

EFFECTS OF SOME COVER CROPS ON LIGHT EXTINCTION AND WEED COVERAGE IN SUNFLOWER FIELD

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ABSTRACT. In order to evaluate the effects of some cover crops on extinction coefficient and weed cover percentage in sunflower, a field experiment was conducted based on a randomized complete block design with nine treatments and three replicates at the Agricultural Research Station, Tabriz University of Iran, during growing season 2012-2013. Treatments were triticale, hairy vetch, rapeseed, triticale + hairy vetch, triticale + rapeseed, hairy vetch + rapeseed, application of trifluralin herbicide, and controls (weed infested and weed free without planting cover crop). Result indicated that once established, living mulches can rapidly occupy the open space between the rows of the main crop and use the light that would otherwise be available to weeds. In the all cover crops treatments, the light extinction coefficient was increased and weed cover percentage was reduced. Highest reduction in total weed species was observed in hairy vetch + rapeseed and triticale + rapeseed cover crop 61.92% and 61.43 %, respectively, compared to weed infested, so this treatment was better than trifluralin application. It concluded that cover crops could be considered as integrated strategies for weed sustainable management.

Key words: Hairy vetch; Light extinction coefficient; Rapeseed; Triticale; Weed Sustainable Management.

INTRODUCTION

Plant communities are aggregations of various species entities that compete to acquire vital resources (light, water and nutrients) in the vegetation season. Weed interference is one of the most important limiting factors which decrease crop yields and consequently global food production. Weed can suppress crop yield by competing for environmental resources like water, light and nutrients and production of allelopathic compounds (Singh *et al.* 2003; Dunea, 2008).

Light and nitrogen are two of the most important resources for plant life. Light is the energy source with which plants through photosynthesis (Bjorskman and Demming-Adams, 1995). Light is known to be an important trigger of seed germination and is one of the main factors

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explaining the stimulating effect of soil cultivation on weed seedling emergence (Wesson and Wareing, 1969; Hartmann and Nezadal, 1990; Benech-Arnold *et al.*, 2000).

The study of the light extinction coefficient (k) is related to the leaf inclination angle, phyllotaxy (leaf arrangement in the stem), the leaf area index (LAI), providing an indication of the plants efficiency on intercepting the solar radiation. Yunusa *et al.* (1993) related that a higher value of k might be assigned to a more uniform distribution of the leaf area and to the plainer architecture of the canopy.

Crops can be manipulated to increase shading of weeds by the crop canopy, to suppress weed growth, and to maximize crop yield (Borger *et al.* 2010). In general, cropping systems that reduce the quantity and quality of light in the weed canopy can be inhibited some weed seed germination and suppress weed growth and reduce their competition effects (Duke 1985; Borger *et al.*, 2010; Crotser and Witt, 2000; Rajcan *et al.*, 2002; Sattin *et al.*, 1994; Shrestha and Fidelibus, 2005; Teasdale, 1995).

Interception and reflection of short-wave radiation by mulch elements reduces the quantity of light available to the soil surface, the heat absorbed by soils during the day, and the amount of moisture evaporated from soils (Teasdale and Mohler, 1993). Weed seed germination can be negatively affected by quality and quantity of light and the lower amplitude of soil temperature fluctuation that result from the

presence of living mulches (Gallagher *et al.*, 1999; Teasdale, 1998b). Germination of weed seeds may be prevented by complete light interception (Phatak, 1992), living mulch and/or by excretion of allelochemicals (White *et al.*, 1989; Overland, 1966). A delay in emergence of weeds due to presence of living mulches can also adversely affect weed seed production. Also, living mulches leads to greater weeds seed mortality by favoring predators (Cromar *et al.*, 1999).

Researchers have used cover crops such as barley (*Hordeum vulgare* L.) (Overland, 1966), rye (*Secale cereal* L.) (Barnes and Putnam, 1986), sorghum-sudangrass (*Sorghum sudanense*) (Weston *et al.*, 1989), wheat (*Triticum aestivum* L.) (Worsham, 1991), crimson clover (*Trifolium incarnatum* L.), hairy vetch (*Vicia villosa* Roth.) (Teasdale, 1993; White *et al.*, 1989), and so on to suppress weeds. Putnam and DeFrank (1983) reported that rye residue can reduce the emergence of common ragweed (*Ambrosia artemisiifolia* L.), green foxtail (*Setaria viridis* (L.) Beauv.), redroot pigweed (*Amaranthus retroflexus* L.), and common purslane (*Portulaca oleracea* L.) up to 43%, 80%, 95%, and 100%, respectively, but this allelopathic plant had no effect on yellow foxtail (*Setaria glauca* (L.) Beauv.) emergence. Desiccated rye surface mulch in a no-till system reduced aboveground biomass of common lambsquarters (*Chenopodium album* L.), redroot

EFFECTS OF SOME COVER CROPS ON LIGHT EXTINCTION AND WEED COVERAGE

pigweed, and common ragweed up to 99%, 96%, and 92% compared to mulch free control (Shilling *et al.*, 1985).

