fertilizers and herbicides continue to be important management inputs in annual crop production systems. Fertilizers can increase weed density and biomass (Carlson and Hill, 1986). Nitrogen fertilizer was found to increase the development and growth of nitrophilous species such as common lambs quarters (Haas and Streibig, 1992). Moreover, addition of fertilizer can also lead to an overall depletion of the weed seed bank because fertilizers containing nitrates or nitrites can stimulate the germination of dormant seeds (Egley, 1986).

The principal objective of this study was, therefore, to determine the combined effects of tillage intensity, fertilizer and weed management practices on weed population dynamics in bread wheat production system of the western high lands of Ethiopia.

MATERIALS AND METHODS

The field experiments were conducted in 2002 and 2003 at the Ambo (08° 55’ N, 37° 52’ E, 2225 meter above sea level), 125 km west of Addis Ababa in the plant Protection Research Center of the Ethiopian Agricultural Research Organization (EARO). The soil type was black clay vertisol with a pH 7.09 and organic matter content of 1.48 %. The average monthly mean minimum temperatures during the crop-growing season are 11.5°C and the corresponding average monthly mean maximum temperatures are 23.8°C, with total annual rainfall 563.9 mm. The experimental site had been under conventional management practices of plowing, disking and harrowing for many years.

The experiments were arranged as a split-split plot in a Randomized Complete Block Design with three replications. While the tillage treatments were assigned to the main plot of 69.5 by 40.5 square meters, the fertilizer treatments as the sub plot of 21 by 4 square meters and the weed management treatments as the sub-sub plots of 4 by 4 square meters. The treatments included 45 combinations of three tillage-systems including no-tillage, conventional tillage or oxen plow and moldboard plow, three fertilizer levels including 0-0, 69-60 kg/ha basal application and 69-60 kg/ha split application of N-P_2O_5 and the five weed managements including cultural and chemical weed control treatments that included three post emergence herbicides fluroxypyr + MCPA, fenoxaprop-P-ethyl, and a tank-mixture of fluroxypyr + MCPA + fenoxaprop-P-ethyl, two hand weeding at 25 and 55 days after emergence (DAE) and control non weeded (Table 2). The herbicides were applied using a knapsack sprayer with a water volume 250 l/ha at tillering stage (25 DAE). Fenoxaprop-P-ethyl was applied at the rate of 0.01 kg (a.i.)/ha and fluroxypyr + MCPA was applied at the rate of 0.25 kg (a.i.)/ ha.

With regard to the fertilizer treatments, three fertilizer levels (0-0, 69-60 kg/ha basal application and 69-60 kg/ha split application of ($N-P_2O_5$), all N and P rates of 69-60 kg/ha were applied at sowing with basal application, while only half of the nitrogen fertilizer was applied at sowing in the seed rows and the remaining half was top-dressed at the early tillering stage of the crop as split application.

Glyphosate at 0.9 kg (a.i.)/ha was applied in no tillage treatment (NT) to control annual and perennial weeds at two weeks before sowing the crop seeds. Herbicide was applied when the weeds reach 10 cm. The crop seeds were sown into standing stubble of hand rowed. The conventional tillage (CvT) is a traditional ox-plow system of land preparation practiced by the farmers. This included three passes with the local implement called "maresha" to a depth of 20cm and start from the on-set of rains until planting. The modern plow included a primary tillage operation with the moldboard plowing (MP). First plowing was done at the start of the short rain in mid April to a depth of 30cm and followed by disk harrowing in late May and mid June prior to planting. The time interval between each plowing was 3 to 4 weeks. The recommended variety HAR-604 (Galema) was planted in June 19 and 20 in 2002 and 2003 cropping seasons. In each sub-sub plot, seeds were drilled in 20 rows of 20 cm inter-row spacing at the rate of 150 kg/ha.

