Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 10, No. 1, p. 105-114, 2017
http://www.innspub.net

INNSPUB

RESEARCH PAPER OPEN ACCESS

Changes in some physiological traits and yield of corn in response to cover crops

Farhood Yeganehpoor*, Saeid Zehtab-Salmasi, Soheila Dastborhan

Department of Plant Eco-Physiology, Faculty of Agriculture, University of Tabriz, Tabriz, Iran

Article published on January 23, 2017

Key words: Chlorophyll content, Corn, Forage yield, Leaf area, Weed

Abstract

Cover crops as living mulches can suppress weeds in agro-ecosystems and improve the quality and quantity of crop performance. Therefore, to evaluate the effect of cover crops on some physiological traits and forage yield of corn, a field experiment based on RCB design with three replications and 10 treatments was conducted at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran. The treatments included corn monoculture with weed control, corn monoculture with weed interference and intercropping of cover and medicinal plants (red clover, hairy vetch, basil and dill) as synchronic cultivation with corn and 15 days after corn planting. The results indicated that the lack of weed control in corn monoculture led to significant reduction of chlorophyll content index, leaf area index, received light, oil, protein, starch and ultimately forage yields of corn. The simultaneous cultivation of corn-cover crops, especially red clover, considerably improved all evaluated traits compared with delayed planting of cover crops. High chlorophyll content and leaf area index in corn-clover intercropping had a positive effect on received and absorbed light percentages, photosynthesis rate and ultimately forage yield. The high forage yield in synchronic cultivation of corn with clover can be due to rapid growth and high competitiveness of this forage legume in the early stage of growth. In general, simultaneous cultivation of corn with legume cover crops can considerably reduce weeds growth and establishment, leading to reduction of weed interference and increment of corn yield.

***Corresponding Author:** Farhood Yeganehpoor ✉ farhoodyeganeh@yahoo.com

Introduction

Corn (*Zea mays* L.) is an annual crops belonging to the family Poaceae, which is one of the most important cereal crops in the world, after wheat and rice. It is a versatile crop with wide adaptability to varied agro-ecological regions and diverse growing seasons. Besides serving as human and animal food due to its high nutritional value, the importance of this crop is also related to its wide industrial applications (Jhala *et al.*, 2014). It is recently used in production of biofuel (Belel *et al.*, 2014). In addition to the environmental variables, corn yield are mainly affected by competition with weeds (Blackshaw *et al.*, 2002). Weed interference is a basic problem in corn culture, especially in the early growing stages, due to slow early growth rate and wide row spacing.

Weeds compete with the corn plants for resources such as light, nutrients, space, and soil moisture that influence the morphology and phenology of crops and considerably reduce the yield and grains quality (Kremer, 2004). Weeds delay female flowering and maturation and reduce leaf area, biomass, plant height and biomass partitioning of corn plants (Evans *et al.*, 2003). However, if weeds be managed properly, corn can show considerable competition against weeds. Weeds that emerge 4 weeks after corn establishment have less negative impact on corn yield (Knezevic *et al.*, 2002); therefore, control of early-season weeds is extremely important to get a competitive corn yield. Intercropping system as one of the important methods and objectives of sustainable agriculture can increase the quality and quantity of performance and decrease effects of pests, diseases and weeds. Use of cover crops is one of the methods of cultural control of weeds.

Nowadays, environmental pollution especially contamination of surface water and groundwater by herbicides is one of the most important human concerns (Abdin *et al.*, 2000). Intercropping and cover cropping are practices that increase diversity in the cropping system and enhance the utilization of environmental resources such as light and water. Cover crops are the most commonly alternative methods rather than herbicides.

These crops have numerous influences on the agro-ecosystem (Sarrantonio and Gallandt, 2003) and can be used for a variety of purposes including protecting the soil against erosion, improving soil structure, fixing nitrogen, preventing leaching of nutrients, increasing the soil biological activity, managing soil moisture (Teasdale, 1996), increasing the soil organic matter and preventing the growth and development of weeds population (Kruidhof *et al.*, 2008).

However, these effects can vary depending on the type and quantity of cover crops and environmental conditions during the growing season. The spatial arrangement of crops helps in the effective utilization of land, soil moisture, nutrients and solar radiation.

