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Interaction Effects of Weed Interference and Berseem Clover (Trifolium Alexandrinum) as A Living Mulch on Corn (Zea Mays)

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ABSTRACT

In order to investigate the interaction effects of weed interference and berseem clover as a living mulch on corn yield and quality a field experiment was conducted at the Agricultural Research Farm of Razi University, Kermanshah, Iran. The experiment was a factorial with three factors based on a complete block design with four replications. The first factor was the weed treatments (weedy and weed-free for the entire growing season), the second factor was three berseem clover interseeding times (15 days before, simultaneous with and 15 days after corn planting), and the third factor was three berseem clover interseeding rates (0, 20 and 40 kg ha-1). The results revealed that weed interference for the entire growing season significantly reduced corn plant traits including yield, yield components, harvest index and seed oil content. However, in weedy condition the earlier interseeding of the living mulch (15 days before corn planting) notably improved corn plant traits when compared with other two interseeding times. Whereas, in weed free condition the earlier living mulch interseeding showed the negative impacts on some of the studied traits including yield probably due to the higher interspecific corn-berseem clover competition. Therefore, in this condition delayed interseeding of the living mulch is highly recommended.

Key words: Berseem clover, corn, living mulch, weed.

Introduction

Corn is a strategic crop in Iran which is extensively grown as a source of human and animal feed and Kermanshah province is one of the most important corn producer regions in Iran. Among the environmental factors, weeds are serious constraint to increased production in corn and reduce yield, quality and economic returns. Weed competition can cause yield reductions of up to 70% in corn grain yields [31]. Weeds can suppress corn yield by competing for environmental resources [24] and production of allelopathic compounds [25,3].

In sustainable agriculture, an effective method to improve crop yield and reduce the environmental stresses such as weeds is the use of living mulch in cropping systems. Living mulches are plants intercropped with a main crop that can decrease erosion [32], suppress weeds [8], reduce insect pests [17] and increase soil water infiltration [5]. Legume living mulches improve the soil nutrient status through the addition of organic nitrogen [4,12] via fixed atmospheric nitrogen, which improves the physical properties of soil [19,15]. Moreover, interseeded legume living mulch can enhance the yield of the companion main crop [20]. Among legumes, clover species are considered poor competitors because of small seed size, lack of seedling vigor, and slow establishment [16]. Therefore, they can be suitable candidates for these kinds of cropping systems.

Berseem clover (Trifolium alexandrinum L.) is a high yielding, nutritious, cool season forage legume crop thought to have originated in the Middle East (Knight 1985). Berseem clover has potential as a cover crop or annual forage in living mulch cropping systems [26]. It can be mowed several times for forage and then ploughed as green manure, yielding 33-66 kg/ha of nitrogen or it can be allowed to produce seed following the final cutting (Knight 1985). Inter-cropping berseem clover with cereals increased yield and quality of cereal crops and reduced fertilizer needs and increased subsequent crop yields. From the perspective of soil benefits and sustainability, plough-down of berseem clover re-growth could increase soil N, reduce fertilizer requirements and improve soil quality [27].

However, a serious problem in most of the living mulch cropping systems is yield depression of the main crop because of competition which is influenced by several factors. Both the timing and rate of living mulch interseeding are the important

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factors that can determine the 4 success of a corn–living mulch cropping system. These factors are critical to reduce competition by the living mulch with the main crop for environmental resources while allowing the mulch to grow and cover the soil surface sufficiently to reap potential benefits.

The present study was conducted to investigate the interaction effects of weed interference and berseem clover as a living mulch interseeded at different times and rates on corn yield and quality.