Major weed flora was visually assessed prior to tillage operation and during crop growth. Four quadrat measuring of 0.25 square meter each were randomly placed on the border of two rows of the sub-sub plots to determine the weed density just before hand weeding was done or post emergence herbicide was applied at 25 DAE. The second hand weeding was done at 55 DAE. Fresh and dry weed biomasses was also determined from each quadrant by first cut out all the above ground weeds and then separating them into two groups as grasses and broadleaves at 25 and 55 DAE. The weed biomass was subsequently bulked for each plot and oven-dried at 80^0C for 24 hours to enable dry matter determination. All crop yield components were measured at maturity. The weed density data were transformed using the square root of transformation the "actual counts + 1.0" to ensure the homogeneity of variance. All measured variables were subjected to analysis of variance using the General Linear Model procedure of the SAS (SAS 1990). Duncan's multiple range test ($P \leq .05$) was used to compare treatment means.

RESULTS AND DISCUSSION

Effect of tillage

Weed communities of different species composition of the location is given in (Table 1). Among the weed species identified *Polygonum nepalense, Sonchus arvensis, Galinsoga parviflora, Plantago lanceolata, Spergula arvensis, Guzotia scabra, Setaria pumila , Echinocloa colona,* and *Phalaris paradoxa* were the major and most prevalent weeds encountered. Most of the dominant broad leaf and grassy weeds were significantly reduced by tillage in both years (Table 3). There were differences on weed distribution and weed species between tillage systems. The broad leaf weeds density were higher compared to grasses in both years. The dry biomass of broad leaf weeds in NT was higher than other tillage systems at 30 and 60 DAE only in 2003 but not in 2002 (Table 2). Weed density of broad leaf at 30 and 60 DAE in 2002 and 2003, grassy weed at 30 and 60 DAE in 2003 were higher than in NT than in CvT or MP (Table 3). In general, the total amount of weed density was higher in NT than other tillage systems which might be due to the greater deposition of weed seed at the soil surface and plowing each time before planting might killed the germinated weeds. The magnitude change ranges from two to four folds when comparing densities in NT with the others. Emergence of broad leaf and grassy weeds was similar in MP compared with traditional oxen plow at 4 and 8 weeks after sowing. It could be due to uniform distribution of weed residue and recent soil aeration through tillage. This research had a general agreement with previous study of Asefa and Tanner (1998). They reported that tillage may increase or decrease weed seedling densities of certain weed species.

In NT, only the weed seeds those germinated were killed by glyphosate, which was applied once before planting and the remain weed seeds in the soil can germinate later on and might cause yield reduction. Furthermore, the late germinated weeds could produce the seeds for the following wheat season. Therefore, in NT system it is necessary to select proper weed management method to provide great weed control after wheat planting.

The analysis of variance indicated that tillage significantly increased plant heights, grain yields and straw yields. Thousand-kernel weights and harvest index were not affected by tillage in

Table 1 Characteristics for weed species found at Ambo experimental site in 2002 and 2003 cropping seasons.

Botanical name	Family	Characteristics		
		Life cycle[1]	Group[2]	Propagation[3]
Amaranthus retroflexus	Amaranthaceae	a	d	s
Anagallis arvensis	Primulaceae	a	d	s
Avena fatua	Poaceae	a	m	s
Bromus pectinatus	Poaceae	a	m	s
Caylusea abyssinica	Resedaceae	a	d	s
Chenopodium album	Chenopodeaceae	a	d	s
Commelina benghlensisa	Commelinaceae	a /p	m	s/v
Corrigiola capensis	Caryophylaceae	a	d	s
Echinocloa colona	Poaceae	a	m	s
Galinsoga parviflora	Compositae	a	d	s
Ganaphalium unionis	Compositae	a	d	s
Guizotia scabra	Compositae	a	d	s
Medicago polymorpha	Leguminosae	a	d	s
Oxalis corniculata	Oxalidaceae	a/p	d	s/v
Phalaris paradoxa	Poaceae	P	m	s
Plantago lanceolata	Plantignaceae	a/p	m	s
Polygonum aviculare	Polygonaceae	a	d	s
Polygonum convolvulus	Polygonaceae	a	d	s
Polygonum nepalense	Polygonaceae	a	d	s
Rumex abyssinicus	Polygonaceae	a	d	s/v
Setaria pumila	Poaceae	a	m	s
Sinapis arvensis	Compositae	a	d	s
Sonchus arvensis	Compositae	a	d	s
Snowdenia polystachya	Poaceae	a	m	s
Spergula arvensis	Carophyllaceae	a	d	s
Tagetes minuta	Compositae	a	d	s

[1] Life cycle; a = annual, p = perennial. [2]Group; m= monocot, d= dicot. [3]Propagation; s = reproduction by seed, v = reproduction by vegetative means.