They intercept incoming radiation, thereby affecting the temperature of environment and biological activity in the leaf canopy and underlying soils. Cover crops can influence weeds either in the form of living plants or as plant residue remaining after the cover crop is killed (Bayer *et al.*, 2000).

The choice of crop combination is important to successful intercropping. Incompatibility factors such as planting density, root system and nutrient competition need to be considered (Ijoyah and Jimba, 2012). The selection of compatible crops depends on their growth habit, land, light, water and fertilizer utilization (Thayamini and Brintha, 2010). A legume cover crop, such as common vetch, can supply most of nitrogen required for maximum corn yield (Bayer *et al.*, 2000).

The application of herbicides in agriculture is a risky endeavor and not an eco-friendly approach. Biological and cultural control of weeds is important components of integrated weed management (IWM). Although, weed management by ecological means (such as weed management in intercropping) is difficult, it is attractive due to minimal use of chemicals with least disturbance to the environment (Banik *et al.*, 2006). Therefore, the purpose of this research was to investigate the effects of integrated weed management on some physiological traits and forage yield of corn.

Materials and methods

Field conditions

This research was conducted at the Research Farm of the University of Tabriz, Iran (latitude 38°05′N, longitude 46°17′E, altitude 1360 m above sea level) in 2010. Mean annual rainfall, temperature, maximum and minimum temperatures of research area were 271.3 mm, 10°C, 16°C and 2.2°C, respectively.

The soil type was sandy-loam with EC of 0.68 dS m^{-1}, pH of 8.1 and field capacity of 28.8%.

Experimental design

Experiment was carried out based on RCB design with 10 treatments and three replications. The treatments were sole cropping of corn with weed control up to corn harvesting (A_1), sole cropping of corn with weed interference (A_2), and eight intercropping treatments including cultivation of red clover (*Trifolium pratense*), hairy vetch (*Vicia villosa*), basil (*Ocimum basilicum*) and dill (*Anethum graveolens*) as cover crops at the same date (synchronic cultivation with corn) and 15 days after corn sowing (Table 1).

Table 1. Experimental treatments.

	Treatments
A_1	sole cropping of corn + weed control up to corn harvest
A_2	sole cropping of corn + weed interference (without weed control)
A_3	synchronic cultivation of corn-red clover
A_4	red clover sowing 15 days after corn planting
A_5	synchronic cultivation of corn-vetch
A_6	vetch sowing 15 days after corn planting
A_7	synchronic cultivation of corn-basil
A_8	basil sowing 15 days after corn planting
A_9	synchronic cultivation of corn-dill
A_{10}	dill sowing 15 days after corn planting

Experimental conditions

Each plot consisted of 10 sowing rows with 4 m length and 25 cm apart. In each plot, rows alternately planted with corn and one of the cover crops in the specified planting time. Density of corn, red clover, vetch, basil and dill were 8, 100, 75, 38 and 30 plants per m^2, respectively. In the current research, dominant weeds were *Amaranthus retroflexeus*, *Convolvulus arvensis*, *Acroptilon repens* and *Cuscuta* sp.

Measurements

At silking stage, one plant was marked in each plot and chlorophyll content index (CCI) of upper, middle and lower leaves of corn plant were directly measured by a portable chlorophyll meter (CCM-200, Opti-Science, USA). Then leaf area per plant was measured using a leaf area meter (ADC-AM300) and leaf area index (LAI) was calculated as:

LAI = leaf area per plant × number of plants per m^2

At the same time, received light by the upper, middle and lower parts of the corn canopy was measured using a sun scan (SS1) on a sunny day at the time of 12:00 to 14:00 PM.

At corn physiological maturity, 10 plants from each plot were harvested and fresh forage yield of corn was recorded. When seed moisture content was about 14%, corn plants from two middle rows of each plot were harvested and corn grain yield per unit area was recorded. Then, percentages of oil, protein and starch of corn seed for each sample were determined using a seed analyzer (model: Zeltex ZX-50) and subsequently their yield for each treatment at each replicate was calculated.

Statistical analysis

The statistical analysis were performed for 10 treatments based on RCB design and for 8 intercropping treatments (without sole cropping treatments) as factorial based on RCB with MSTAT-C and SPSS software's. The means were compared using the Duncan multiple range test at $p \leq 0.05$. Excel software was used to draw the figures.

