Kasetsart J. (Nat. Sci.) 39 : 186 - 193 (2005)

Weed Control Measures and Moisture Conservation Practices Effects on Seedbank Composition and Vertical Distribution in the Soil

Girma Woldetsadik[1], Sombat Chinawong[2], Rungsit Suwanketnikom[3], Sunanta Juntakool[3] and Visoot Verasan[4]

ABSTRACT

Change in the weed seedbank due to crop production practices is an important determination of subsequent weed problems. Research was conducted to compare weed seed bank composition and vertical distribution of weed seed in the soil among four weed control measures and four moisture conservation practices at Dera Sub-Center and Melkassa Agricultural Research Center.

Seed numbers at 45 cm depth were lower in pre-emergence of primagram at the rate of 3 L/ha treatment (137 seeds/m^{-2}) and pre- and post-emergence of primagram at the rate of 3 L/ha plus 2, 4-D at the rate of 1 L/ha (105 seeds/m^{-2}) at Dera and Melkassa, respectively. More than 60% of the weed seed bank was concentrated in the upper 15 cm of soil layer in post-emergence treatment at Dera and pre plus post-emergence at Melkassa site. The seed bank of the moisture conservation treatments was more uniformly distributed over depth and greater than the other systems. *Chenopodium fasciulosum, Cyprus rotundus, Eragrostis aspera, and Sorghum arundenanceum* were the most commonly found in the seed bank.

Key words: moisture conservation, flat bed, ridge, vertical distribution, and furrow

INTRODUCTION

The weed seed bank, which comprises of viable seeds in the soil and on its surface, is the principal source of annual weeds in the field crops. Size and composition of the seed bank as well as above ground weed flora reflect past and present weed, crop, and soil management (Roberts *et al.*, 1981). Reducing the size of weed seed bank has been a long-term goal of weed management strategies, especially for field cropped continuously (Schweizer *et al.*, 1984). Additions and losses of seed from the seed bank are affected by physical, biological and management factors that interact over time to result in shifts in weed flora (Cavers and Benoit,1989).

Many weed infestations in cropping seasons arise from the weed seed bank, so changes in the seed bank due to agricultural management practices ultimately result in changing in observed weed flora. However, seed bank changes must be of sufficient magnitude to produce detectable changes in weed flora since only a small percentage of seed residing in soil is expressed as flora during any

[1] Bako Agricultural Research Center, P.O. Box-3, Bako, Ethiopia.
[2] Faculty of Agriculture at Kamphaeng Saen, Department of Agronomy, Kasetsart University, Nakom Pathom 73140, Thailand.
[3] Faculty of Agriculture, Department of Agronomy, Kasetsart University, Bangkok 10900, Thailand.

Received date : 04/10/04 Accepted date : 31/01/05

given growing season (Roberts, 1963; Harper, 1977).

Weed control by herbicides and mulch are two primary practices that have an impact on weed seed banks. Recognizing the importance of herbicide and mulching in altering species composition in the weed seed bank can lead to improved strategies for weed management.

Weed seed depth in the soil influences germination and seedling. Seed at or just below the soil surface often germinate more than seed buried deeper in the soil (Chepil, 1946; Herr *et al.*, 1970). Seed placed deep by plowing may remain dormant until further tillage places them where germination may occur. Weed species with long dormancy are favored by plowing. Seed buried deep in the soil also takes longer to emerge and develops seedling characteristics than weed placed shallow (Mester and Buhler, 1990). Weak seedlings are easier to kill by chemical or mechanical methods than more vigorous plants (Herr *et al.*, 1970, Mester and Buhler, 1990). Depth for optimum germination and development varies among species. Thus, it is very important to analyze the seed bank in the soil, because seed density estimates is useful for predicting weed infestation and enables a minimum use of herbicides (Buhler *et al.*, 1992).