Table 2 Dry weed biomass in wheat under different management systems at Ambo in 2002 and 2003 cropping seasons.

Treatment	2002				2003			
	30 DAE [1]		60 DAE		30 DAE		60 DAE	
	BLW[2]	GW	BLW	GW	BLW	GW	BLW	GW
	(g/m^2)							
Tillage								
1. No tillage	272.5a[3]	124.6a	174.1a	87.2a	149.5a	21.5a	287.3a	19.0a
2. Oxen plow	165.9a	116.1a	220.9a	97.9a	117.5b	19.2a	120.1b	15.0a
3. Moldboard plow	120.5a	109.0a	185.5a	112.2a	115.3b	11.0a	108.9b	15.8a
Fertilizer								
1. 0-0 N- P_2O_5 kg/ha	506.3c	118.9b	177.5c	86.2c	98.1b	31.3c	114.7b	16.9c
2. 60-69 N- P_2O_5 kg/ha basal application	1780.9a	214.3a	220.0b	184.8b	133.8a	43.0b	261.9a	87.8b
3. 60-69 N- P_2O_5 kg/ha split application	1159.4b	225.7a	482.0a	216.3a	126.3a	71.4a	181.1a	105.2a
Weed management								
1. Unweeded control	1111.6a	53.1a	346.6a	42.4a	39.9a	16.1a	352.0a	8.2ab
2. Hand weeded twice @ (25-30 and 55 –60 DAE)	1060.2a	33.4a	59.2b	9.8c	28.0a	4.1b	51.0b	5.5bc
3. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha	1473.3a	35.8a	337.4a	6.8c	25.6a	4.3b	297.5a	3.1c
4. Fluroxypyr + MCPA @ 0.25 kg (a. i.)/ ha	1098.0a	49.6a	33.9c	25.9b	25.9a	11.2ab	80.3b	11.4a
5. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha + fluroxypyr +MCPA @ 0.25 kg (a. i.)/ ha	1023.5a	43.0a	85.0b	11.8c	28.0a	3.7b	88.5b	5.0bc
Tillage	ns	ns	ns	ns	*	ns	*	ns
Fertilizer	*[4]	*	*	*	*	*	*	*
Tillage X fertilizer	*	ns	ns	ns	ns	ns	ns	ns
Weed management	ns	ns	**	*	ns	*	*	*
Tillage X weed management	ns	ns	ns	ns	ns	ns	ns	ns
Fertilizer X weed management	ns	ns	ns	ns	ns	ns	*	*
Tillage X fertilizer X weed management	ns	ns	ns	ns	ns	ns	ns	ns

[1] DAE = days after emergence. [2] BLW = broad leaf weeds, GW= grass weeds. [3]Means followed by the same letter within the same column and the same parameter are not significantly different at the 5% level according to Ducan's new multiple range test. [4]* and ** significance at the 0.05 and 0.01 levels, respectively, ns indicates nonsignificant.

Table 3 Effect of crop management practice on weed population density in wheat at 30 and 60 days after crop emergence at Ambo in the year 2002 and 2003.

