J. BIOL. ENVIRON. SCI.,
2012, 6(17), 189-193

Effects of Cowpea Living Mulch on Weed Control and Maize Yield

Reza Moradi Talebbeigi* **and Hossein Ghadiri**
Department of Crop Production and Plant Breeding, College of Agriculture, Shiraz University, Shiraz, IRAN

Received: 29.11.2011; Accepted: 29.05.2012; Available Online: 11.07.2012

ABSTRACT

Field experiments were conducted in 2009 and 2010 in research station of college of agriculture, Shiraz University of Iran, to evaluate the effects of cowpea (*Vigna unguiculata* L.) living mulch on weed suppression, maize (*Zea mays* L.) grain yield and yield components. Treatments were cowpea living mulch densities (7, 15, 22 and 30 plants m^{-2}), suppression periods of cowpea growth with 2,4-D (30, 45, 60, 75 and 90 days after maize planting), and two control treatments, a weed free and a weedy check. Results of both years showed that cowpea densities significantly controlled weeds. The lowest weeds biomass and the highest maize grain yield were obtained from 30 and 22 plants m^{-2} of cowpea living mulch density, respectively. In both years, the lowest weeds biomass and the highest maize grain yield, in comparison to the weedy check, were obtained when cowpea growth was terminated 90 and 75 days after maize planting, respectively. It is concluded that, to achieve the highest maize grain yield and yield components and to suppress the weeds, cowpea living mulch at 22 plants m^{-2} and suppression period of cowpea at 75 days after maize planting, is recommended as a step toward sustainable agriculture.

Key Words: Maize yield, Sustainable agriculture, Redroot pigweed, common lambsquarters

INTRODUCTION

Weed control is a major challenge in maize production because weeds can reduce yield up to 86% (Bijanzadeh and Ghadiri 2006). A broad spectrum of grasses and broadleaved weeds infests maize fields in Iran among which redroot pigweed (*Amaranthus retroflexus* L.) and common lambsquarters (*Chenopodium album*.L.) are the most troublesome (Zaremohazabieh and Ghadiri 2011). Herbicide use is an essential component of successful maize production. However, the use of large quantities of herbicides is often associated with environmental pollution (Hall et al. 1992). The adoption of sustainable and organic agricultural production in recent years has resulted in an increased use of living mulch systems. Such systems consist of a species pre-sown or interplanted with a main crop in order to serve as a soil cover, which contributes, among other things, towards weed suppression (Teasdale 1996, and Theunissen 1997), the protection against soil erosion and the improvement of soil structure (Duda et al. 2003). Other agronomic benefits of living mulches are summarized in the review by Feil and Liedgens (2001). Legumes such as cowpea used in these practices play a dual role in agroecosystems by protecting the soil from erosion and by enriching it with organic matter and nitrogen through *Rhizobium* symbiosis (Caamal-Maldonado et al. 2001). In addition, the impaired weed growth by the use of cowpea may result from a combination of reduced light and prevented extreme temperature changes due to the ability of cowpea to grow well in warm season and produce a high biomass (Hall et al. 1984, and Harrison et al. 2006). The success of this system is dependent on proper suppression time of living mulch growth. Living mulches can compete for nutrients and water with the main crop, (Echtenkamp and Moomaw 1989) and this can reduce yields. Meanwhile, living mulches may eventually need to be mechanically or chemically killed (Brandsaeter et al. 1998, and Tharp and Dells 2001). The objectives of this experiment were to determine the optimum planting density of the cowpea living mulch and suppression time, and to evaluate effects of cowpea living mulch on weed control and yield and yield components of maize.

MATERIALS AND METHODS

Field experiments were conducted during the 2009 and 2010 at the experimental research center (Badjgah), Shiraz University (52° 46' E, 29° 50' N and 1810 m), Iran. In both years, plots were located on a silty clay loam soil with 1.16% organic matter, 15 to 18% sand, 50 to 56% silt, 15 to 20% clay and pH of 7.8. The mean monthly temperature in two years is given in table 1. Seedbed preparation included moldboard plowing and subsequently disc-harrowed. The field was fertilized according to soil test recommendations with 150 kg triple superphosphate fertilizer ha^{-1} and 450 kg urea fertilizer ha^{-1}. Maize seeds (SC 704) were planted 5 cm deep by Pneumatic drill on May 28th in both years. Each plot was 3 m wide by 6 m long and consisted of 4 rows of maize with 75 cm between-row and 15 cm within-row spacing. The seeds of cowpea CV. Mashhad (purchased from Dezfull Agriculture Research Department) were hand sown in two lines on ridges in plot on May 29th in both years.

