Tillage and herbicide application affect weed control and performance of tomato

B.S Alabi[1], A.A Osobu[1], Josephine O. Makinde[2], O.F Owolade[2], E.A Makinde[1] and Albert O. Ayeni[3]

[1]Senior Lecturer, Federal College or Agriculture, IAR&T, PMB 5029, Ibadan,
[2] IAR&T,PMB 5029, Ibadan,
[3]Program associate, Rutgers University, New Brunswick, NJ 080901.

Abstract

Tillage is being considered as a method to reduce weed infestation and improve the efficacy of applied herbicides in Nigeria. A field experiment was conducted to investigate the influence of tillage methods (conventional, manually formed ridges, no-till) and herbicides on weed control and the performance of tomato at the Institute of Agricultural Research and Training, Ibadan in 2002 and 2003. Weed biomass was higher in no-tillage than in conventional tillage. Conventional tillage gave the highest marketable fruit yield of tomato followed by manually formed ridges. No-tillage had the lowest yield. Metolachlor+ metobromuron at 2.5 $kg \cdot ha^{-1}$ a.i., and pendimethalin at 2.0 $kg \cdot ha^{-1}$ a.i., produced yields that were comparable with hand weeding. The levels of tillage tried did not increase the efficacy of the herbicides.

Media Summary

Tillage reduced weed biomass and improved the yield of tomato. Tillage did not improve the efficacy of applied herbicides.

Keywords

Weed biomass, hoe ridging, conventional tillage, no-tillage.

Introduction

Producers apply different tillage practices for water, soil and weed management. Tillage activities vary with soil and the type of crop to be planted (Lal, 1985; Babalola and Opara-Nadi, 1993). Soil moisture regime and other environmental factors will influence the choice of tillage practice to adopt. No-tillage practices results in better water storage (Diaz-Zorita et al., 2002), and could improve crop growth in arid and semi-arid regions over the use of conventional tillage. Sammis and Wu (1986) had indicated that water availability increases tomato yield. In soils where organic matter is low, no-tillage will be advantageous as it leads to a greater accumulation of organic matter at the surface level (De Maria et al., 1999*)* while conventional plowing and harrowing techniques result in the movement of soil organic matter into deeper soil profile (Lal, 1997; Machado et al., 2003). High accumulation of organic matter in the top layer of no-tillage soils and reduced soil disturbance promote greater population of earthworms (Radke and Berry, 1993). These are the reasons why yields of soybean *(Glycine max* (L.) Merrill) and sorghum (*Sorghum bicolor* L.) were reportedly higher in no-tillage than conventionally tilled soils (Diaz-Zoritta et al., 2002).

Tillage is advantageous where soil moisture is high, and causes low nitrogen mobilization, improves rooting pattern and leads to better weed management (McMaster et al., 2002). Unger (1984), Nitant and Singh (1995) have reported reduced weed population with tillage. Apart from reducing weed population, tillage also provides an environment where weeds and herbicides can interact (Buhler and Daniel, 1988). Efficacy of herbicides, which are mostly manufactured and labeled in temperate environment for use in specific crops are often tested in Nigeria to ascertain their performance in our tropical environment against native species of weeds under the conditions which our local producers operate. Recommendations are then made after these trials. The adoption of no-tillage or tillage will therefore depend on crop species and on weed management. There is the need to study the response of crops to tillage and weed control practices. The objective of this study was therefore to determine how tillage and herbicide would affect weed, and tomato growth and yield.

