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Weed Population Dynamics as Influenced by Tillage, Fertilizer and Weed Management in Wheat *(Triticum aestivum* L.) Cropping Systems of Central Ethiopia

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ABSTRACT

Field experiments were conducted at Holetta, central highlands of 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 ranged from two to four folds when comparing densities in no tillage with the others. Among the dominant weeds, *Polygonum nepalense*, *Galinsoga parviflora*, *Plantago lanceolata*, *Ganaplium unions*, *Spergula arvensis*, *Setaria pumila*, *Bromus pectinatus*, *Echinocloa colona*, *Snowdenia polystachya* and *Phalaris paradoxa*, were significantly reduced in density (P<0.05) by moldboard plowing relative to other tillage systems. Tillage did not influence yield in both years. Tank mixture of fenoxaprop-P-ethyl and fluroxypyr +MCPA resulted in a significant reduction of total weed number and increased wheat yield by 30% followed by hand weeding twice in both years. Applications of fertilizer increased total broad leaf and grass weed biomasses. Fertilizer is more important than tillage in affecting yields and yield components. It improved grain yield up to 40% over the untreated control plots in both years. Weeding without fertilizer did not affect grain yield. Weeding and fertilizer significantly increased grain yield in both years. The interactions between tillage and fertilizer, between tillage and weed management and between fertilizer and weed management for total weed densiies, weed biomasses, plant heights, straw yields and grain yields were 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 (Rezene, 1985; Tanner and Giref, 1991; Assefa and Tanner, 1998; 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

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production problems faced by wheat producers in the Ethiopia. Farmers in the major wheat producing agro-ecologies of Ethiopia recognize weed competition as one of the principal constraints to bread wheat (*Triticum aestivum* L.) production both in the peasant and state farm sectors (Tanner *et al.*, 1991; Kefyalew *et al*., 1996; Kassahun and Tanner, 1998).

McClockey *et al.* (1996) investigated the influence of a different weed management practices and found that tillage affected weed population more than did the nutrient sources. Understanding the patterns and extent of seedling emergence from the seed bank is necessary to develop effective weed management systems and to aid in predicting the long-term consequences of these systems (Oryokot *et al.*, 1997; Mulugeta and Stoltenberg, 2001).

In Ethiopia, conservation tillage systems for wheat production have not been extensively researched, despite the extremely serious problem of soil erosion in highland regions (Tanner, 1999). The management of weeds is an essential aspect of maintaining crop productivity within an economically viable and ecologically sustainable agricultural system.

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).

In Ethiopia although there are some few documented cases of piecemeal weed management practices on wheat, the information on weed emergence patterns of weed community in relation with method of different seedbed preparation, tillage operations and cropping systems is critically inadequate. From a weed management standpoint, cultural and chemical factors that affect the weed population dynamics are of great importance. In order to sustain yields and encourage wheat growers by reducing weed competition, it is important to study weed control management, which includes tillage, fertilizer and herbicide application practices in an integrated manner.

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 central high lands of Ethiopia.

MATERIALS AND METHODS

The field experiments were conducted in 2002 and 2003 at the Holetta (09° 03′N, 38° 30′E, and 2400 meter above sea level) 45 km west of Addis Ababa in the Research Centers of the Ethiopian Agricultural Research Organization (EARO) of Ethiopia. Soil types were considered at Holetta, Eutric Nito with pH of 4.59. Available P of soil was 4.2 and organic matter contents of 2.71%. The average monthly mean minimum temperatures during the crop growing season is 6.4°C and the corresponding average monthly mean maximum temperatures is 21.3°C, with total annual rainfall of 924.5 mm, respectively. The rainfall is bimodal about 70% of the precipitation falls from June to November, which is also the wheat-growing season and the rest from January to May. The field had been under conventional management practices of plowing, disking and harrowing for the last 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, 60-69 kg /ha basal application and 60-69 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 at 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, 60-69 kg/ha basal application, and 60-69 kg/ha split application of N-P_2O_5) were applied respectively. All N and P rates of 60 and 69 kg/ha were applied at sowing with basal application, while only half rate of N and whole rate of P fertilizer were applied at sowing in the seed rows and the remaining half of N 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 reached 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 started 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 wheat variety HAR-604 (Galema) was planted in June 19 and 20 in 2002 and 2003 cropping seasons. It is the popular bread wheat cultivar with high yield potential in the central and western parts of Ethiopia. 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 0.25sq m 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 were 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°C 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 DICUSSION