* Corresponding author: reza.2000mt24@gmail.com

Table 1. Average temperatures (ºC) during growing seasons in 2009 and 2010.

Months	2009	2010
May-Jun	22.58	21.57
Jun-Jul	26.00	24.71
Jul-Aug	24.11	25.91
Aug-Sep	22.21	22.03

The experimental design was split plot arranged in randomized complete blocks design with four replications. Cowpea densities were considered as main factors at four levels (7, 15, 22 and 30 plants m^{-2}) and suppression periods of cowpea with 2,4-D (Trade name: U46, 0.72 kg ai L^{-1}) were sub factors at five levels (30, 45, 60, 75 and 90 days after maize planting). Two control treatments, weed free and weedy check, were also included. In weed free plots, weeds were controlled by hand. Plots were uniformly irrigated by siphon at planting time. Maize grain yield was determined by harvesting of maize plants from the middle two rows of each plot. The harvested cobs were shelled, weighed and grain weight adjusted to 15% moisture. Weeds were harvested from 1 m^{-2} area in each plot. Weeds were separated by species, counted, then oven dried at 75ºC for 48h, and weighed. Grain yield data and all other data were submitted to an analysis of variance (ANOVA) and Least Significant Different test (LSD) was used to verify the significant differences among treatment means at the 5% probability level (Little and Jackson 1978).

RESULTS

Weeds control

In both years, predominant weed species were redroot pigweed and common lambsquarters. Results of both years showed that cowpea living mulch had significant effect on weeds. In 2009 and 2010, the lowest biomass, density and height of redroot pigweed and common lambsquarters were obtained with application of cowpea living mulch at 30 plants m^{-2} (Table 2). Application of cowpea living mulch at 30 plants m^{-2} reduced redroot pigweed biomass (approximately 41 and 39% during 2009 and 2010, respectively) and common lambsquarters biomass (approximately 35 and 29% during 2009 and 2010, respectively). On the contrary, the application of cowpea living mulch at 7 plants m^{-2} couldn't control weeds (Table 2).

Table 2. Effect of cowpea living mulch densities on weed growth during 2009 and 2010.

Year	Cowpea living mulch density (plant/m^{-2})	*Amaranthus retroflexus* L.			*Chenopodium album* L.		
		Biomass (g/m^{-2})	density (weed/m^{-2})	height (cm)	Biomass (g/m^{-2})	density (weed/m^{-2})	height (cm)
2009	7	397.10	3.8	179.3	527.08	4.7	145.5
	15	308.91	3.3	178.7	415.12	3.5	137.2
	22	259.19	2.8	170.9	395.26	3.6	131.5
	30	231.29	2.5	163.7	320.08	3.1	114.5
	LSD (5%)	**62.95**	**0.57**	**7.46**	**49.73**	**0.42**	**8.21**
2010	7	300.52	2.9	130.1	226.60	2.0	125.4
	15	246.83	2.7	120.4	258.94	2.3	118.5
	22	216.60	2.4	114.3	216.60	2.1	96.1
	30	194.38	2.0	107.8	158.75	1.6	80.7
	LSD (5%)	**39.22**	**0.48**	**2.16**	**57.65**	**0.36**	**21.08**

Results showed that growth suppression periods of cowpea living mulch had significant effect on weeds. In both years, maximum control of redroot pigweed and common lambsquarters was obtained when cowpea living mulch growth was terminated at 90 days after maize planting (12 leaf stage of maize) (Table 3). Minimum control of redroot pigweed and common lambsquarters were obtained when cowpea living mulch growth was terminated at 45 and 60 days after maize planting (6 and 8 leaf stages of maize) and worst control of weeds was achieved cowpea living mulch growth was terminated at 30 days after maize planting (4 leaf stage of maize) (Table 3). In both years, growth suppression period of cowpea living mulch with 2,4-D at 90 days after maize planting, in comparison to the weedy check, reduced redroot pigweed biomass (up to 50%) and common lambsquarters (up to 35%) (Table 3).

Table 3. Effect of suppression period of cowpea living mulch on weed growth during 2009 and 2010.