Kruidhof *et al.* (2008) found that weed suppression is positively correlated to early light interception by the living mulch and is sustained by the strong negative correlation between cumulative light interception and weed biomass. For weed competition and weed suppression, earliness has also been reported an important characteristic (De Haan *et al.*, 1994). This system could, theoretically, help reduce soil erosion, increase soil organic matter and aggregation, trap excess nitrogen, and suppress weeds without cultivation (Bowman *et al.*, 1998; Hartwig and Ammon, 2002; Ruffo *et al.*, 2004). The effects of a cover crop or living mulch are achieved by a rapid occupation of the open space between the rows of the main crop or generally, the niches that would normally be filled by weeds (Teasdale, 1998a). Thus, the aims of this study were to survey the effects of triticale (\times *Triticosecale*), hairy vetch (*Vicia villosa* Roth.) and rapeseed (*Brassica napus* L.) cover crops on light extinction coefficient and weed cover percentage.

MATERIAL AND METHODS

Field study

This study was conducted during 2012 at the Research Farm of Faculty of Agriculture, University of Tabriz, Iran (38°01' North latitude, 46°25' East longitude, and an altitude of 1676 meters).

Soil analysis showed that this field soil type is loam (42.4% sand, 38% silt, 19.6% clay) with 0.17% organic matter, pH 7.4, and Ec 0.93 ds/m. The experiment was arranged on the basis of randomized complete block design with nine treatments and three replicates. Treatments included planting triticale, hairy vetch, rapeseed, triticale + hairy vetch, triticale + rapeseed, hairy vetch + rapeseed cover crops two weeks before sunflower (*Helianthus annuus* L) planting, application of trifluralin (2,6-Dinitro-*N,N*-dipropyl-4-(trifluoromethyl) aniline) two weeks before sunflower planting, and controls (weed infested and weed free without planting cover crops before sunflower planting). Triticale, hairy vetch, rapeseed were down furrow drilled at 180, 45, and 9 kg ha⁻¹, respectively. Cover crops were allowed to grown during sunflower growing seasons. Oil hybrid sunflower (CV. Urofoure) was direct top of the furrow drilled (seven rows per plot; 50 cm row spacing; 86,000 seeds ha⁻¹) two weeks after cover crop planting.

Light extinction coefficient

In order to examine light distribution and extinction coefficient (k) by cover crops in the canopy structure, sun scan canopy analyzing system was used in the grain filling stage of sunflower. Light extinction coefficient was measured by a flowing equivalent:

$$k = \frac{-\ln \frac{\text{PAR}(t)}{\text{PAR}(i)}}{\text{LAI}}$$

where PAR (t) = PAR transmitted (at bottom of canopy), PAR (i) = PAR incoming (at top of canopy), LAI = Leaf Area Index.

Sampling of weeds and statistical analysis

To evaluate the effects of cover crops on weeds cover percentage during sunflower growth, sampling was done in

$$\text{Inhibition (-) or stimulation (+)} = \frac{\text{GST} - \text{GSC}}{\text{GSC}} \times 100$$

where GST is weed seed germinated in treatments and GSC is weed seed germinated in control (Hassannejad and Ghafarbi, 2013). Data were analyzed using SAS (ver. 9.1) and mean comparison was conducted according to the Duncan's t-test.

six times. Inhibitory or stimulatory effects of cover crops on weed seed germination were calculated according to the following equation:

RESULTS AND DISCUSSION

Effects of treatments on light extinction coefficient

Analysis of variances indicated that light extinction coefficient was significantly affected by treatments (Table 1).