Treatment	2002				2003			
	30 DAE [1]		60 DAE		30 DAE		60 DAE	
	BLW[2]	GW	BLW	GW	BLW	GW	BLW	GW
	(no./m^2)							
Tillage								
1. No tillage	907.8a[3]	22.5a	1244.4a	75.1a	346.2a	41.3a	260.2a	22.5a
2. Oxen plow	765.4b	38.5a	1006.6b	75.0a	200.0b	18.2b	181.9b	14.9b
3. Moldboard plow	411.9c	25.2a	948.9b	88.2a	269.2b	15.9b	162.5b	13.9b
Fertilizer								
1. 0-0 N- P_2O_5 kg/ ha	745.7a	31.6a	269.9a	13.9a	290.5a	61.1a	225.4ab	20.7a
2. 60-69 N- P_2O_5 kg/ ha basal application	739.5a	16.5a	152.3a	10.3a	321.5a	45.1b	185.8b	12.9b
3. 60-69 N- P_2O_5 kg/ ha split application	699.4a	20.1a	178.8a	23.4a	299.3a	29.3ab	294.4a	17.8ab
Weed management								
1. Unweeded control	735.6a	28.9a	655.9a	21.9ab	316.7a	18.9a	207.0ab	27.3a
2. Hand weeded twice @ (25-30 and 55 –60 DAE)	748.3a	20.5a	137.1b	9.3b	296.9a	15.9a	54.1b	11.9b
3. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha	740.2a	23.3a	674.7a	4.2c	319.8a	12.1a	218.9a	8.0c
4. Fluroxypyr + MCPA @ 0.25 kg (a. i.)/ ha	672.2a	29.3a	95.9c	25.9a	284.3a	16.5a	22.7c	18.5b
Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha+ fluroxypyr +MCPA @ 0.25 kg (a. i.)/ ha	746.4a	24.9a	136.5b	7.2bc	302.1a	19.1a	24.5c	11.1b
Tillage	*[4]	ns	*	ns	ns	*	*	*
Fertilizer	ns	ns	ns	ns	ns	*	*	*
Tillage X fertilizer	*	*	ns	ns	*	ns	ns	*
Weed management	ns	ns	*	**	ns	ns	**	**
Tillage X weed management	ns	ns	ns	ns	ns	ns	ns	ns
Fertilizer X weed management	ns	ns	ns	ns	ns	ns	ns	ns
Tillage X fertilizer X weed management	ns	ns	ns	ns	ns	ns	ns	ns

[1] DAE = days after emergence. [2]BLW = broad leaf weeds, GW= grass weeds. [3]Means followed by the same letter within the same columns and the same parameter are not significantly different at the 5% level according to Ducan's new multiple range test. [4]* and ** indicate significance at the 0.05 and 0.01 levels respectively, ns indicates nonsignificant.

both years. The highest mean yield was recorded from MP 2656, followed by CvT 2583 and lowest 1831 kg/ha in NT systems. Tillage increased the yield by 31%. The wheat yield was reduced by 50% in 2002 compared to 2003, which was the result of high disease infestation during the crop-growing season (Table 4). However, these experiments were conducted only two year, if NT was practiced in a long period of time, the effect of CVT on yield of wheat and weed population might be difference from these results.

Effect of fertilizer

The results indicated that fertilizer increased biomass of grassy weed at 30 DAE and broad leaf weeds at 30 and 60 DAE 2003. The total broad leaf and grass weed biomasses which were more often attributed by fertilizer application, were greater in fertilized plots relative to unfertilized plots in 2002 and 2003 (Table 2). The total broad leaf and grass weed density was not affected by application of fertilizer in 2002. The total broad leaf and grass weed density of control without fertilizer was higher than fertilized at 30 and 60 DAE in 2002. While, in 2003 growing season the opposite occurred higher number of weeds were observed on fertilized plot relative to unfertilized, which might be due to the residue effect of the crop. The result indicated that broad leaf weeds, like *Phalaris* sp. and *Setaria* spp. respond directly to fertilizer application (Data not shown). The research result was in line with previous studies of Peterson and Nalewaja (1992) who found that application of N fertilizer benefited green foxtail over cereal crop.

Most of the parameters were influenced by fertilizer application. Significant effect was observed on plant height, 1,000-kernel weight, straw yield, grain yield and harvest index. In terms of yield it was found that fertilized plots produced more grain yield than unfertilized plots. The highest mean grain yield 2,828 kg/ha was obtained from split application of nitrogen and 2,653 kg/ha from basal application of nitrogen. On the contrary, the lowest grain yields 1,472 kg/ha was from the unfertilized control plot. No statistical differences were observed between split and basal application of nitrogen fertilizer when treatment means were compared (Table 4). Fertilizer application in this study improved grain yield up to 48%, which was similar to the previous research of fertilizer studies. Poor soil fertility has been documented as major wheat yield constraint in Ethiopian high land soils (Amsal *et al.*, 1996).