Effects of tillage

Natural weed communities of different species composition at Holetta are given in (Table

1). Among the weed species identified, *Polygonum nepalense*, *Galinsoga parviflora*, *Plantago lanceolata*, *Ganaplium unions*, *Spergula arvensis*, *Setaria pumila*, *Bromus pectinatus*, *Echinocloa colona*, *Snowdenia polystachya* 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. There were differences on weed distribution and weed species between tillage systems. The broad leaf weeds density were higher compared to grasses. Dry biomass of broad leaf weeds in NT was higher than other tillage systems at 30 and 60 DAE in 2002 only but not in 2003 (Table 2). Weed density of broad leaf in tillage system at 30 DAE in 2002 and grassy weed at 30 and 60 DAE in 2003 were higher than in NT (Table 3). In general, the total amount of weed density

Table 1 Botanical names and characteristics of weed species found at Holetta 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
Snowdenia polystachya	Poaceae	a	m	s
Spergula arvensis	Carophyllaceae	a	d	s
Tagetes minuta	Compositae	a	d	s

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

was higher in NT than CvT or MP 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 (Table 3). The magnitude change ranges from two to four folds when comparing densities in NT with the others (data did not shown). Emergences of broad leaf and grassy weeds were 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 several previous studies of Forcella and Lindstrom (1988), Ball and Miller (1990), Amanuel and Tanner (1991), Mohler (1993), Assefa and Tanner (1998). They reported that tillage might increase or decrease weed seedling densities of certain weed species.

The experiments were done only two seasons. In NT, only the weed seeds germinated were killed by glyphosate, which was applied once before planting. Glyphosate is not soil residue herbicide therefore, 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, straw yields, thousand-kernel weights and harvest index in 2002. However, in 2003 the opposite results were occurred. Plant height and harvest index were increased by tillage. As far as grain yield concerned there was not significant differences between tillage systems in both years. The lowest grain yield recorded from the NT plot compared to the other tillage systems. The wheat was reduced by 50% in 2003 compared to 2002 which was the result of high disease infestation during the crop-growing season. It might be due to mono cropping system (Table 4).

Effects of fertilizer

The results indicated that fertilizer increased biomass of grassy weeds at 30 DAE and broad leaf weeds at 60 DAE in 2002 (Table 2). However, weed density of control without fertilizer was higher than fertilized at 60 DAE in both years (Table 3).

Over the growing season, higher number of weeds were observed on unfertilized plot relative to fertilized, which might be due to the residue effect of the crop (Table 3). Total broad leaf and grassy weed biomasses which were more often attributed by fertilizer application, were greater in fertilized plots relative to unfertilized plots in 2003 while no difference effect was observed in 2002. The result indicated that broad leaf weeds, like *Snowdenia* sp., *Phalaris* sp. and *Bromus* sp. responded directly to fertilizer application. 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, 1000-kernel weight, straw yield, grain yield and harvest index. In term of yield, it was found that fertilized plots produced more grain yield than unfertilized plots. The highest mean grain yield was obtained from basal application of nitrogen. On the contrary, the lowest grain yields were from the unfertilized control plot. No statistical differences were obtained between split and basal application on nitrogen fertilizer when treatment means were compared (Table 4). Fertilizer application in this study improved grain yield up to 40 %, 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).