Effective weed management is critical for successful maize production. The use of herbicides can also influence the species composition of the seed bank, and may increase or decrease it, depending on the chemicals used (Ball *et al.*, 1989), and they can also cause species shifting (Roberts, 1968). In general, it can be said that interactions among herbicides, land preparation and cultural practice have altered the sizes and natures of seed bank (Roberts, 1981). One key factor that can influence herbicide effectiveness is the propertied weed populations in a field. The numbers of weed seed found in the soil seed bank determine the propertied weed population in a field. The seed bank is a continuous fluctuation due to introductions of new weed seed and losses of seed from germination or decay (Maxwell and Ghersa, 1992). The soil seed bank population declined by more than 90% after five years of continuous maize with excellent control (Schweizer *et al.*, 1984). However, the seed bank rapidly increased when the level of weed management reduced. The level of input required to obtain acceptable weed control is related to the size of the seed bank.

Little work has been done quantifying depth distribution of weed seed by herbicide and moisture conservation practices under field conditions. No previous work in herbicide and mulch effects on seed germination was found in Ethiopia. This experiment evaluated effects of herbicide and weed management on numbers, depth distribution, and viability of the soil weed seed bank.

The objective of this study was to compare weed seed bank composition and vertical distribution of weed seed in the soil among four weed control measures and four moisture conservation practices.

MATERIALS AND METHODS

Study site and agronomic practices

A field experiment was conducted at Dera sub-Center and Melkassa Agricultural Research Center during the rainy season of 2003. The soil types at Dera and Melkassa are diverse, most of them are shallow and the organic matter content is quite low between 0 and 2% in most areas, resulting in poor water–holding capacity. The soils are generally brown, grayish brown or light brown. The textures of the soil are either clay loam, loam or sandy loam. The experiment was laid out in a split- split - plot design, comprising 3 levels of soil depth [0-15 cm, 15-30 cm, and 30- 45 cm] in main plots, 4 levels of fertilizer [N_0, Control, N_1, 10, $N_{2,}$ 20, and $N_{3,}$ 30 kg N/ha] in sub-plots and 4 weed control treatments [W_0, weedy check, W_1, primagram Gold 660 SC 3 L/ha (pre-emergence); W_2, primagram Gold 660 SC 3 L/ha and 2, 4-D 1

L/ha (pre and post-emergence); W_3, 2, 4-D 1 L/ha (post-emergence)] in sub- sub – plots and was replicated thrice. Maize variety Melkassa-1 double top-cross early duration was sown in rows of 25 cm apart on 8 July 2003 and 29 June 2003 at Dera and Melkassa, respectively. Full dose of P_2O_5 and half dose of N were applied basal and remaining N was top dressed in 2 equal splits.

The cropping system was a maize -pulse rotation, except for 2002 to 2003 where maize followed maize. Agronomic practices and herbicide treatments were consistent with those recommended for maize in Melkassa agricultural research center. Weed control treatments representing those most commonly used in the areas included primagram at the rate of 3 L/ha. The herbicide was applied within 3 days after maize planting and before weeds had begun to emerge. Post-emergence of 2, 4-D was used at the rate of 1 L/ha one month after maize emergence.

Seed bank analysis

Studies on seed bank in cultivated soil have led to the development of many techniques for estimating seed density from soil samples. To determine the numbers of viable seed in the soil, soil samples were taken on 15 May 2003, after seedbed preparation but prior to seeding and herbicide application. To measure the vertical distribution of weed seed to a depth of 45 cm in the soil, the soil was collected at surface of 0-15 cm, 16-30 cm and 31- 45 cm depths and the 3 samples from each depth were pooled. The soil was air-dried and sieved through a 2 mm screen to break up large soil peds. The soil was spreaded in 22 cm square trays and watered twice daily in a greenhouse. Soil samples containing seeds were watered as needed and maintained with water at a depth of 1 cm. Weed seedlings that emerged were identified and counted by species and removed every 7 days from the beginning of weed emergence until no weed emergence was observed at the seed-leaf stage or 1-leaf stage to avoid the periodic interaction of weeds, throughout the growing period.