Effect of weed management

The results reveled that there were significant differences between weed management on both grass and broad leaf weed densities and biomasses. The best control of both annual broadleaf and grass weeds was achieved with herbicide application followed by twice hand weeding (Table 2 and 6). Fluroxypyr +MCPA controlled the highest percentage of broad leaf weeds, *P. nepalense*, *G. parviflora*, *P. lanceolata*, *S. arvensis*, *A. arvensis*, *M. polymorpha*, *G. scabra*, and *C. benghalensis*. Fenoxaprop-P-ethyl was outstanding against most of grass weeds, *E. colona, P. paradoxa, S. pumila* for about 60 days after application. The combination of broadleaf and grass herbisides significantly reduced the greatest number of broad leaf and grass weeds up to 75 % which seemed to be of considerable potential for successful use against noxious grass and broadleaf weeds in wheat. This study was supported by the findings of Roberts and Neilson (1981), which reported the use of herbicides to complement standard cultivation practices that could drastically reduce the population of weed seeds in the soil. It also emphasized the depending on herbicide use when certain species might be decreased in the seed bank and others increased. All the tested herbicides were not able to suppress all weeds species except the hand weeding treatment. Several researchers Kassahun and Tanner (1998), Asefa and Tanner (1998) have

Table 4 Effect of crop management practice on plant height, yield and yield attributes of wheat at Ambo in 2002 and 2003 cropping seasons.

Treatment	2002					2003				
	HT[1]	GY	HI	SY	TKW	HT	GY	HI	SY	TKW
Tillage	(cm)	(kg/ha)	(%)	(kg/ha)	(g)	(cm)	(kg/ha)	(%)	(kg/ha)	(g)
1. No tillage	97.4b[2]	2608b	36.5a	4665b	29.5a	78.9b	1053c	36.7a	1918c	28.7a
2. Oxen plow	99.8ab	3490a	38.2a	57894a	30.2a	94.2a	1675b	36.9a	3340b	30.3a
3. Moldboard plow	102.3a	3454a	37.0a	5983a	29.5a	96.2a	1857a	38.5a	3786a	29.7a
Fertilizer										
1. 0-0 N- P_2O_5 kg/ha	88.6b	2069b	31.1b	3209b	27.6a	82.1b	828b	39.5a	1571b	26.9b
2. 60-69 N- P_2O_5 kg/ha basal application	104.6a	3618a	36.2a	6375a	30.3a	98.7a	1688a	36.9a	3603a	30.7a
3. 60-69 N- P_2O_5 kg/ha split application	104.6a	3706a	39.5a	6466a	31.4a	99.4a	1930a	38.2a	3524a	30.9a
Weed management										
1. Unweeded control	78.8b	2149c	27.8b	3675c	28.1a	79.5c	991c	30.3a	1884.7c	30.2a
2. Hand weeded twice @ (25-30 and 55 –60 DAE [1])	99.8a	3436ab	36.9a	5919a	30.2a	101.4a	1801a	37.9a	3630.0a	30.1a
3. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha	100.3a	3262b	37.3a	5543b	28.4a	94.8ab	1209b	38.8a	1865.7c	29.6a
4. Fluroxypyr + MCPA @ 0.25 kg (a. i.)/ ha	98.2a	3124bc	37.9a	5243b	31.0a	94.6ab	1384ab	36.5a	2862.0b	29.4a
5. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha + fluroxypyr +MCPA @ 0.25 kg (a. i.)/ ha	98.1a	3667a	37.8a	5983a	30.3a	90.8b	1592ab	36.6a	3619.2a	30.1a
Tillage	*[3]	*	ns	*	ns	*	*	*	*	ns
Fertilizer	*	*	*	*	ns	*	*	ns	*	*
Tillage X fertilizer	*	**	ns	ns	ns	*	ns	ns	ns	*
Weed management	*	*	*	*	ns	*	*	ns	*	ns
Tillage X weed management	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Fertilizer X weed management	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Tillage X fertilizer X weed management	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

[1] HT= plant height , HI = harvest index, GY= grain yield, SY= Straw yield, TKW = thousand kernel weight. [2]Means followed by the same letter within the same column and the same parameter are not significantly different at the 5% level according to Ducan's new multiple range test. [3]* and ** indicate significance at the 0.05 and 0.01 levels,respectively, ns indicates nonsignificant.

reported that the herbicide treatments need to be supplemented with hand weeding as necessary that was depending on the weed flora and persistence of applied herbicides.