Year	Suppression period of cowpea living mulch (days after maize planting)	*Amaranthus retroflexus* L.			*Chenopodium album* L.		
		Biomass (g/m^{-2})	density ($weed/m^{-2}$)	height (cm)	Biomass (g/m^{-2})	density ($weed/m^{-2}$)	height (cm)
2009	Weedy check	521.60	5.1	219.0	364.42	3.6	168.5
	30	398.29	4.0	211.3	305.83	3.1	141.8
	45	363.76	3.8	209.0	291.58	3.1	136.8
	60	289.70	3.1	207.3	256.33	2.8 b	136.1
	75	267.78	2.9	194.3	225.24	2.5	127.1
	90	252.73	2.8	171.1	233.68	2.4	116.7
	LSD (5%)	**61.50**	**0.61**	**9.80**	**43.33**	**0.44**	**4.67**
2010	Weedy check	686.87	6.6	184.8	398.06	3.8	160.7
	30	552.66	4.8	163.6	290.76	2.5	137.1
	45	496.63	4.5	159.6	174.08	1.6	103.4
	60	464.95	4.2	149.6	170.54	1.5	95.4
	75	404.41	3.5	138.1	228.41	2.0	118.9
	90	295.17	2.7	129.3	244.70	2.5	120.7
	LSD (5%)	**92.17**	**0.85**	**8.17**	**75.42**	**0.74**	**28.25**

Maize grain yield and yield components

Results showed that increasing density of cowpea living mulch from 7 to 30 plants m^{-2} had significant changes on the maize grain yield and yield components. The number of grains per cob plays an important role in determining the final yield of maize. In 2009 and 2010, cowpea living mulch density at 22 plants m^{-2} improved maize grain yields compared to the other treatments (Table 4). Meanwhile, this treatment had the highest maize grain yield, 1000 grain weight, number of grains per row, number of rows per cob and number of grains per cob (Table 4). Application of cowpea living mulch at 22 plants m^{-2} increased maize grain yield (up to 11 and 26% during 2009 and 2010, respectively). In both years, cowpea living mulch density at 7 plants m^{-2} didn't completely control weeds and therefore, maize grain yield and yield components especially number of grains per cob decreased (Table 4).

Table 4. Effect of cowpea living mulch on maize grain yield, 1000 grain weight, number of grains per row, number of rows per cob and number of grains per cob during 2009 and 2010.

Year	Cowpea living mulch density (plant/m)	Grain yield (t/ha^{-1})	1000 grain weight (g)	Number of grains per row	Number of rows per cob	Number of grains per cob
2009	7	10.3	257.39	47.1	10.6	500.3
	15	10.9	264.28	50.6	10.5	513.3
	22	11.5	265.42	53.3	10.5	542.2
	30	10.9	265.07	49.7	10.7	515.9
	LSD (5%)	**0.83**	**4.17**	**2.65**	**0.47**	**40.87**
2010	7	8.9	254.21	37.2	11.6	440.5
	15	9.1	252.03	39.9	11.2	453.2
	22	11.3	256.00	42.2	13.1	557.2
	30	10.1	258.64	40.7	11.8	488.7
	LSD (5%)	**1.18**	**4.81**	**1.67**	**1.32**	**64.49**

In both years, weed free check had the highest maize grain yields (14.8 t/ha in 2009 and 12.4 t/ha in 2010). Maize yields in weedy checks were reduced by approximately 41% (Table 5). Results showed that growth suppression periods of cowpea living mulch had significant effect on maize grain yield and yield components. All growth suppression periods of cowpea living mulch treatments improved maize grain yields compared to the weedy check. In both years, the highest maize grain yield (11.4 t/ha in 2009 and 10.5 t/ha in 2010), in comparison to the weedy check, were obtained when cowpea living mulch growth was terminated at 75 days after maize planting (10 leaf stage of maize) (Table 5). In both years, the number of grains per cob increased (approximately 22 and 40% during 2009 and 2010, respectively) when cowpea living mulch growth was terminated at 75 days after maize planting compared to the weedy check (Table 5).

Table 5. Effect of suppression period of cowpea living mulch on maize grain yield, 1000 grain weight, number of grains per row, number of rows per cob and number of grains per cob during 2009 and 2010.