Material and Methods

This study was carried out at the Institute of Agricultural Research and Training, Ibadan (Latitude 7? 30'N, Longitude 3?54'E) in 2002 and 2003. The soil is a Ferric Luvisol (FAO/UNESCO, 1989), and had been under continuous cropping for several years before it was left fallow for 2 years prior to this study. The experiment was a split plot design, arranged in a randomized complete block with three replications. Tillage operations were assigned to main plots while herbicide treatments were assigned to the subplots. Each subplot was 3 m by 3 m, and plots were separated by 2 m wide unplanted areas. The tillage operations of conventional tillage (the soil was plowed once and then harrowed using implements manufactured by Massey Ferguson, U.K.); hoe ridging (ridges were manually made 0.75 m apart using locally manufactured hoe); and no-tillage were applied. Pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl–2,6–dinitrobenzenzamine] (Stomp?) was applied at 2 $kg \cdot ha^{-1}$, a.i.; metholachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-6-methoxy-1-methulethyl) acetamide] (Dual?) was applied at 2.5 $kg \cdot ha^{-1}$, a.i.; and metolachlor+Metobromuron [3-(P-bromophenyl)-1-methoxy-1-methylurea] (Galex?) was applied 2.5 $kg \cdot ha^{-1}$, a.i.. An unweeded plot, and a hand weeded plot [where weeds were manually removed at 3 and 6 weeks after transplanting (WAT)] were also established. The herbicides were applied with a knapsack sprayer at a volume of 200 $L \cdot ha^{-1}$ with spraying pressure of 2 kg/cm^2. Tomato seedlings (Local variety) were transplanted to the field first week of September in each cropping year, after raising the seedlings for four weeks in the nursery. Individual plants were 0.5 m apart in rows.

Weeds were harvested from randomly selected areas (0.5m by 0.5m quadrat) within each plot, oven dried and biomass determined at 6 WAT. Stand establishment of tomato was counted 4 WAT. Plant height, stem girth and numbers of leaves were determined at 2, 4 and 6 WAT. Marketable fruit (Considered as matured fruits reaching 3.5cm diameter or about 35g weight) were picked at 2 days interval (beginning from 11 WAT) and weighed. Data collected were subjected to Analysis of Variance and means were separated using Duncan's multiple range test (DMRT).

Results and Discussion

Tillage effects

Effect of tillage on weed biomass is presented in Figure 1. In 2002, weed biomass was significantly higher in the no-tillage than in the conventional tillage and hoe ridging treatments. This result is corroborated by the findings of Unger (1984), Nitant and Singh (1995). Weed seeds vary in sensitivity to environmental factors. Tillage that buries some weed seed to where conditions are inadequate for germination may also expose some negatively photosensitive seeds to the surface where light condition prevents germination or where moisture is inadequate for germination (Egley and Duke, 1986). In 2003 cropping, no significant difference in weed biomass was recorded between treatments.

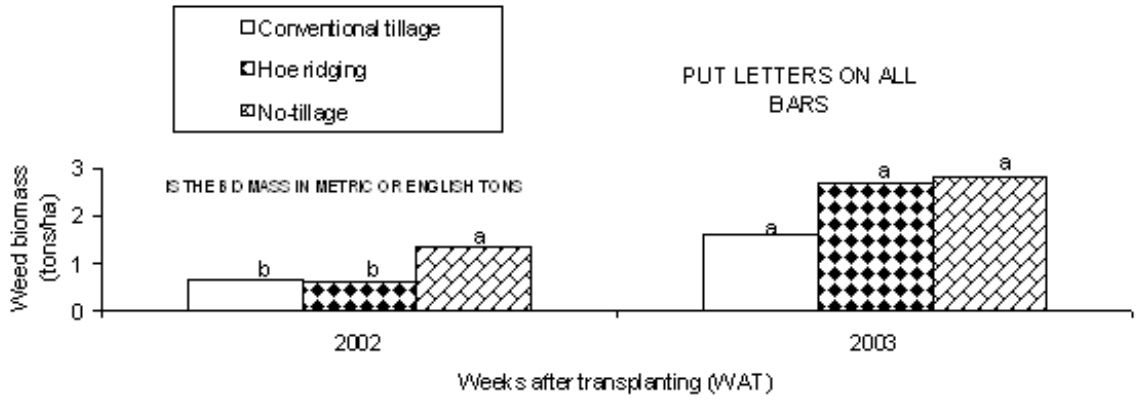

Fig. 1. Effect of tillage method on weed biomass at 6 WAT. Bars denoted by same letter are not different at 5% level according to Duncan's Multiple Range test.