Materials and Methods

The study was carried out in 2009 at the Agricultural Research Farm of Razi University, Kermanshah, western Iran. The soil type was a silty clay with a pH of 7.8 and 0.8% organic matter. The land was plowed and disked before planting. Fertilizers were applied according to the soil test recommendation. The corn cultivar used was "KSC 704" (a grain corn cultivar which is commonly planted in the region). In order to protect against soil-borne diseases, prior to seeding, the corn seeds were treated with benomyl at 0.2% (w/w). The crop was planted on 15 May 2009. Corn is an irrigated crop in western Iran; therefore, it is not dependent on seasonal rainfall. Irrigations were carried out as needed throughout the growing season (at 7–9 day intervals). The experiment was conducted in a factorial arrangement based on a complete block design with four replications. The first factor was the weed treatments (weedy and weed-free for all of the growing season), the second factor was three berseem clover interseeding times (15 days before, simultaneous with and 15 days after corn planting) and the third factor was three berseem clover interseeding rates (0, 20 and 40 kg ha-1). The dominant weed species were Amaranthus retroflexus L. (redroot amaranth), Chenopodium album L. (lamb's quarters), Xanthium strumarium L. (cocklebur), Sorghum halepense L. (johnson grass) and Purtulaca oleracea L. (common purslane), which are common weed species in corn fields in the region. In the weed-free plots, manual weeding was carried out throughout the growing season. Each plot consisted of six corn rows of 6 m length, with a row spacing of 75 cm and with 20 cm between plants in the same row. Berseem clover was manually broadcasted over the plots at the predetermined seeding rates and times.

To determine the biological yield (the total aboveground biomass), at maturity the corn plants which were located 5 m from the two center rows of each plot were harvested manually, allowed to dry to a constant weight and weighed. Then the corn plants were threshed and cleaned and seed yield was determined. Harvest index (HI) was calculated using the following equation:

$$HI = (\text{seed yield} / \text{biological yield}) \times 100$$

Before final harvesting, corn yield components, including the number of ear per plant and the number of seed per ear were determined on twenty randomly selected plants in the center rows of each plot. Additionally, 100-seed weight was determined according to the recommendations of the International Seed Testing Association (ISTA) [7]. Seed oil content was measured according to the methods of the American Oil Chemists Society [2]. The data analyses were carried out by using SAS software [28].

Results and Discussion

Analysis of variance (data not shown) revealed that all of the traits under study including seed yield (SY), the number of ear per plant (NEP), the number of seed per ear (NSE), 100- seed weight (SW), harvest index (HI) and seed oil content (SOC) were significantly influenced by the weed treatments (at the 0.01 level of probability). Moreover, a significant three-way interaction (weed treatment × berseem clover interseeding time × berseem clover interseeding rate) was observed for all of the evaluated traits.

Weedy condition for the entire growing season reduced SY, NEP, NSE, SW, HI and SOC by 41.1, 3.6, 23.1, 21.0, 9.3 and 40.0%, respectively as compared with full season weed free condition (Table 1). This can be attributed to the weed-crop competition to obtain the environmental resources such as light, water and nutrients [24]. Other researchers found that weed interference can cause reductions of 35-70% in the corn yield [31,10]. In other studies Mohammadi [20.21] reported that full season weed infestation decreased corn yield by 30.7- 48.2% as compared with weed free condition. According to Rajcan and Swanton [24] excluding environmental variables, yield losses in corn are caused mainly by competition from weeds. Oil content of corn seeds was also significantly reduced due to weed interference (Table 1). Similar results were reported by Johnson [13] working with sunflower, Friesen [11] working with flax seed, RajabLarijani and AghaAlikhani [23] working with canola. In present study, weedy condition also decreased harvest index. It can be attributed to the lower corn efficiency to allocate the photoassimilates to the seeds in the presence of the weeds. Cavero *et al*. [6] also found that harvest index of corn was reduced by the presence of the competing weeds.

The highest corn yield was obtained from the control plot (the weed free plot in which no living mulch was interseeded) (Table 2). In general, in weed free condition, berseem clover at 20 or 40 kg ha-1 interseeded simultaneous with or 15 days after corn planting (DACP) didn't significantly influence corn yield as compared with control (Table 2) probably due to the lack of a severe competition between the main crop and living mulch in these treatments. Abdin *et al*., [1] found that interseeding of different living mulches either 10 or 20 days after corn planting had no significant effect on corn yield. Mohammadi [21] also reported that corn yield was not significantly influenced when hairy vetch (as a living mulch) was interseeded simultaneous with corn planting or 10 days after corn emergence. However, in the present study, living mulch interseeded 15 days before corn planting (DBCP) notably reduced corn yield in the plots in which the weeds were controlled for all of the growing season (Table 2). This is in agreement with Exner and Cruse (1993) who reported that corn yields were reduced if the interseeding date for the forage legumes was early.