Year	Suppression period of cowpea living mulch (days after maize planting)	Grain yield (t/ha^{-1})	1000 grain weight (g)	Number of grains per row	Number of rows per cob	Number of grains per cob
2009	Weed free check	14.8	284.93	59.6	11.5	649.6
	Weedy check	8.7	249.56	43.1	10.3	439.0
	30	9.5	258.31	45.8	10.2	463.5
	45	10.2	258.93	48.3	10.6	494.0
	60	10.7	261.75	50.1	10.5	512.5
	75	11.4	267.06	51.6	10.8	535.6
	90	11.0	260.75	52.6	10.2	531.3
	LSD (5%)	**0.86**	**5.33**	**3.76**	**0.62**	**39.41**
2010	Weed free check	12.4	259.43	43.8	13.7	601.8
	Weedy check	7.3	247.81	36.8	10.0	371.3
	30	8.5	255.68	36.9	11.2	418.2
	45	9.8	252.50	40.6	11.8	488.8
	60	10.5	257.31	41.0	12.3	513.0
	75	10.5	254.00	41.4	12.5	521.7
	90	9.9	259.81	39.5	11.8	479.6
	LSD (5%)	**1.27**	**6.92**	**2.80**	**1.09**	**65.84**

DISCUSSION

Since cowpea living mulch had significant effect on weed growth, it is concluded that, minimum reduction in weed growth was obtained from low cowpea living mulch densities which were significantly different from the other treatments. Meanwhile, high living mulch densities provided better weed control compared to the low densities. In this research, cowpea living mulch density at 30 plants m^{-2} obtained the highest rank compared with the other cowpea densities. Brady and Weil (2002) reported that living mulch could function as a weed management tool via competition for resources and light. Moosavi et al. (2005) found that increasing bean density from 20 to 30 and 40 plants m^{-2} caused an increase in the threshold of economic damage of redroot pigweed from 0.5 to 1 and 2.7 plants m^{-2}. Research showed that the highest maize grain yields were obtained from 22 plants m^{-2} of cowpea living mulch density probably due to reduced effect of weed competition (Akobundu 1993). Low cowpea living mulch densities of 7 and 15 plants m^{-2} decreased maize grain yield due to poor control of weeds and greater competition for light, water, and nutrients between weeds and maize (Thorsted et al. 2006). Maize grain yield reduction with high density of cowpea living mulch (30 plants m^{-2}) could have been due to a higher degree of interspecific competition in mixed stands as compared to the absence of interspecific competition in monoculture (Agboola and Fayemi 1971, and Enyi 1973).

In both years, growth suppression periods of cowpea living mulch decreased weed growth probably due to either changes in soil temperature, release of allelopathic chemicals, or physical impediments to weed seedlings (Facelli and Pickett 1991, Teasdale and Mohler 1993, and Teasdale 1996). There are a number of mechanisms responsible for the effect of cowpea living mulch on weeds. The living mulch can reduce light (Teasdale and Mohler 1993) and moisture available to germinating seeds. Filtration of red light by the leaf canopy of live vegetation is known to reduce the red to far-red ratio of transmitted light causing an inactivation of phytochrome and inhibition of seed germination (Taylorson 1969). Meanwhile, results showed that retaining cowpea living mulch at 60 to 75 days after maize planting can increase maize grain yield due to better weed control. Weeds reduction could have occurred either through resource competition, promoting conditions that are unfavorable for germination and establishment (Teasdale 1993), retaining cowpea residues on the soil surface, or by means of allelopathy (Adler and Chase 2007). Hutchinson and McGiffen (2000) reported that retaining cowpea living mulch at 60 days after planting reduced weed populations in bell pepper (*Capsicum annum* L.). In addition, results showed that retaining cowpea living mulch up to 75 days after maize planting reduced maize grain yield due to great competition between maize and cowpea (Akobundu 1982, and Echtencamp and Moomaw 1989).

The results suggest that cowpea living mulch is a good candidate for use as the summer companion with maize. Cowpea living mulch suppressed weeds and can reduce weed growth. Likewise, control of weeds through cowpea living mulch may ultimately result in reduction in herbicide inputs. Overall, it is concluded that to guarantee the maximum maize grain yield and minimum weeds growth, as compared to the weedy check, cowpea living mulch at 22 plants m^{-2} and suppression period of cowpea at 75 days after maize planting is recommended.

ACKNOWLEDGMENT

This project was funded by a grant from the Research Council and Graduate Center of Shiraz University, Shiraz, Iran.