Analysis

Analyses of variance (ANOVAs) were used to test the effect of weed control and moisture conservation practices on the seed banks and vertical distribution of seeds in the soil. Means were separated by LSD $_{(0.05)}$. Vertical distribution of seed was expressed as a proportion of the total seed bank.

RESULTS AND DISCUSSION

Seed bank size

Sizes of the seed bank differed among weed control measures and moisture conservation practices (Table 1). The highest total seed number was found in the Melkassa soil where 366 and 300 seeds/ m^{-2} were observed in post herbicide application and ridge and furrow treatments, respectively. Weedy check gave 222 total weed seeds/ m^{-2} at Melkassa after post herbicide 2, 4-D. Even though the total weed seeds at Dera for weed control measurers were similar to the highest total weed seeds/ 187 m^{-2} was from weedy check. Primagram at the rate of 3 L/ha caused no difference in seed numbers across weed management due to effective weed control and low seed numbers. In contrast, 2, 4-D at the rate 1 L/ha caused greatest difference for weed management by depth. Primagram plus 2, 4 –D had fewer seed in the soil profile than 2, 4-D. Lower seed numbers in pre plus post herbicide application than in control might be due to better weed control in these weed control treatments and to the stimulatory effect of weed control in inducing weed seed germination (Barralis and Chadoeuf, 1980). Seed numbers in ridge and furrow were higher than those in flat bed; flat bed plus straw mulching and ridge and furrow plus straw mulching at the Melkassa site. Differences among sites could be attributed in part to differences in previous vegetative cover in addition to differences in soil type. Pre-emergence of primagram plus post-emergence of 2, 4-D at both sites were best to suppress weeds from weed control measures. The effect of mulch to control weeds was found effective only at Melkassa.

Vertical distribution

The vertical distributions of seed in the soil varied among weed control treatments (Table 2). The top 0-15 cm of soil contained 43.5, 40.2, 40, and 61 % of the seed bank in weedy check, primagram, primagram plus 2, 4-D, and 2, 4-D at Dera, respectively. At Melkasaa, the top 0-15 cm of soil contained 59.1, 56.8, 62.7, and 58.3 % in weedy check, primagram, primagram plus 2, 4-D and 2, 4-D weed control measures, respectively which were greater as compared to those at Dera site. The highest concentrations of weed seed were found in 0-15 cm layer. In 16-30 cm, distribution of weed seeds in the soil declined and were found in the ranges from 18.4 in post-emergence of 2, 4-D to 46.5% in pre-emergence of primagram at Dera and from 19.7 in post-emergence of 2, 4-D to 33.5% in pre-emergence of primagram at Melkassa, which were almost similar in weed seeds in the soil among the four weed management systems. Seeds in 31-45 cm soil depth declined steadily and were found in the range from 13.3 in pre-emergence of primagram to 22.7 % in pre plus post-emergence of primagram plus 2, 4-D at Dera in the order of primagram at the rate of 3 L/ha, weedy check, 2, 4-D at the rate of 1 L/ha and primagram @ 3 L/ha plus 2, 4-D at the rate of 1 L/ha, respectively.

In moisture conservation practice, at Dera flat bed plus straw mulching recorded the lowest percent of weed seed at 0-15 cm soil depth and the highest at 16-30 cm were recorded. Ridge and furrow recorded the highest weed seed at 0-15 cm and the lowest at 31-45 cm, while ridge and furrow plus straw mulching recorded the lowest percent of weed seed at 16-30 cm and the highest at 31-45 cm. At Melkassa flat bed plus straw mulching showed the lowest percent of weed seed at 0-15 cm and 31- 45 cm and the highest at 16-30 cm where as flat bed without straw mulching treatment recorded the highest percent of weed seed at 16-30 cm and the lowest at 16-30 cm. Ridge and furrow with and without straw mulching expressed medium percents of weed seed at the three depths and which were not different from one another. At both sites, flat bed plus straw mulching recorded the lowest percentage of weed seed at 0-15 cm layer.