Results and discussion

The analysis of variance of data based on randomized complete block design showed positive and significant effect of weed control and synchronic cultivation of corn and cover crops on chlorophyll content index (CCI), leaf area index (LAI), received light, and yields of oil, starch, protein and fresh forage of corn (Table 2).

Table 2. Analysis of variance of the effect of different treatments on some physiological traits and yield of corn.

Sources of variation	df	Mean squares						
		CCI	LAI	Received light	Oil yield	Starch yield	Protein yield	Forage yield
Replication	2	0.03 ^{ns}	0.005 ^{ns}	95.13 ^{ns}	2.33 ^{ns}	1.06 ^{ns}	3.95 ^{ns}	171.22 ^{ns}
Treatments	9	0.15**	0.45**	195.67**	4807.35**	671.11**	2003.05**	5532.05**
Error	18	0.54	0.12	30.4	10.03	3.19	4.37	127.2
C.V. (%)	-	3.3	4.9	10.1	9.5	7.1	5.2	6.3

ns, **: No significant and significant at $p \leq 0.01$, respectively.

The highest and the lowest chlorophyll content index, leaf area index, oil, starch, protein and fresh forage yields of corn were related to weeds control in sole cropping of corn (A_1) and sole cropping of corn without weed control (A_2), respectively. The presence of cover crops reduced CCI, LAI and yields of oil, starch, protein and forage of corn compared with corn sole cropping under weeds control conditions. Received light in intercropping treatments, especially in synchronic cultivation of corn-red clover, was higher than sole cropping in weed control conditions (A1). Although there were no significant difference between delayed and synchronic planting of cover crops with corn in some studied traits, delayed planting of cover crops led to reduction of physiological traits and yield of corn plants. All evaluated traits in corn-clover intercropping were higher than other intercropping treatments (Table 3).

Table 3. Means of some physiological parameters of corn affected by different cover crops and their planting time.

Treatments	CCI	LAI	Received light (%)	Oil yield (kg ha^{-1})	Starch yield (kg ha^{-1})	Protein yield (kg ha^{-1})	Forage yield (g m^{-2})
A_1	37.5 ^{a}	3.61 ^{a}	57.3 ^{e}	260.6 ^{a}	426.7 ^{a}	198.3 ^{a}	76.1 ^{a}
A_2	16.7 ^{f}	2.78 ^{g}	43.3 ^{f}	41.8 ^{e}	78.9 ^{f}	33.3 ^{e}	31.1 ^{f}
A_3	33.8 ^{b}	3.45 ^{b}	82.1 ^{a}	175.6 ^{b}	289.6 ^{b}	127.9 ^{b}	57.9 ^{b}
A_4	31.9 ^{b}	3.39 ^{c}	68.5 ^{c}	165.0 ^{b}	271.6 ^{b}	118.8 ^{c}	55.2 ^{b}
A_5	32.6 ^{b}	3.40 ^{c}	75.3 ^{b}	160.6 ^{b}	264.2 ^{b}	116.0 ^{c}	55.2 ^{b}
A_6	27.9 ^{c}	3.31^{cd}	68.1 ^{c}	148.7 ^{c}	238.3 ^{c}	108.1^{cd}	50.1 ^{c}
A_7	27.4 ^{c}	3.26 ^{d}	69.8 ^{c}	145.5 ^{c}	233.7 ^{c}	103.0 ^{d}	48.2^{cd}
A_8	24.5 ^{d}	3.20 ^{e}	60.3 ^{d}	131.4 ^{d}	206.7 ^{d}	98.2 ^{d}	45.5 ^{d}
A_9	20.2 ^{e}	3.18 ^{e}	61.6 ^{d}	134.2 ^{d}	212.6 ^{d}	92.4 ^{d}	43.7^{de}
A_{10}	19.7 ^{e}	3.11 ^{f}	59.9 ^{d}	129.0 ^{d}	180.1 ^{e}	78.7 ^{de}	40.3 ^{e}

Different letters at each column indicate significant difference at $p \leq 0.05$.