Table 1 - Analysis of variances of light extinction coefficient

S.O.V	df	light extinction coefficient
Replicate	2	0.003 ns
Treatments	8	0.006 *
Error	16	0.002
CV (%)	-	7.73

*=Significant at 5% level, **= Significant at 1% level, ns=Non-significance

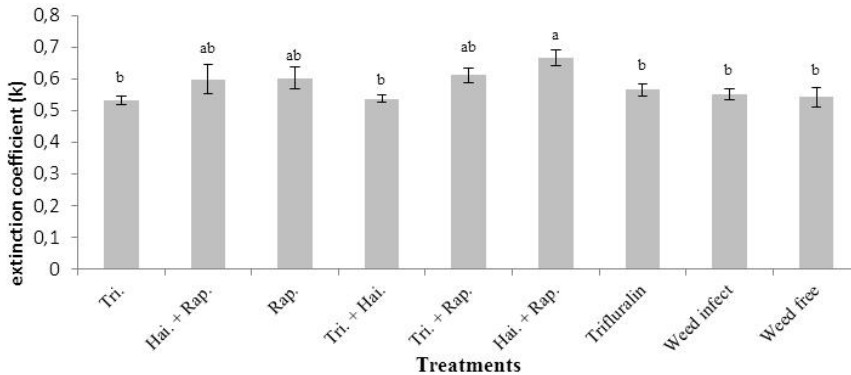


Figure 1 - Effect of cover crops on light extinction coefficient (Tri.= Triticale; Hai.= Hairy vetch; Rap.= Rapeseed)

Mean comparisons indicated some cover crops in comparison with cover crop free treatments, light extinction coefficient was increased

and the light passes through the canopy was decreased. Although hairy vetch + rapeseed cover crop had highest effect on light extinction

EFFECTS OF SOME COVER CROPS ON LIGHT EXTINCTION AND WEED COVERAGE

coefficient, triticale and triticale + hairy vetch cover crop had same effect with non-cover crop treatments (Fig. 1).

In general, one of the main factors of weed suppression mechanisms of living mulch is light interception. Living mulches are blocking sunlight reaching the weeds, especially decumbent ones, cannot get enough light for germination and growth. According to Steinmaus *et al.* (2008), weed suppression was linked to light interception by the mulch cover for most weed species. Caamal-Maldonado *et al.* (2001) also found that canopy closure of velvet bean (*Mucuna pruriens*) decreased the amount of light reaching to soil and inhibited weed growth. They reported that smooth pigweed (*Amaranthus hybridus* L.) and spiny amaranth (*Amaranthus spinosus* L.), among other weeds, were well controlled by a velvet bean living mulch. Studying the biological impact of species on the capture and utilization efficiency of radiation resource offers support in weed control and breeding programs, which will help the creation of many competitive cultivars (Motcă *et al.*, 2007; Vintu *et al.*, 2004). Bilalis *et al.* (2009) reported that decreases of available light for weeds cause reduction in their number and dry matter in vetch crop, in comparison to the red clover crop or fallow treatment. According to Carvalho *et al.* (2007), the different extinction coefficient (k) values observed, for different kinds of vegetable species, due to the morphological differences

of the studied species and their responses to the variability of light quantity and quality inside the canopy structure.

Cover crops coverage and biomass

Analysis of variances showed that cover crops coverage and biomass were significantly affected by treatments, times and their interaction (Table 2).

Hairy vetch and rapeseed cover crops with 48% and 47.33% coverage of soil surface (15 days after planting) had higher coverage, respectively. Mean comparisons indicated that between all treatments at the end of season, hairy vetch + rapeseed had higher coverage and triticale had lowest coverage (Fig. 2).

Rapeseed with 200.8 g/m² biomass, 15 days after planting, had higher biomass. Also triticale + rapeseed at the harvesting time had highest biomass, but only presence of triticale had lowest biomass (Fig. 3).

In fact, rapid canopy closure and produce a large and late-maturing canopy were positively associated with competitive ability of canopy (So *et al.*, 2009). Living mulches such as cover crops can rapidly occupy free spaces between the rows of the main crops and compete with weeds for the light, water, and nutritional resources. So weed seed germination was inhibited and their seedlings growth was reduced. Moreover, physical impediments to weed seedlings are another mechanism to suppress weeds (Facelli and Pickett, 1991; Teasdale, 1996; Teasdale and Mohler, 1993).