Table 1: Means comparison of the weed treatment, living mulch interseeding rate and living mulch interseeding time effects on the traits under study.

Treatment	Yield (ton ha-1)	Ear/plant	Seed/ear	100-seed weight(g)	Harvest index (%)	Seed oil content(%)
			Weed			
WI	9.12 b	1.06 b	455.8 b	26.15 b	42.42 b	3.12 b
WF	15.48 a	1.10 a	593.1 a	33.12 a	46.77 a	5.20 a
			Interseeding rate			
D0	12.18 a	1.07 b	531.6 a	24.9 b	44.01 b	4.10 b
D1	12.29 a	1.11 a	509.1 a	26.5 a	44.79 a	4.28 ab
D2	12.45 a	1.06 b	532.6 a	27.05 a	44.99 a	4.36 a
			Interseeding time			
T1	12.86 a	1.09 a	538.2 a	30.17 a	45.44 a	4.58 a
T2	12.19 b	1.08 ab	524.5 ab	29.18 b	44.37 b	4.08 b
T3	11.86 b	1.06 b	510.5 b	29.6 b	43.98 b	4.08 b

Dissimilar letters in each column indicate a significant difference at the 0.05 level of probability (Duncan test).
Abbreviations: WI and WF: weedy and weed free for the entire growing season, respectively; D0, D1 and D2: berseem clover interseeded at 0, 20 and 40 kg ha-1, respectively; T1, T2 and T3: berseem clover interseeded 15 days before, simultaneous with and 15 days after corn planting, respectively.

Table 2: Means comparison of the weed treatment × berseem clover interseeding rate × berseem clover interseeding time interaction for the traits under study.

Treatment	Yield (ton ha-1)	Ear/plant	Seed/ear	100-seed weight(g)	Harvest index (%)	Seed oil content(%)
WF0 (weedy control)	8.05 f	1.04 bcd	434.6 f	24.84 cd	41.31 b	3.0 d
WID1T1	12.92 cd	1.16 a	538.3 cde	28.94 b	45.67 a	4.0 c
WID1T2	7.79 f	1.12 ab	402.6 f	24.10 d	41.98 b	2.8 d
WID1T3	8.26 f	1.04 bc	418.2 f	26.61 c	40.99 b	2.8 d
WID2T1	12.21 d	1.10 abc	530.5 de	29.40 b	45.90 a	4.6 b
WID2T2	9.73 e	1.02 cd	504.7 e	26.40 c	42.40 b	2.8 d
WID2T3	7.04 f	0.96 d	404.2 f	25.36 cd	40.93 b	2.9 d
WI0(weed free control)	16.30 a	1.10 abc	628.6 a	32.90 a	46.71 a	5.2 a
WFD1T1	13.98 bc	1.12 ab	544.8 cde	32.03 a	46.14 a	5.3 a
WFD1T2	15.18 ab	1.11 ab	569.0 abcd	32.62 a	47.03 a	5.2 a
WFD1T3	15.61 a	1.12 ab	581.2 abcd	33.67 a	46.92 a	5.3 a
WFD2T1	13.69 c	1.05 bc	552.4 bcde	32.90 a	46.91 a	5.2 a
WFD2T2	16.09 a	1.12 ab	607.7 ab	33.09 a	46.76 a	5.3 a
WFD2T3	15.90 a	1.09 abc	596.3 abc	34.10 a	47.04 a	5.3 a

Dissimilar letters in each column indicate a significant difference at the 0.05 level of probability (Duncan test).
Abbreviations: WI and WF: weedy and weed free for the entire growing season, respectively; D1 and D2: berseem clover interseeded at 20 and 40 kg ha-1, respectively; T1, T2 and T3: berseem clover interseeded 15 days before, simultaneous with and 15 days after corn planting, respectively.