Table 2 Dry weed biomasses in wheat under different management systems at Holetta, 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	277a[3]	13a	280 a	75a	26a	14a	357a	40a
2. Oxen plow	178b	10a	257ab	40a	54a	6b	221a	39a
3. Moldboard plow	191ab	14a	184b	34a	24a	4b	278a	9a
Fertilizer								
1. 0-0 N- P_2O_5 kg/ha	201a	15a	198a	47a	101a	6b	233b	11a
2. 60-69 N- P_2O_5 kg/ha basal application	201a	10a	224a	46a	56b	9a	667ab	31a
3. 60-69 N- P_2O_5 kg/ha split application	242a	13a	296a	56a	39b	9a	954a	46a
Weed management								
1. Unweeded control	201a	15a	393a	80a	51a	9b	1317a	43ab
2. Hand weeded twice @ (25-30 and 55 –60 DAE)	224a	13a	71b	28b	23b	6bc	63b	17b
3. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha	224a	17a	441a	22b	42ab	5c	1544a	9b
4. Fluroxypyr + MCPA @ 0.25 kg (a. i.)/ ha	224a	12a	177b	100a	36ab	12a	84b	62a
5. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha + fluroxypyr +MCPA @ 0.25 kg (a. i.)/ ha	201a	7a	125b	19b	26ab	7bc	120b	16b
Tillage	*[4]	ns	*	ns	ns	*	ns	ns
Fertilizer	ns	ns	ns	ns	*	*	*	ns
Tillage X fertilizer	**	ns	ns	ns	*	ns	*	*
Weed management	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 column and the same parameter are not significantly different at the 5% level according to Ducan's multiple range test. [4]* and ** indicate significance at the 0.05 and 0.01 levels, respectively, ns, indicates nonsignificant. .

Table 3 Effects of crop management practice on weed population density in wheat at 30 and 60 days after crop emergence at Holetta, 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
Tillage	(no./m^2)							
1. No tillage	861a[3]	162a	444a	126a	832b	371a	595ab	302a
2. Oxen plow	664b	100a	421a	104a	992a	212b	707a	150b
3. Moldboard plow	716ab	99a	388a	78a	871b	134c	537b	116b
Fertilizer								
1. 0-0 N- P_2O_5 kg/ ha	746a	123a	541a	133a	848a	284a	680a	246a
2. 60-69 N- P_2O_5 kg/ ha basal application	708a	123a	342b	90b	932a	182b	578b	159b
3. 60-69 N- P_2O_5 kg/ ha split application	785a	114a	371b	87b	916a	248a	585b	162b
Weed management								
1. Unweeded control	712b	119a	488a	126a	1004a	231b	886a	173bc
2. Hand weeded twice @ (25-30 and 55 –60 DAE)	745ab	124a	386b	148a	796b	190bc	422b	191b
3. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha	799a	116a	529a	50b	1092a	159c	861a	99d
4. Fluroxypyr + MCPA @ 0.25 kg (a. i.)/ ha	761ab	113a	346b	130a	799b	399a	486b	343a
5. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha + fluroxypyr +MCPA @ 0.25 kg (a. i.)/ ha	714b	128a	344b	62b	807b	210bc	422b	135cd
Tillage	**[4]	ns	ns	ns	**	**	*	**
Fertilizer	ns	ns	**	*	ns	*	*	**
Tillage X Fertilizer	**	*	ns	ns	ns	**	ns	ns
Weed management	**	ns	**	**	**	**	**	**
Tillage X weed management	ns	ns	ns	*	*	*	*	ns
Fertilizer X weed management	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 column and the same parameter are not significantly different at the 5% level according to Ducan's multiple range test. [4]* and ** indicate significance at the 0.05 and 0.01 levels respectively, ns, indicates nonsignificant.