The effects of tillage methods on plant growth are presented in Table 1. In 2002, plant height was not significantly affected by tillage throughout the period of the experiment. Stem girth was significantly affected by tillage after four weeks of transplanting. Tomato plants in the conventional tillage had thicker stems than hoe ridging and no-tillage. In 2003, Plant height was not significantly affected by tillage practice except at 6 WAT. At this time, plant heights in the conventional and hoe ridging were comparable but greater than in no-tillage. This same trend was observed in stem thickness and leaf production at 6 WAT.

Marketable fruit yield in hoe ridging was not better than in no-tillage in 2002 (Table 2). In both years, conventional tillage had the greatest fruit yield. However, the yield in hoe ridging in 2003 was comparable to that of conventional tillage. Previous studies report that tillage gave higher yield of safflower (*Carthamus tinctorius* L.), mustard (*Brassica juncea* L. Gern and Coss), yellow Sarson (*Brassica compestris* var sarson Prain) (Mandal et al., 1994), soybean and sorghum (Diaz-Zorita et al., 2002) than no-tillage. However, corn yield was reportedly greater with conventional tillage than no-tillage probably because of nitrogen deficiency in no-tillage systems (Diaz-Zorita et al., 2002).

Table 1. Effect of tillage method on plant height, stem girth and number of leaves.

Tillage method	Plant height (m/plant)			Stem girth (cm)			Number of leaves /plant			Fruit yield (tonnes/ha)
	2 WAT	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT	
					2002					
Conventional tillage	0.13a[Z]	0.22a	0.37a	0.30a	0.53a	0. 61a	4.5b	10.3	15.4a	92.2a
Hoe ridging	0.11a	0.26a	0.35a	0.22a	0.38b	0.42b	5.8a	11.9	25.7a	25.5b
No-tillage	0.09a	0.20a	0.33a	0.25a	0.35b	0.39b	4.9b	10.0	15.4a	16.6b
					2003					
Conventional tillage	0.23a	0.36a	0.64a	0.13a	0.14a	0.18a	4.4a	8.0	13.7a	225.0a
Hoe ridging	0.19a	0.26a	0.63a	0.09a	0.15a	0.16a	4.3a	7.3	13.2a	174.6a
No-tillage	0.22a	0.32a	0.43a	0.11a	0.13a	0.12b	3.9a	5.2	7.2b	47.0b

[Z] values followed by the same letter are not significantly different, $P \leq 0.05$, Duncan's Multiple Range test.

Table 2. Effect of herbicide application on plant height, stem girth and number of leaves of tomato.

Treatment	Dosage ($kg \cdot ha^{-1}$)	Plant height (m/plant)			Stem girth (cm)			No. leaves/plant		
		2 WAP	4 WAP	6 WAP	2 WAP	4 WAP	6 WAP	2 WAP	4 WAP	6 WAP
					2002					
Metolachlor	2.5	0.12a [Z]	0.21a	0.39a	0.28a	0.40a	0.49a	47a	120a	289a
Pendimethalin	2.0	0.11a	0.29a	0.31a	0.27a	0.47a	0.45a	53a	114a	219a
Metolachlor+ Metobromuron	2.5	0.11a	0.22a	0.37a	0.24a	0.43a	0.48a	49a	86a	181a
Hand weeding	3,6WAP	0.13a	0.22a	0.35a	0.26a	0.48a	0.46a	58a	88a	224a
Unweeded check		0.09a	0.20a	0.32a	0.23a	0.40a	0.49a	57a	119a	211a
					2003					
Metobehlor	2.5	0.22	0.29a	0.56a	0.11a	0.14a	0.15a	44a	104b	128b
Pendimethalin	2.0	0.21	0.28a	0.53a	0.10a	0.14a	0.17a	41a	142ab	151b
Metolachlor+ Metobrumuron	2.5	0.21	0.32a	0.60a	0.14a	0.13a	0.17a	44a	157a	260a
Hand weeding	3,6WAP	0.22	0.31a	0.58a	0.10a	0.14a	0.17a	40a	87c	106b
Unweeded check		0.23	0.33a	0.54a	0.09a	0.14a	0.12b	45a	80c	78b

[Z] values followed by the same letter are not significantly different, $P \leq 0.05$, Duncan's Multiple Range test.