The highest number of weed seed among the four weed control measures was obtained from weedy check followed by primagram @ 3 L/ha treated plots (Table 3). Ridge and furrow also gave the highest total weed seed followed by flat bed. The control measure with mulch gave less number of weed seed as compared to without mulch. Over 52.7% seeds were concentrated in the top 0-15 cm layer in 2, 4-D @ 1 L/ha herbicide applied treatment and flat bed planting method (Table 3). Weed control measurers ranked 2, 4- D > weedy check > primagram > primagram + 2, 4-D for total seed in the top 45 cm soil depth. Depths by weed control interaction were also significant at both sites.

Species composition

At four weed control measures, twenty-eight weed species were identified in the seed bank or in the field. Almost all of the species observed only in seed bank samples were relatively common at the experimental site; hence it was surprising that these species appeared in the soil samples. Over 90 % of each seed bank among weed control treatments and soils were composed of fewer weed species with 18 species being common to both sites (Table 4). The weeds in different combinations were found at each seed bank. The results showed that the weed seed bank was mainly composed of *Chenopodium fasciulosum*, *Eragrostis aspera*, *Cyperus rotundus*, *Sorghum arundenanceum*, *Flaveria trinerva*, *Argemone mexicana*, *Hetilotropium cineraseioen*, *Amaranthus hybridus*, *Anagalis arvensis*, *Nicandra* *phylasoides*, *Datura stramonium*, *Galinsoga parviflora*, *Euphorbia heterophylla*, *Launea comuta*, *Portulaca oleracea*, *Foeum vulgare*, etc. at the two sites. *Chenopodium fasciulosum* was the only species present in each weed control treated plots constituted 21.7 % of the total seed bank across two locations and consistently made up greater percentages of the seed bank in pre-, pre - plus post- and post- emergences than weedy check. *Cyprus rotundus, Eragrostis aspera and Sorghum arundenanceum* were the next most abundant species at each site. *Galinsoga parviflora* was

Table 1 Numbers of seed per m^2 at a depth of 45 cm in four-weed control measures and averaged moisture conservation practices.

Total weed seeds	Dera	Melkassa
Weed control measures		
W_0 (weedy check)	187	222
W_1 (Primagram)	184	144
W_2 (Primagram + 2, 4-D)	137	105
W_3 (2, 4-D)	135	366
LSD (0.05)	29.92	66.51
Moisture conservation practices		
FB (Flat bed)	154	262
R & F (Ridge and furrow)	160	300
FB + SM (Flat bed + straw mulch)	167	168
R & F + SM (Ridge and furrow + straw mulch)	152	203
LSD (0.05)	35.22	37.08

Table 2 Influences of weed control measure and moisture conservation practices on vertical distributions of total weed seed (%) to a 45 cm soil depth after maize cropping.

	Dera				Melkassa			
Depth (cm)	Weed control measures							
	W_0	W_1	W_2	W_3	W_0	W_1	W_2	W_3
0-15	43.5	40.2	40	61	59.1	56.8	62.7	58.3
15-30	39.8	46.5	37.3	18.4	28.7	33.5	22.9	19.7
30-45	16.8	13.3	22.7	20.6	12.2	9.7	14.4	22
Moisture conservation practices								
Depth (cm)	FB	R & F	FB + SM	R & F + SM	FB	R & F	FB + SM	R and F + SM
0-15	48.8	51.8	36.5	48.6	61.3	59.2	58.8	55.9
15-30	31	33.8	46.9	30.3	23.2	28.7	30.4	26
30-45	20.2	10.6	10.8	21.1	15.5	12.1	10.8	18.1

W_0 = weedy check, W_1= primagram @ 3 L/ha, W_2 = primagram @ 3 L/ha + 2, 4-D @ 1 L/ha, and W_3 = 2, 4-D @ 1 L/ha. FB = flat bed, R & F = ridge and furrow, FB + SM= flat bed + straw mulch, and R & F + SM = ridge and furrow + straw mulch. L_1 = Dera and L_2 = Melkassa found in all weed control measures at both sites but was not present in post herbicide treatment.