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

Treatment	2002					2003				
	HT[1] (cm)	GY (kg/ha)	HI (%)	SY (kg/ha)	TKW (g)	HT (cm)	GY (kg/ha)	HI (%)	SY (kg/ha)	TKW (g)
Tillage										
1. No tillage	94.5b[2]	2780a	35.2a	5150b	40.6a	92.5a	1150a	46.5a	2480a	34.4a
2. Oxen plow	101.5a	3020a	35.1a	5530ab	37.9b	93.3a	1140a	52.7a	2730ab	32.7a
3. Moldboard plow	102.2a	3090a	34.1b	5890a	36.4c	94.5a	1580a	47.5a	3370a	30.1b
Fertilizer										
1. 0-0 N- P_2O_5 kg/ha	91.1b	1960b	33.8b	3880b	33.7b	84.9b	880c	43.7b	2050c	29.1b
2. 60-69 N- P_2O_5 kg/ha basal application	107.4a	3540a	35.6a	6430a	39.9a	98.1a	1840a	53.8a	3490a	34.0a
3. 60-69 N- P_2O_5 kg/ha split application	106.4a	3370a	34.9ab	6240a	40.9a	97.0a	1440b	49.1ab	3020b	33.9a
Weed management										
1. Unweeded control	103.3a	2730c	34.2a	5200c	39.6a	92.0b	1180c	57.1a	2040d	34.5a
2. Hand weeded twice @ (25-30 and 55 –60 DAE [1])	101.5a	3030ab	34.4a	5760ab	36.4d	93.6ab	1460ab	43.8b	3360a	28.4c
3. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha	101.5a	2910bc	35.4a	5330bc	39.3ab	92.8b	1290bc	51.5ab	2390c	34.7a
4. Fluroxypyr + MCPA @ 0.25 kg (a. i.)/ ha	101.6a	2880c	34.4a	5470abc	38.1bc	92.7b	1360bc	46.1b	2910b	32.7b
5. Fenoxaprop-P-ethyl @ 0.01 kg (a. i.)/ ha + fluroxypyr +MCPA @ 0.25 kg (a. i.)/ ha	100.8a	3260a	35.5a	5830a	37.8c	95.9a	1660a	46.5b	3580a	31.7b
Tillage	*[3]	ns	*	*	*	ns	ns	ns	**	**
Fertilizer	*	*	*	**	*	*	**	**	**	**
Tillage X Fertilizer	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Weed management	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
Tillage X Fertilizer X weed management	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

[1]HT= plant height, GY= grain yield, HI = harvest index, 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 multiple range test. [3]* and ** indicate significance at the 0.05 and 0.01 levels, respectively, ns, indicates nonsignificant.

Effect of weed management

The results revealed that there were significant differences between weed management on both grassy and broad leaf weed densities and biomasses. The best control of both annual broadleaf and grassy weeds was achieved with herbicide application followed by twice hand weeding (Table 2). Fluroxypyr +MCPA controlled the highest percentage of broad leaf weeds, *P. nepalense, P. aviculare, G. parviflora, P. lanceolata, C. littoralis, S. arvensis, A. arvensis, M. polymorpha, G. scabra,* and *C. benghalensis.* Fenoxaprop-ethyl was outstanding against most of grass weeds, *E. colona, S. polystachya, P. paradoxa, S. pumila* for about two months after application. They significantly reduced the greatest number of broad leaf and grassy weeds ranging from 30-80% which seemed to be of considerable potential for successful use against noxious grassy 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 decrease in the seed bank while others increased. All the tested herbicides were not able to suppress weeds species like, *B. pectinatus* except the hand weeding treatment. Several researchers Kassahun and Tanner (1998), Asefa and Tanner (1998) have reported that the herbicide treatments need to be supplemented with hand weeding as necessary which was depending on the weed flora and persistence of applied herbicides.

Treatment effects were highly significant for plant height, harvest index and yield components considered. Using tank mixture of fenoxaprop-P-ethyl and fluroxypyr +MCPA significantly increased the plant height, straw yield and thousand-kernel weight. The grain yield increased by 35% over the unweeded control, which was better than twice hand weeding treatment in both years (Table 4). It was found that these results agreed with the study of many researchers (Schweizer and Zimdahl, 1984; Rezene 1985; Tanner *et al.*, 1991; Kassahun and Tanner., 1998).

Tillage and weed management interaction

More than 50% of broad leaf and grassy weeds were suppressed by tillage (Table 5). The interactive effects of tillage and weed management on broadleaf and grassy weed densities were significant at 30 and 60 DAE in the year 2003. The total numbers of broad leaf weeds were higher in NT plots than tilled plots. The numbers of grassy weeds significantly increased in NT plots with application of broad leaf weed killers fluroxypyr +MCPA (Table 5). This might be due to low competitive effect of broad leaf weeds in the crop. In NT, the tank mixture of fenoxaprop-P-ethyl and fluroxypyr + MCPA was superior to the other treatments except hand weeding (Table 5). The result of this experiment indicated that to reduce the composition of the weed flora, tillage with recommended rate of herbicide and proper time of application was very important. The results showed that the highest grain yield was resulted from MP with floroxypyr + MCPA. Wheat yield differences among tillage systems with the same herbicide treatment was appeared, which might be due to the differences in weed control. In this experiment, tillage alone did not increase wheat yield under weed free condition.