Although, weedy condition drastically reduced corn yield as compared with weed free condition, but in the weedy treatments, the earlier interseeding of berseem clover (15 DBCP) notably improved corn yield as compared with weedy control treatment (the weedy plot in which no living mulch was interseeded) (Table 2). In other words, when the plots were kept un-weeded for the entire growing season, the earlier planting of living mulch had significant positive effect on corn yield (Table 2). This can be related to the earlier establishment of berseem clover and consequently more efficient competition with the weeds which could reduce the harmful effects of the weeds on corn yield. Generally, living mulches can reduce negative effects of the weeds by competing for light [30], water and nutrients [18], as well as through the production of allelopathic compounds [33]. However, in weedy condition, interseeding of berseem clover simultaneous with or 15 DACP didn’t significantly enhance corn yield over the weedy control treatment (Table 2). In general, in the presence of the weeds earlier establishment of living mulches in the field can lead to the higher suppressive effects of these plants on the weeds and consequently reduce the negative effects of the weeds on the main crop.

Harvest index, 100-seed weight and seed oil content were not significantly different between the weed free treatments (Table 2). In other words, when the field was kept free of weeds for the entire growing season, the living mulch interseeded at different rates or times had no significant effects on these traits. However, in weedy condition the earlier interseeding of berseem clover (15 DBCP) improved HI, SW and SOC as compared with weedy control treatment (Table 2).

In weed free condition, the living mulch treatments had no significant effects on the number of ear per plant with the exception of the treatment in which berseem clover was interseeded at 40 kg ha-1 and 15 days before corn planting which showed a reducing effect on this trait (Table 2). However, in the weedy plots the earlier interseeding time of the living mulch had a positive effect on the number of ear per plant (Table 2).

The number of seed per ear also showed dissimilar responses to different living mulch treatments in weedy and weed free conditions. Although, the highest number of seed per ear was occurred in the weed free control plot, but berseem clover interseeded simultaneous with or 15 days after corn planting didn't significantly reduce this yield component when the plots were kept free of weeds for the entire growing season (Table 2). In contrast, in weedy condition the later interseeding of the living mulch (simultaneous with or 15 DACP) notably decreased the number of seed per ear especially at the lower interseeding rate (20 kg ha-1) (Table 2).

In general, for both weedy and weed free conditions, interseeding time of the living mulch had more obvious influence on the traits under study as compared with interseeding rate (20 or 40 kg ha-1) (Table 2) indicating the higher importance of this factor on corn-living mulch interactions. Rahimi Petroudi *et al*. [22] also reported that the performance of rice-berseem clover intercrops was notably influenced by planting date of berseem clover. Although, in our study the appropriate time to interseed berseem clover into the corn field was different in weedy and weed free conditions. However, increased interseeding rate of the living mulch from 20 to 40 kg ha-1 had no notable effect on most of the studied traits including yield (Table 1). This can be attributed to the growth flexibility of the forage legumes such as berseem clover when they are interseeded at different rates. In another study, Mohammadi [21] found that increasing hairy vetch interseeding rate from 25 to 50 kg ha-1 didn't significantly affect corn yield.

Correlation coefficients between the corn traits (Table 3) indicated that all of the traits under study had positive and significant correlations with corn yield. Among the yield components, the number of seed per ear and 100-seed weight showed the higher positive correlations with the yield indicating the high determining effects of these components on corn yield. Similar result was reported by Mohammadi [21]. The correlation between the yield and harvest index was also positive and significant (at the 0.01 level of probability). Harvest index is the fraction of the total aboveground biomass allocated to the economic yield [29,34]. The higher HI indicates the higher crop efficiency to allocate the produced biomass to the seed yield.

Table 3: Correlation coefficients between the traits under study.