Herbicide effect.

In both years, weed biomass was highest in the unweeded plots and where herbicides were applied (Figure 2). In 2003, the hand weeding gave the lowest weed biomass, while weed biomass in herbicide treated plots were statistically comparable. Herbicide application did not significantly affect stand establishment of the transplanted tomato seedlings (data not presented). In 2002, herbicide application did not significantly affect plant growth (Table 2). This may be due to low weed biomass observed in the experimental site during the growth period. In 2003, stem thickness at 6 WAT, and leaf production at 4 and 6 WAT were significantly affected by herbicide treatments. Stem thickness was lowest in the

unweeded control. Stem thickness was not different between the herbicide treatments and the hand weeding operation.

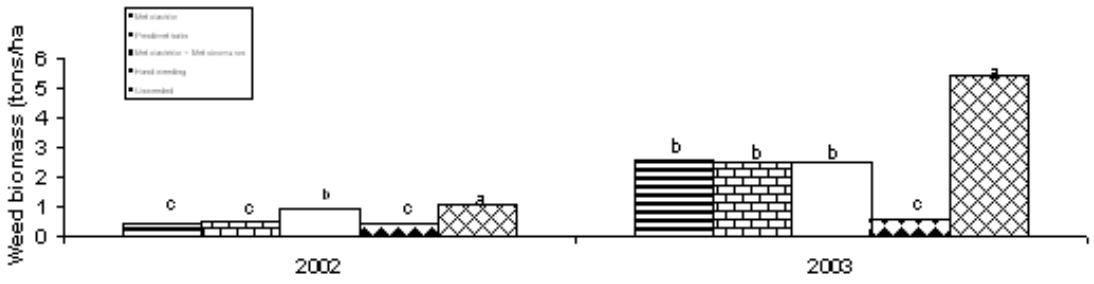

Fig. 2: Effect of herbicide application on weed biomass Bars denoted by same letter or no letter are not different at 5% level according to Duncan's multiple range test.

The greatest number of leaves occurred in plots treated with metolachlor + metobromuron (Galex[?]) at 2.5 kg·ha^{-1} a.i.. This same treatment gave the highest marketable fruit yield of tomato in 2003 cropping (Table 3). Even though, the mean yields were not significantly different from one another, percent yield increase from plots treated with Galex was 131.2% above the unweeded check. Usoro (1988) had recommended Galex at 2.0 to 4.0 kg·ha^{-1}, a.i., for good yield of marketable fruits of tomato. Pendimethalin at 2.0 kg·ha^{-1}, a.i., gave marketable fruit yield of tomato that was statistically comparable with the hand weeded plots**.**

Table 3. Effect of herbicide application on marketable fruit yield of tomato.

Treatment	Fruit yield (tonnes)		% minimum yield	
	2002	2003	2002	2003
Metolachlor (2.5 kg·ha^{-1})	39.8a	111.6a	86.0	15.5
Pendimethalin (2.0 kg·ha^{-1})	45.2a	158.8a	111.2	64.4
Metolachlor + metobromuron (2.5 kg·ha^{-1})	34.4a	223.3a	60.7	131.2
Hand weeding at 3 and 6 WAP	33.4a	150.0a	56.1	55.2
Unweeded check	21.4a	96.6a	0	0

[Z] values followed by the same letter are not significantly different, $P \leq 0.05$, Duncan's Multiple Range test.

Interaction between tillage and herbicides.