Table 2 - Analysis of variances of cover crop treatment

S.O.V	df	Cover crop biomass	Cover crop coverage
Replicate	2	2615.08 ns	207.50 ns
Treatments	5	47148.04 **	2443.32 **
Errore (a)	10	5327.55	244.20
Times	5	8688.3 **	1804.74 **
Treatments × times	25	9409.01 **	335.08 **
Replicate × times	10	4335.69 ns	270.93 **
Errore (a)	50	2471.57	117.08
CV (%)	-	33.77	23.22

*=Significant at 5% level; **= Significant at 1% level; ns=Non-significance

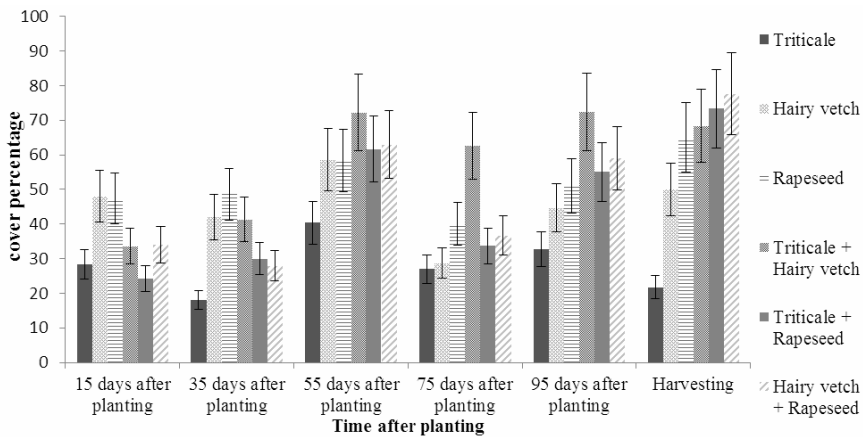


Figure 2 - Effect of interactions treatments and times on cover crops coverage

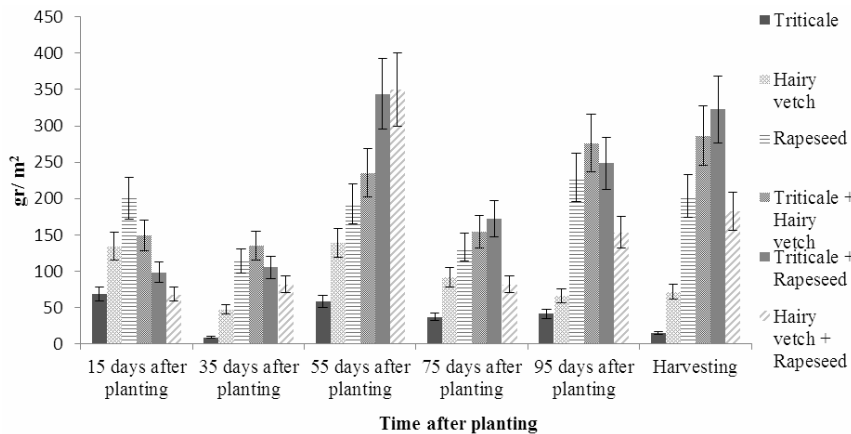


Figure 3 - Effect of interactions treatments and times on cover crops biomass

EFFECTS OF SOME COVER CROPS ON LIGHT EXTINCTION AND WEED COVERAGE

Effects of treatments on weed coverage

Weed coverage was significantly affected by treatments, times and their interaction (Table 3).

Main weed species observed in this field were common lambsquarters (*Chenopodium album* L.), bindweed (*Convolvulus arvensis* L.), green bristlegrass (*Setaria viridis* L.),

pigweed (*Amaranthus* sp). In all cover crops treatments, weed species coverage were reduced. The highest weed species coverage was found in weed infested treatment at the end of season. Rapeseed effect on weed coverage was higher than other cover crops, and cover crops treatments were better than trifluralin application (Fig. 4).

Table 3 - Analysis of variances on weed cover percentage

S.O.V	df	Weed cover percentage
Replicate	2	93.44 ns
Treatments	7	446.83 **
Errore(a)	14	31.8
Times	5	978.99 **
Treatments × times	35	43.82 **
Replicate × times	10	12.31 ns
Errore (a)	70	8.44
CV (%)	-	22.23