	Yield	Ear/plant	Seed/ear	100-seed weight	Harvest index	Seed oil content
Yield	1					
Ear/plant	0.64**	1				
Seed/ear	0.98**	0.58**	1			
100-seed weight	0.97**	0.55**	0.93**	1		
Harvest index	0.97**	0.68**	0.94**	0.95**	1	
Seed oil content	0.96**	0.61**	0.91**	0.97**	0.96**	1

**: Significant at the 0.01 level of probability.

Conclusion:

In general, weedy condition for the entire growing season significantly reduced the corn plant traits when compared with full season weed free condition. However, in weed free plots the earlier interseeding time of the living mulch (15 DBCP) had negative effects on some of the traits under study including yield. Therefore, when the corn field is kept free of weeds during the growing season, living mulch should be interseeded simultaneous with or after corn planting. However, in weed infested condition the earlier interseeding of the living mulch (before corn planting) is more beneficial, probably due to the higher suppressive effect of berseem clover on weed species which consequently can lower the negative impacts of the weeds on corn. It can be concluded that the appropriate time to interseed berseem clover as a living mulch into the corn cropping systems is different in weedy and weed free conditions. In addition, interseeding rates of the living mulch (20 or 40 kg ha-1) showed fewer effects on most of the evaluated traits when compared with the living mulch interseeding times. So that, there was no significant difference between two interseeding rates of the living mulch for corn yield when the field was kept weed-free for the entire growing season.

References

1. Abdin, O., B.E. Coulman, D. Cloutier, M.A. Faris, Z. Zhou, D.L. Smith, 1998. Yield and yield components of corn interseeded with cover crops. Agron J, 90: 63-68.
2. A.O.C.S., 1982. Official and Tentative Methods of American Oil Chemists Society. Published by