Tillage and fertilizer interaction

Tillage exerted a pronounced effect on weed seedling densities. Oxen plow and MP at 30 and 60 DAE significantly decreased total broad leaf and grassy weed densities in the year 2003 (Table 6). Thus the overall 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 plots showed higher weed biomasses

Table 5 Fertilizer and weed management interaction and tillage and weed management interaction effects on density of grass and broad leaf weeds at Holetta in 2002 and 2003.

Fertilizer	Weed management	No. of grasses in 2003 60 DAE [1] (no./m^2)	Tillage	Weed management	No. of grasses in 2002 (no./m^2) 30DAE	No. of grasses in 2002 (no./m^2) 60DAE	No. of broad leaves in 2003 30 DAE	No. of broad leaves in 2003 60 DAE
No fertilizer	Unweeded control	18.4abc[2]	N0-tillage	Unweeded control	35.7ab	20.7ab	88.1a	62.7ab
	Hand weeded twice	11.2bcde		Hand weeded twice	26.4bc	19.6abc	76.1abc	50.9bc
	Fenoxaprop-P-ethyl	7.2def		Fenoxaprop-P-ethyl	21.5c	15.9bcde	74.2abc	52.9bc
	Fluroxypyr + MCPA	16.5bcd		Fluroxypyr + MCPA	28.5bc	21.5ab	78.0ab	24.1ef
	Fenoxaprop-P-ethyl+fluroxypyr +MCPA	10.2cdef		Fenoxaprop-P-ethyl+fluroxypyr +MCPA	43.8a	21.9a	71.2abc	27.1ef
N-P_2O_5basal application	Unweeded control	26.4a	Oxen plow	Unweeded control	21.2c	17.0abcd	88.0a	66.9a
	Hand weeded twice	5.8ef		Hand weeded twice	26.1bc	11.6def	67.5bc	27.9ef
	Fenoxaprop-P-ethyl	3.2f		Fenoxaprop-P-ethyl	19.7c	11.4ef	81.3ab	50.4bc
	Fluroxypyr + MCPA	9.6cdef		Fluroxypyr + MCPA	18.3c	9.9f	79.5ab	44.1cd
	Fenoxaprop-P-ethyl+fluroxypyr +MCPA	9.1cdef		Fenoxaprop-P-ethyl+ fluroxypyr +MCPA	25.9bc	21.8a	60.8c	33.1def
N-P_2O_5split application	Unweeded control	17.5abc	Moldboard plow	Unweeded control	29.1bc	17.2abc	80.1ab	36.4de
	Hand weeded twice	20.6ab		Hand weeded twice	24.9bc	16.4abcde	77.9ab	21.7f
	Fenoxaprop-P-ethyl	13.6bcde		Fenoxaprop-P-ethyl	20.6c	14.9cdef	67.8bc	29.9ef
	Fluroxypyr + MCPA	7.5def		Fluroxypyr + MCPA	26.2bc	10.3f	81.2ab	28.0ef
	Fenoxaprop-P-ethyl+ fluroxypyr +MCPA	4.1ef		Fenoxaprop-P-ethyl+ fluroxypyr +MCPA	18.9c	11.5def	76.9abc	21.3f

[1]DAE = days after emergence. [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. All data were transformed by SQRT (no./m^2 +1.0)

than the unfertilized plots (Table 6 and 7).

Tillage had a pronounced effect on plant height, straw yield and 1000 kernel weight. Grain yield did not affect by tillage. The grain yield of wheat and its component viz. plant height, straw yield, 1000-kernel weight and harvest index increased with fertilizer applications in both seasons.

Table 6 Tillage and fertilizer interaction effects on grass and broad leaf weeds dry biomasses in 2002 and 2003.

Tillage	Fertilizer	Broadleaves			Grass
		2002 30 DAE [1]	20032 30 DAE	2003 60 DAE	2003 60 DAE
		(g/m^2)			
No-tillage	No fertilizer	4.0c[2]	2.7bc	5.5c	8.6a
	N-P_2O_5basal application	5.1b	4.2a	12.9c	7.5ab
	N-P_2O_5split application	5.9a	3.4ab	47.5abc	6.9ab
Oxen plow	No fertilizer	2.1g	2.2cd	29.6abc	5.1ab
	N-P_2O_5basal application	3.5d	2.9bc	94.7ab	5.1ab
	N-P_2O_5split application	3.3de	2.6bcd	104.8a	5.9ab
Moldboard plow	No fertilizer	2.2ge	1.6d	7.9c	5.1b
	N-P_2O_5basal application	2.8def	2.2cd	17.5bc	4.5b
	N-P_2O_5split application	2.7efg	2.6bcd	26.7abc	5.6ab

[1]DAE = days after emergence. [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 test. Data were transformed by SQRT (g/m^2+1.0)

Table 7 Tillage and fertilizer interaction effects on grass and broad leaf weed densiies in 2002 and 2003.