Treatment effects were highly significant for yield and yield components considered. Using tank mixture of fenoxaprop-P-ethyl and fluroxypyr +MCPA was significantly increased the plant height, straw yield and thousand-kernel weight. The grain yield increased by 40% over the unweeded control, which was similar to twice hand weeding treatment in both years (Table 4). It was found that these results agreed with the study of many researchers (Rezene, 1985; Tanner *et al.*, 1991).

Tillage and fertilizer interaction

Tillage exerted a pronounced effect on weed broad-leaved weed biomass 30 DAE in the year 2002 and broad leaved and grass weed seedling densities. Oxen plow and MP at 30 and 60 DAE significantly decreased total broad leaf and grass weed densities in the year 2002 and 2003 (Table 6 and 7). Thus the over all tendencies were for weed populations to increase under NT. Fertilizer application did not increase the weed density. For the weed biomass the opposite occurred. The fertilized plot showed higher weed biomasses than unfertilized plot (Table 6).

The effect of tillage on plant height, grain yield and 1,000-kernel weight significantly interacted with fertility level. The grain yield of wheat increased with fertilizer application in 2002 and other component viz. plant height in both years and 1,000-kernl weight in the year 2003(Table 8). In terms of methods of fertilizer application both split and basal application of nitrogen fertilizer caused increases in plant height, grain yield and 1,000-kernel weight. In general, a fertilizer application was more important than tillage in increasing yield and yield components.

Table 5 Fertilizer and weed management interaction effects on density of grass and biomass of broad leaf weeds 60 DAE[1] at Ambo in 2003.

Fertilizer	Weed management	No. of grasses (no./m^2)	Broadleaf weeds (g./m^2)
No fertilizer	Unweeded control	84.9a[2]	149.2bcde
	Hand weeded twice	16.1c	250.0b
	Fenoxaprop- P -ethyl	23.9bc	224.0bc
	Fluroxypyr + MCPA	23.1bc	80.2cde
	Fenoxaprop- P -ethyl+fluroxypyr +MCPA	12.7bc	92.0cd
N-P_2O_5basal application	Unweeded control	27.44bc	23.6e
	Hand weeded twice	2.7e	488.9a
	Fenoxaprop- P -ethyl	8.6d	570.6a
	Fluroxypyr + MCPA	12.8bc	211.6bc
	Fenoxaprop- P -ethyl+ fluroxypyr +MCPA	46.8b	136.5bcde
N-P_2O_5split application	Unweeded control	18.9bc	70.2cde
	Hand weeded twice	22.1b	34.1de
	Fenoxaprop- P -ethyl	15.4c	160.4bcde
	Fluroxypyr + MCPA	15.8c	51.6de
	Fenoxaprop-P-ethyl+ fluroxypyr +MCPA	12.6c	34.5de

[1] DAE = days after emergence. [2] Means with in the same column and the same parameter grouping followed by the same letter are not significantly different at the 5% level according to Duncan's new multiple range tests.

Fertilizer and weed management interaction

The result revealed that total grass weed density and total broad leaf weed biomass were significantly influenced by fertilizer and weed management interactions 60 DAE in the year 2003. Total broad leaf weed biomass increased under both fertilizer levels, the increment was little to no difference between split and basal application of nitrogen fertilizer (Table 5). The total grass weed density was significantly affected by weed management practices rather than fertilizer application. The number of grass weeds was significantly increased in unweeded and non-fertilized plot. In this study, weed management was found to be the most important factor affecting total grass weed density. Regarding total broad leaf weed biomass application of fertilizer was more important.

Table 6 Tillage and fertilizer interaction effects on broad leaf weeds dry biomass 30 days after emergence at Ambo in 2002.