the American Oil Chemists Society 35, East. Wacker Drive, Chicago, U.S.A.
3. Bhowmik, P.C., J.D. Doll, 1982. Corn and soybean response to allelopathic effects of weed and crop residues. Agron J, 74: 601-606.
4. Brown, R.W., G.E. Varvel, C.A. Shapiro, 1993. Residual effects of interseeded hairy vetch on soil nitrate–nitrogen levels. Soil Sci Soc Am J, 57: 121-124.
5. Bruce, R.R., G.W. Langdale, L.T. West, W.P. Miller, 1992. Soil surface modification by biomass inputs affecting rainfall infiltration. Soil Sci Soc Am J, 56: 1614-1620.
6. Cavero, J., C. Zaragoza, M.L. Suso, A. Pardo, 1999. Competition between maize and Datura stramonium in an irrigated field under semi-arid conditions. Weed Res., 39: 225-240.
7. Draper, S.R. 1985. International rules for seed testing. Seed Sci and Technol, 13: 342-343.
8. Enache, A.J., R.D. Ilnicki, 1990. Weed control by subterranean clover (Trifolium subterraneum) used as a living mulch. Weed Technol, 4: 534-538.
9. Exner, D.N., R.M. Cruse, 1993. Interseeded forage legume potential as a winter ground cover, nitrogen source, and competitor. J Prod Agric, 6: 226-231.
10. Ford, G.T., J. Mt Pleasant, 1994. Competitive abilities of six corn (Zea mays L.) hybrids with four weed control practices. Weed Technol, 8: 124-128.
11. Friesen, G.H., 1986. Effect of weed interference on yield and quality of flax seed oil. Can J. Plant Sci., 66: 1037-1040.
12. Holderbaum, J.F., A.M. Decker, J.J. Meisinger, F.R. Mulford, L.R. Vough, 1990. Fall-seeded legume cover crops for no-tillage corn in the humid east. Agron J., 82: 117-124.
13. Johnson, B.J., 1971 Effect of weed competition on sunflowers. Weed Sci., 19: 378-380.
14. Knight, W.E., 1985. Miscellaneous annual clovers. In: Taylor, N.L. (Ed.), Clover Science and Technology. No. 25 in the Series Agronomy. American Society of Agronomy, Inc., Crop Science Society of America, Inc., Soil Science Society of America, Publishers, Madison, Wisconsin, pp: 547-562. Chapter 25.
15. Latif, M.A., G.R. Mehuys, A.F. Mackenzie, I. Alli, M.A. Faris, 1992. Effect of legumes on soil physical quality in a maize crop. Plant and Soil., 140: 15-23.
16. Lee, WO., 1985. Weed control. In N.L. Taylor (Ed.), Clover science and technology. Agronomy monograph 25 (pp. 295–308). Madison, WI, USA: Agronomy Society of America.
17. Litsinger, J.A., K. Moody, 1976. Integrated pest management in multiple cropping systems, pp: 239-316. In R.I. Papendick (ed.) Multiple cropping. ASA Spec. Publ. 27. ASA, CSSA, and SSSA, Madison, WI.
18. Mayer, J.B., N.L. Hartwig, 1986. Corn yield in crown vetch relative to dead mulches. Proc Annu Meet Northeast. Weed Sci Soc., 40: 34-35.
19. McVay, K.A., D.E. Radcliffe, W.L. Hargrove, 1989. Winter legume effects on soil properties and nitrogen fertilizer requirements. Soil Sci Soc Am J., 53: 1856-1862.
20. Mohammadi, G.R., 2009. The effects of legumes as living mulches on weed control and plant traits of corn (Zea mays L.). Korean J Weed Sci., 29: 222-228.
21. Mohammadi, G.R., 2010. Weed control in corn (Zea mays L.) by hairy vetch (Vicia villosa L.) interseeded at different rates and times. Weed Biol and Manage, 10: 25-32.
22. Rahimi Petroudi, E., G. Noormohammadi, M.J. Mirhadi, H. Madani, H.R. Mobasser, 2011. Effects of nitrogen fertilization and rice harvest height on agronomic yield indices of ratoon rice–berseem clover intercropping system. Aust J Crop Sci., 5: 566-574.
23. RajabLarijani, H.R., M. AghaAlikhani, 2011. Non-chemical weed control in winter canola (Brassica napus L.). 2nd International Conference on Agricultural and Animal Science, 22: 30-34, November 25-26, 2011, Singapore.
24. Rajcan, I., C.J. Swanton, 2001. Understanding maize–weed competition, resource competition, light quality and the whole plant. Field Crops Res., 71: 139-150.
25. Rice, E.L., 1984. Allelopathy. Orlando, Florida, Academic Press (Second Edition), 422.
26. Ross, S.M., J.R. King, R. Ce´sar Izaurralde, J.T. O'Donovan, 2001. Weed Suppression by Seven Clover Species. Agron J., 93: 820-827.
27. Ross, S.M., J.R. King, J.T. O'Donovan, D. Spaner, 2004. Forage potential of inter-cropping berseem clover with barley, oat, or triticale. Agron J., 96: 1013-1020.
28. SAS Institute, 2003. SAS/STAT. User's Guide. Version 9.1. SAS Inst., Inc., Cary, NC.
29. Sto¨ckle, C.O., S.A. Martin, G.S. Campbell, 1994. CropSyst, a cropping systems simulation model: water/nitrogen budgets and crop yield. Agric Sys., 46: 335-359.
30. Teasdale, J.R., 1993. Reduced-herbicide weed management systems for no-tillage corn (Zea mays) in a hairy vetch (Vicia villosa) cover crop. Weed Technol., 7: 879-883.
31. Teasdale, J.R., 1995. Influence of narrow row/high population corn (Zea mays) on weed control and light transmittance. Weed Technol., 9: 113-118.
32. Wall, G.J., E.A. Pringle, R.W. Sheard, 1991. Intercropping red clover with silage corn for soil erosion control. Can J Soil Sci., 71: 137-145.
33. White, R.H., A.D. Worsham, U. Blum, 1989. Allelopathic potential of legume debris and aqueous extracts.Weed Sci., 37: 674-679.
34. Williams, J.R., C.A. Jones, J.R. Kiniry, D.A. Spanel, 1989. The EPIC crop growth model. Trans ASAE, 32: 497-511.