The interaction between tillage and herbicide treatments was not significant for all the parameters taken in the two years of the experiment. Results of research on tillage effect on herbicide are highly variable with herbicide type, soil and moisture conditions. Some studies have reported greater losses of herbicide in reduced tillage than in conventional tillage (Thelen et al., 1988; Wienhold and Gish, 1994) while some

showed that more herbicide leaching occurs with reduced tillage (Hall et al., 1989; Hall and Mumma, 1994).

References

Babalola, O and OA Opara-Nadi (1993) Tillage systems and soil properties in West Africa. Soil and Tillage Research 27:149-174.

Buhler, DD and TC Daniel (1988) Influence of tillage systems on giant foxtail*, Setaria faberi* and velvetleaf, *Abutilon theophrast* density and control in corn, *Zea mays* L. Weed Science 36,642-647.

De Maria, IC, PC Nnabude and OM Castro (1999) Long term tillage and crop rotation effects on soil chemical properties of a Rhodic Ferralsol in southern Brazil. Soil and Tillage Research 51,71-79.

Diaz-Zorita, M, GA Duarte and JH Grove (2002) A review of no-tillage systems and soil management for sustainable crop production in the subhumid and semiarid Pampas of Argentina. Soil and Tillage Research 65,1-18.

Egley, GH and SO Duke (1986) Physiology of weed seed germination in soil, p. 57-61. In: D.W. Newman and K.G. Wilson (Eds.). Models in plant physiology and biochemistry. CRC Press, Inc., Boca Raton, FL.

Food and Agriculture Organisation of the United Nations Educational, Scientific and Cultural Organisation (FAO/UNESCO). 1989. Soil Map of the World. Wageningen, The Netherlands.

Hall, JK, MR Murray and NL Hatwig (1989) Herbicide leaching and distribution in tilled and untilled soils. Journal of Environmental Quality 18,439-445.

Hall, JK and RO Mumma (1994) Dicamba mobility in conventionally tilled and non-tilled soils. Soil and Tillage Research 30:3-17.

Lal, R (1985) A soil suitability guide for different tillage systems in the tropics, soil tillage systems in the tropics. Soil and Tillage Research 5,179-196.

Lal, R (1997) Residue management, conservation tillage and soil restoration for mitigating greenhouse effects by $C0_2$ – enrichment. Soil and Tillage Research 43,81-107.

Machado, PLOA, SP Sohi and JL Gaunt (2003) Effect of no-tillage on turnover of organic matter in a Rhodic Ferrosol. Soil use and management 19,250-256.

Mandal, BK, A Saha, MC Dhara and SR Bhunia (1994) Effects of zero and conventional tillage on winter oilseed crops in West Bengal. Soil and Tillage Research 29,49-57.

McMaster, GS, DB Palic and GH Dunn (2002) Soil management alters seedling emergency and subsequent autumn growth and yield in dryland winter wheat-fallow systems in the Central Great Plains on a clay loam soil. Soil and Tillage Research 65,193-206.

Nitant, HS and P Singh (1995) Effect of deep tillage on dry land production of red grain (*Cajanus cajan* L.) in central India. Soil and Tillage Research 34,17-26.

Radke, JK and EC Berry (1993) Infiltration as a tool for detecting soils changes due to cropping, tillage and grazing livestock. American Journal of Alternative Agriculture 8,164-174.

Sammis, TW and IP Wu (1986) Fresh market tomato yield as affected by deficit irrigation using a micro-irrigation system. Agricultural Water Management 12,117-126.

Thelen, KD, J.K Kells and D Penner (1988) Comparison of application methods and tillage practices on volatilization of clomazone. Weed Technology 2,323-326.

Usoro, NJ (1988) Field screening of herbicides for weed control in tomato (*Lycopersicon esculentum* L.). Nigerian Journal of Weed Science 1,59-63.

Unger, PW (1984) Tillage effects on surface soil physical conditions and sorghum emergence. Soil Science Society American Journal 48,1423-1432.

Wienhold, BJ and TJ Gish (1994) Effect of formulation and tillage practice on atrazine and alachlor. Journal of Environmental Quality 23,292-298.