Tillage	Fertilizer	Biomass
		(g/m^2)
No-tillage	No fertilizer	1726.3cd[1]
	N-P_2O_5basal application	1855.3bc
	N-P_2O_5split application	1235.9bc
Oxen plow	No fertilizer	438.6d
	N-P_2O_5basal application	1402.1abc
	N-P_2O_5split application	1315.2bc
Moldboard plow	No fertilizer	349.3d
	N-P_2O_5basal application	2085.2a
	N-P_2O_5split application	927.0cd

[1] Means within the same column grouping followed by the same letter are not significantly different at the 5% level according to Duncan's new multiple range test.

Table 7 Tillage and fertilizer interaction effects on grass and broad leaf weeds density at Ambo in 2002 and 2003.

Tillage	Fertilizer	Broadleaves 30 DAE[1]		Grasses in 2002	
		2002	2003	30DAE	60 DAE
		(no/m^2)			
No-tillage	No fertilizer	1028.2a[2]	297.8bc	31.9abc	17.2b
	N-P_2O_5basal application	949.1ab	397.8a	15.7c	14.6b
	N-P_2O_5split application	746.0bc	360.9ab	19.8bc	13.5b
Oxen plow	No fertilizer	789.9abc	302.7bc	40.1ab	21.0b
	N-P_2O_5basal application	738.9bc	293.9bc	18.9bc	7.4b
	N-P_2O_5split application	768.9bc	291.9bc	27.3abc	16.9b
Moldboard plow	No fertilizer	722.0bc	271.8c	47.8a	29.9a
	N-P_2O_5basal application	530.5cd	290.7bc	14.9c	8.8b
	N-P_2O_5split application	583.3cd	245.2c	12.9c	4.2b

[1] DAE = days after emergence. [2]Means with in the same column grouping followed by the same letter are not significantly different at the 5% level according to Duncan's new multiple range test.

Table 8 Tillage and fertilizer interaction effect on plant height and grain yield 1000-kernel weight at Ambo in 2002 and 2003.

Tillage	Fertilizer	Plant height		Grain yield	TKW[1]
		2002	2003	2002	2003
		(cm)		(kg)	(gm)
No-tillage	No fertilizer	86.3d[2]	70.1d	1655a	26.8d
	$N-P_2O_5$basal application	101.5b	96.9a	2970c	31.6a
Oxen plow	$N-P_2O_5$split application	106.1ab	97.9a	3569b	30.2abc
	No fertilizer	88.0cd	83.7c	2143d	29.2c
	$N-P_2O_5$basal application	105.5ab	97.5a	3987a	31.2ab
	$N-P_2O_5$split application	102.8ab	96.1a	3735ab	30.1abc
Moldboard plow	No fertilizer	92.0c	90.1b	2496a	29.6b
	$N-P_2O_5$basal application	106.8a	100.3a	3731ab	29.3c
	$N-P_2O_5$split application	106.5a	99.7a	4047a	29.7bc

[1] TKW = thousand kernel weight

[2] Means within the same column and the same parameter grouping followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range tests.

CONCLUSIONS

From the two-year results it could be conclude that MP relative to other two tillage systems significantly reduced density of most of the dominant broad leaf and grassy weeds followed by ox plow. Glyphosate based NT systems reduced weed population and the total labor required for wheat production. Among the weed management treatments tested, a tank mixture of both fenoxaprop-P-ethyl and fluroxypyr +MCPA significantly reduced the greatest number of broad leaf and grassy weeds, which, seems to have considerable potential for successful use against noxious grass and broadleaf weeds in wheat. Therefore, herbicide combinations need to be promoted to control a broader spectrum of weed species and often permit the use of lower rates of each individual product. Weed management and application of fertilizer were the optimum limiting factors of yield components of wheat production in central highlands of the country. This suggests that using integrated management systems can make considerable yield increase in wheat at different wheat growing agro ecological zones of Ethiopia. However, because of the variation in fecundity estimates in the study, further research is necessary in order to provide more accurate estimates of seed production by weeds subjected to competition from crop plants so that more accurate long-term predictions related to the population dynamics of weeds can be made.

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