Commelina benghalensis, Agenatum spp, Convolvulus spp were very small in number and commonly found in Dera while *Euphorbia heterophylla, Leucas martini, Sidaalba spp, Tagets minuta, Tribulus spp, and Portulaca oleracea* were found only in Melkassa.

CONCLUSION

In this study, the herbicides and residues could influence weed population levels, the rate of population growth and species composition. This might indicate that herbicides and residues were effective enough to prevent excessive weed seed production. This result was obtained from one-year data, the long–term effects of herbicide and residue on weed populations were not studied. Further studies are needed to examine the interaction effects of herbicide with residue application, allelophaty and shading effects and may result in reduced weed seedling emergence. It also needs further study on farmer's field where

Table 3 Distribution of weed seed by soil depth as affected by weed control and moisture conservation practices.

Weed control	Moisture conservation	Dera 0-15	Dera 16-30	Dera 31-45	Melkassa 0-15	Melkassa 16-30	Melkassa 31-45
		Weed seed as affected by depth (cm) No m^{-2}					
Weedy check (control)							
	FB	35	18	3	42	16	14
	R & F	24	20	5	31	11	6
	FB + SM	28	14	5	21	10	16
	R & F +SM	23	7	5	29	14	12
Primagram @ 3 L/ha (pre-emergence)							
	FB	23	15	1	18	12	8
	R & F	42	16	12	17	10	5
	FB + SM	25	12	4	15	13	4
	R & F + SM	12	20	2	27	7	8
Primagram @ 3 L/ha and 2, 4-D @ 1 L/ha (pre and post-emergence)							
	FB	6	87	3	13	7	7
	R & F	15	7	2	19	8	5
	FB + SM	37	12	6	11	5	4
	R & F + SM	16	19	6	15	5	6
2, 4-D @ 1 L/ha (post-emergence)							
	FB	33	4	5	85	22	19
	R & F	13	8	6	82	25	25
	FB + SM	14	8	2	13	8	7
	R & F + SM	21	15	6	45	20	15

FB = flat bed, R & F = ridge and furrow, FB + SM= flat bed + straw mulch, and R & F + SM = Ridge and furrow + straw mulch. L_1 = Dera and L_2 = Melkassa herbicides and residues were rarely or not applied. The results and information obtained would expedite the development of management strategies to reduce populations of weed with seed bank regeneration strategies and to manage the successional dynamics of weed in weed control measures.

Table 4 Seed bank compositions (45 cm deep) in two sites after one year of maize cropping with four weed control measures.

Species	Seed bank composition as affected by soil and weed control							
	Dera				Melkassa			
	W_0	W_1	W_2	W_3	W_0	W_1	W_2	W_3
Chenopodium fasciulosum	*43*	*89*	*56*	*55*	*10*	*30*	*9*	*11*
Flaveria trinerva	12	3	1	1	24	13	7	12
Cyperus rotundus	26	19	7	2	12	6	1	27
Amaranthus hybridus	2	2	4	1	5	14	11	6
Eragrostis aspera	19	9	36	24	5	3	6	19
Argemone mexicana	15	9	7	3	16	7	5	3
Sorghum arundenanceum	26	13	3	22	9	2	1	19
Nicandra physaloides	1	3	5	3	3	4	12	6
Heliotropism cineraseioen	7	13	8	11	5	8	6	2
Anagalis arvensis	12	3	2	7	9	3	2	3
Datura stramonium	3	7	0	0	3	7	0	0
Euphorbia heterophylla	*	*	*	*	4	1	0	2
Galinsoga parviflora	1	3	1	0	1	3	1	0
Launea comuta	2	0	1	2	2	1	1	1
Portulaca oleracea	*	*	*	*	1	1	1	0
Foeum vulgare	1	1	1	2	0	0	0	2
Tagetes minuta	*	*	*	*	0	2	0	0
Erucastrum arabicum	2	3	3	4	0	1	1	0
Setaria pumila	1	1	1	0	0	1	1	0
Eleusine indica	0	1	0	0	0	1	0	0
Xanthium strumarium	2	0	2	0	1	0	0	0
Commelina benghalensis	1	0	0	0	*	*	*	*
Ageratum conyzoides	1	3	0	1	*	*	*	*
Convolvulus arvensis	3	0	0	1	*	*	*	*
Leucas martini	*	*	*	*	0	1	0	1
Sidaalba spinosa	*	*	*	*	0	0	0	1
Tribulus terrestris	*	*	*	*	1	1	1	1