Tillage	Fertilizer	Broad leaves	Grasses	
		2002 30 DAE [1]	2002 30 DAE	2003 30 DAE
		(no./m^2)		
No-tillage	No fertilizer	71.8a[2]	25.5a	40.3a
	N-P_2O_5basal application	63.5bc	21.1ab	25.2c
	N-P_2O_5split application	68.0ab	19.7b	34.2ab
Oxen plow	No fertilizer	58.0c	16.6c	28.2bc
	N-P_2O_5basal application	59.0c	17.1c	22.1c
	N-P_2O_5split application	63.5bc	16.2c	24.7c
Moldboard plow	No fertilizer	59.4c	16.1c	21.6c
	N-P_2O_5basal application	63.3bc	16.8c	20.6c
	N-P_2O_5split application	62.2c	17.0c	19.8c

[1]DAE = days after emergence. [2]Means within the same column and the same parameter grouping followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test. Data were transformed by SQRT (no./m^2 +1.0)

Table 8 Fertilizer and weed management interactions and tillage effects on grain yield and straw yield in 2002 and 2003.

Fertilizer	Weed management	Holetta 2002 Straw yield	Holetta 2002 Grain yield	Holetta 2003 Straw yield	Holetta 2003 Grain yield
		(kg/ha)			
No fertilizer	Unweeded control	3992e[1]	1956e	1826c	882d
	Hand weeded twice	5502d	2973d	2319bc	983cd
	Fenoxaprop-P-ethyl	5869bcd	3193cd	2169bc	1049cd
	Fluroxypyr + MCPA	3981e	2297e	1923c	857d
	Fenoxaprop-P-ethyl+fluroxypyr +MCPA	6589abc	3559abc	3949a	1554b
N- basal application	Unweeded control	3703e	1834e	1952c	880d
	Hand weeded twice	3927e	3580abc	2962a	1090ed
	Fenoxaprop-P-ethyl	6407abcd	2197e	2127bc	1045cd
	Fluroxypyr + MCPA	5960cd	3111cd	2397bc	903d
	Fenoxaprop-P-ethyl+fluroxypyr +MCPA	6703ab	3407bcd	2659bc	1097cd
N- split application	Unweeded control	3673e	1869e	2159bc	884d
	Hand weeded twice	6855a	3831ab	3831a	1406bc
	Fenoxaprop-P-ethyl	5845bcd	2976d	2893b	1002cd
	Fluroxypyr + MCPA	6782ab	3916ab	4678a	1142cd
	Fenoxaprop-P-ethyl+fluroxypyr +MCPA	7103a	3982a	3918a	2073a

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

Fertilizer and weed management interaction

The result revealed that total broad leaf and grassy weed biomasses were significantly influenced by fertilizer and weed management interactions 60 DAE in the year 2003. Weed biomasses increased under both fertilizer levels and the increment was little to no difference between split and basal application of nitrogen fertilizer (Table 5).

In this study, weed management was found to be the most important factor affecing plant height, straw yield, grain yield, and 1000-grain weight followed by fertilizer application. The effect of weeding on straw and grain yield was significantly interacted with fertilizer. Proper weed management with fertilizer application gave higher yield. Similarly, the yield of weed-free crop with split or basal application of fertilizer was equal to the yield obtained from herbicide treated plot. In both seasons weeding and fertilizer significantly increased grain yield. Weeding without fertilizer did not affect grain yield (Table 8).

CONCLUSIONS

MP relative to other two tillage systems significantly reduced density of most of the dominant broad leaf and grassy weeds.

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 seemed to have considerable potential for successful use against noxious grassy and broadleaf weeds in wheat in Central Ethiopia.

From the two-year results it could be concluded that 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 growing at 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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