REFERENCES

Adler MJ, and Chase CA (2007). A comparative analysis of the allelopathic potential of leguminous summer cover crops: cowpea, sunn hemp and velvetbean. Hort Science 42: 289-293.

Agboola AA, and Fayemi AA (1971). Preliminary trials on the intercropping of Maize with different tropical legumes in western Nigeria. Journal of Agricultural Science (Cambridge) 77: 219-225.

Akobundu IO (1982). Live mulch crop production in the tropics. World Crops 34: 125-126.

Akobundu IO (1993). Integrated weed management techniques to reduce soil degradation. International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria Research Notes 6: 11–16.

Bijanzadeh E, and Hossein G (2006). Effect of separate and combined treatments of herbicides on weed control and maize (*Zea mays* L.) yield. Weed Technol 20:40-645.

Brandsaeter LO, Netland J, and Meadow R (1998). Yields, weeds, pests and soil nitrogen in a white cabbage-living mulch systems. Biol Agric Hortic 16: 291–309.

Brady NC, and Weil RR (2002). The nature and properties of soils. Upper Saddle River, N.J., Prentice Hall, 13th edition.

Caamal-Maldonado JA, Jimenez-Osornio JJ, Torres-Barragan A, and Anaya AL (2001). The use of allelopathic legume cover and mulch species for weed control in cropping systems. Agron J 93: 27-36.

Duda GP, Guerra JGM, Moneiro MT, De Polli H, and Teixeira MG (2003). Perennial herbaceous legumes as live soil mulches and their effects on C, N and P of the microbial biomass. Scientia Agricola 60: 139–147.

Echtenkamp G, and Moomaw R (1989). No-till corn production in a living mulch system. Weed Technol 3: 261-266.

Enyi BAC (1973). Effects of intercropping maize or sorghum with cowpeas, pigeon peas or beans. Exp Agric 9: 83-90.

Facelli JM, and Pickett STA (1991). Plant litter: Its dynamics and effects on plant community structure. Bot Rev 57: 1-32.

Feil B, and Liedgens M (2001). Crop production in living mulches: a review (in German, with English abstract). Flanzenbauwissenschaften 5: 15–23.

Hall JK, Hartwig NI, and Hoffman LD (1984). Cyanazine losses in runoff from no-tillage corn in living mulch and dead mulches vs. unmulched conventional tillage. J Environ Qual 13: 105–110.

Hall MR, Swanton CJ, and Anderson GW (1992). The critical period of weed control in grain maize (*Zea mays*). Weed Sci 40:441-447.

Harrison HF, Thies JA, and Fery RL (2006). Evaluation of cowpea genotypes for use as a cover crop. Hort Science 41: 1145-1148.

Hutchinson CM, and McGiffen Jr. ME (2000). Cowpea cover crop mulch for weed control in desert pepper production. Hort Science 35: 196-198.

Little TM, and Jackson FJ (1978). Agricultural Experimentation: Design and Analysis. Wiley, New York, 350pp.

Moosavi k, Zand E, and Baghestani MA (2005). Effects of crop density on interference of common bean (*Phaseolus vulgaris* L.) and weeds. Pests and Disease Journal 73: 79-92.

Zaremohazabieh S, and Hossein G (2011). Effects of rimsulfuron, roramsulfuron and conventional herbicides on weed control and maize yield at three planting dates. J Biol Environ Sci 5: 47-56.

Taylorson RB, and Borthwick HA (1969). Light filtration by foliar canopies: significance for light-controlled weed seed germination. Weed Sci 17: 48-51.

Teasdale JR (1996). Contribution of cover crops to weed management in sustainable agricultural systems. J Prod Agric 9: 475–479.

Teasdale JR, and Mohler CL (1993). Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. Agron J 85: 673–680.

Tharp BE, and Dells JJ (2001). Delayed burndown in no-tillage glyphosate-resistant corn (*Zea mays*) planted into soybean (*Glycine max*) residue and a wheat (*Triticum aestivum*) cover crop. Weed Technol 15: 467-473.

Theunissen J (1997). Application of intercropping in organic agriculture. Biol Agric Hortic 15: 251–259.

Thorsted MD, Olesen JE and Weiner J (2006). Width of clover strips and wheat rows influence grain yield in winter wheat/white clover intercropping. Field Crops Res 95: 280–290.