Values are means of 3 replications at Melkassa and Dera sites.* Species not found at that site; W_0 = weedy check (control); W_1 = Primagram 660 SC @ 3 L/ha (pre emergence); W_2 = Primagram 660 SC @ 3 L/ha and 2, 4-D @ 1 L/ha (pre and post emergence); W_3 = 2, 4-D @ 1 L/ha (post emergence). L_1 = Dera and L_2 = Melkassa

LITERATURE CITED

Ball, D. A. and S. D. Miller. 1989. A composition of techniques for estimation of arable soil seed banks and relationship to weed flora. **Weed Res.** 29: 365-373.

Barralis, G. and R. Chadoeuf. 1980. Etude de la dynanique d' une communaute adventice. 1. Evolution de la flora adventice au course du cycle vegetative d'une culture. **Weed Res.** 20: 231-237.

Buhler, D. D., J. L. Gunsolus and D. F. Ralston. 1992. Integrated weed management techniques to reduce herbicide inputs in Soybean. **Agron. J.** 84: 973-978.

Burnside , O. C., R. S. Moomaw, F. W. Roeth, G. A. Wicks and R. G. Wilson. 1986. Weed seed demise in soil in weed free corn (*Zea mays* L.) production across Nebraska. **Weed Sci.** 34: 248-251.

Cavers, P. B. and D. L. Benoit 1989. Seed banks in arable land. pp 309-328 *in* M. A. Leck, V. T. Parker and R. L. Simpson, eds. Ecology of Soil Seed Banks. **Academic Press New York**

Chepil, W. S. 1946. Germination of weed seeds: 11. The influence of tillage treatments on germination. **Science. Agric** 8: 347-357.

Harper, C. A. 1977.The seed bank, pp 83-110. *In: P*opulation Biology of plants. **Academic Press, London**.

Herr, D. E. and E. W. Stroube. 1970. Velvetleaf control as influenced by herbicide placement and seed depth. **Weed Sci.** 18: 459-461.

Maxwell, B.D. and C. Ghersa. 1992. The influence of weed seed dispersion versus the effect of competition on crop yield. **Weed Techn.** 6: 196-204.

Mester, J. C. and D. D.Buhler.1990. Effect of seedling depth on Velvetleaf seedling development and response to cynazine. **Weed Sci.** 38: 34-38.

Roberts, H. A. 1963. Studies ion the weeds of vegetable crops. 111. Effect of different t primary cultivation on the w weed seeds in the soil. **J. of Ecology** 51: 83-95.

Roberts, H. A. 1968. The changing population of viable weeds seeds in an arable soil. **Weed Res.** 8: 253-256.

Roberts, H. A. and J. E. Neilson. 1981. Seed banks in soils**. Adv. Appl. Biology** 6: 1-55.

Schweitzer, E. E. and R. L. Zimdahl. 1984. Weed seed decline in irrigated soil after six years of continuous corn (*Zea mays* L.) and herbicides. **Weed Sci.** 32: 76-3.