*=Significant at 5% level; **= Significant at 1% level; ns=Non-significance

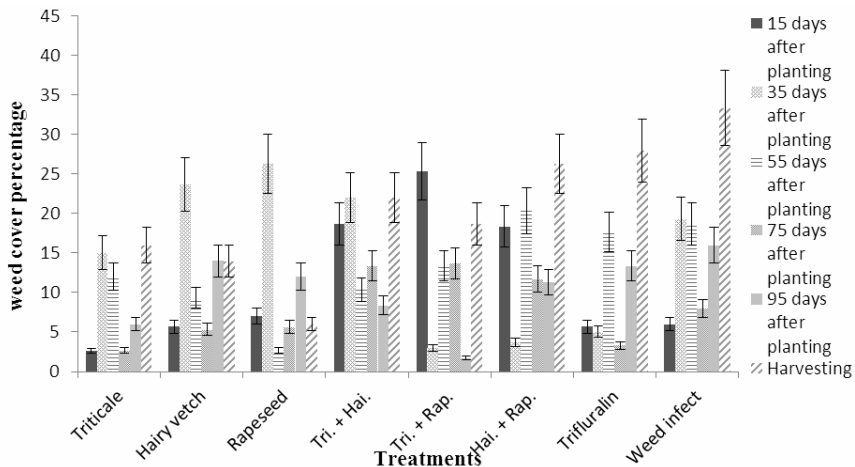


Figure 4 - Effect of interactions treatments and times on weed cover percentage (Tri.= Triticale; Hai.= Hairy vetch; Rap.= Rapeseed)

Maximum reduction in total weed species was observed in hairy vetch + rapeseed (61.92%). Also 61.43 % reduction was observed in rapeseed and triticale + rapeseed compared to weed infested treatment. Minimum reduction in total weed species was observed in hairy vetch treatment (27.27%). Common lambsquarters coverage was reduced 56.67% in triticale treatment compared to weed infested and minimum reduction in coverage of this weed was observed in trifluralin

treatment. Maximum reduction of bindweed coverage was observed in rapeseed (88.79%) and cover crops had greater effect than application of trifluralin. The green bristlegrass coverage was reduced 65.71% after application of trifluralin, but in hairy vetch treatment, it's coverage was increased (42.86 %). Although rapeseed caused 76.09% reduction in pigweed coverage, but it's coverage was increased (13.04 %) in triticale + hairy vetch (Table 4).

Table 4 - Inhibition percentage of treatments on weed coverage (Che. alb = *Chenopodium album* L.; Con. arv= *Convolvulus arvensis* L.; Set. vir.= *Setaria viridis* L.; Ama. sp.= *Amaranthus* spp.; Lot. cor.= *Lotus corniculatus* L.)

Treatments	Che. alb.	Con. arv.	Set. vir.	Ama. sp.	All weeds
Triticale	-56.67 a	-33.64 b	-34.29 c	-50 b	-42.75 ab
Hairy vetch	-52.22 a	-50.47 ab	+42.86 d	-41 bc	-27.27 c
Rapeseed	-40 b	-88.79 a	-64.76 ab	-76.09 a	-61.43 a
Triticale + hairy vetch	-20 bc	-81.31 a	-40 b	+13.04 d	-38.82 b
Triticale + rapeseed	-51.11 a	-75.70 a	-65.71 ab	-65.22 ab	-61.43 a
Hairy vetch + rapeseed	-43.33 ab	-79.44 a	-61.90 ab	-50 b	-61.92 a
Application of trifluralin	-7.78 c	-44.86 b	-99.52 a	-21.74 c	-46.68 ab

*=Significant at 5% level; **= Significant at 1% level; ns=Non-significance

Differences in soil coverage development depended on species differences in morphology and physiology. So that, small-seeded species may be more sensitive to conditions that might cause a poor establishment (Den Hollander *et al.*, 2007). Morphological growth characteristics, such as early relative growth rate of leaf area and earliness of height development, have been identified to determine competition in intercropping systems (Kropff and Van

Laar, 1993). Weed suppression benefits from a rapid soil coverage, as reduces weed seed germination, seedling establishment and their relative competitive ability (Ross and Lembi, 1985). The relative growth rate reflects the increase of characteristics like soil coverage and dry matter accumulation during early development, when growth is still exponential. The relative growth rate of a plant species was affected by light capturing ability, by the

EFFECTS OF SOME COVER CROPS ON LIGHT EXTINCTION AND WEED COVERAGE

efficiency by which it converts light into biomass and by the fraction of newly produced biomass which is invested in leaves (Den Hollander *et al.*, 2007). There is wide agreement in the literature that a vigorous living mulch will suppress weeds growing at the same time as the living mulch (Stivers-Young, 1998; Akobundu *et al.*, 2000; Creamer and Baldwin, 2000; Blackshaw *et al.*, 2001; Favero *et al.*, 2001; Grimmer and Masiunas, 2004; Peachey *et al.*, 2004; Brennan and Smith, 2005).

CONCLUSION

It could be suggested that cover cropping of triticale, hairy vetch, and rapeseed by effect on light extinction coefficient and preventing light penetration to underneath can inhibit weed seed germination and weed seedling establishment in integrated weed management (IWM).

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EFFECTS OF SOME COVER CROPS ON LIGHT EXTINCTION AND WEED COVERAGE

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S. HASSANNEJAD, A.R. MOBLI

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