Leaf chlorophyll content index (CCI)

Effects of cover crops and sowing time of these plants were significant for chlorophyll content index of corn leaves. However, the interaction of cover crops × sowing date was not significant for this trait (Table 4). The highest and the lowest leaf chlorophyll content index were recorded for corn-clover and corn-dill intercropping, respectively (Fig. 1). Simultaneous culture of corn and cover plants significantly increased chlorophyll content of corn leaves (Table 5). Advantage of clover in intercropping with corn can be attributed to higher capacity of this cover crop in weed control through its extensive coverage, fast establishment and growth, and high capacity in N_2 fixation (Zaefarian *et al.*, 2012). The weed suppression through cover crops has been reported by many researchers (Campiglia *et al.*, 2009; Yeganehpoor *et al.*, 2015).

Chlorophyll plays a key role in trapping sunlight and converting it into chemical energy, so any disturbance in chlorophyll content may result in a reduction in photosynthesis (Azhar *et al.*, 2011). CCI is proportional to the amount of chlorophyll in leaf and a linear relationship exists between CCI and leaf nitrogen concentration (Anwar *et al.*, 2011). On the other hand, there is a significant relationship between CCI and corn yield (Argenta *et al.*, 2004).

Table 4. Analysis of variance for some physiological traits and yield of corn affected by cover crops and their sowing time

Sources of variation	df	Mean squares						
		CCI	LAI	Received light	Seed oil yield	Seed starch yield	Seed protein yield	Forage yield
Replication	2	0.05 **	0.001ns	44.61 ns	0.12 **	0.204 ns	0.20 ns	201.61ns
Cover crops (C)	3	0.63 **	0.109 **	201.13**	14.2 **	10.39 **	21.28 **	11705.4 **
Sowing time (S)	1	0.44 **	0.016 *	193.44 **	1.75 **	9.07 **	20.40 **	7518.25**
C × S	3	0.08 ns	0.109 ns	17.25 ns	0.27 ns	0.057 ns	0.33 ns	555.25 ns
Error	14	0.97	0.06	39.7	0.35	0.268	0.44	35202
C.V. (%)	---	4.9	3.4	8.6	6.6	5.2	7.7	10.4

ns, *,**: No significant and significant at $p \le 0.05$ and $p \le 0.01$, respectively.

Table 5. Changes in some physiological parameters and yield of corn affected by sowing time of cover crops.

Treatments	CCI	LAI	Received light (%)	Oil yield (kg ha^{-1})	Starch yield (kg ha^{-1})	Protein yield (kg ha^{-1})	Forage yield (g m^{-2})
Synchronic with corn planting	31.2 a	3.38 a	71.7 a	153.5 a	249.7 a	109.5 a	54.2 a
15 days after corn planting	25.5 b	3.24 b	63.8 b	142.8 b	223.3 b	99.2 b	41.4 b

Different letters at each column indicate significant difference at $p \le 0.05$ (Duncan test).

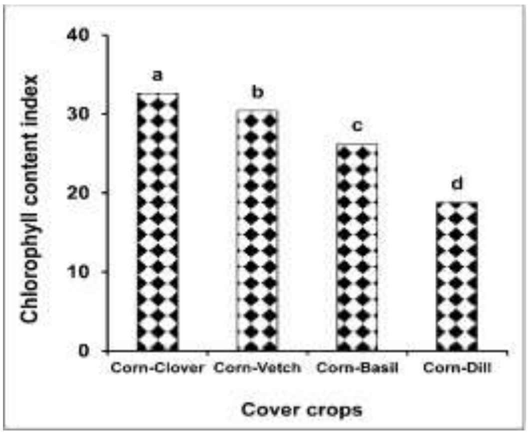

Fig. 1. Means of chlorophyll content index of corn leaves affected by different cover crops Different letters indicate significant difference at $p \le 0.05$ (Duncan test).

Leaf Area Index (LAI)

Corn leaf area index was significantly influenced by cover crops and their sowing times. Interaction of cover crops × sowing time was not significant for LAI (Table 4).

Leaf area index of corn in corn-clover intercropping was significantly higher than other cover crops. The lowest LAI was also related to corn-dill intercropping (Fig 2). Corn planted at the same time with cover crops had higher LAI compared with corn planted 15 days before cover crops planting (Table 5). Weed biomass in delayed planting of cover crops in corn field has been reported lower than synchronic cultivation (Yeganehpoor *et al.*, 2015). Therefore, low leaf area in delayed planting of cover crops is probably due to weed interference with corn and environmental resources limitation, which caused reduction of corn leaf area expansion. Since the sunlight helps to the growth and development of weeds in bare soil, cover crops are used to manage weeds in some organic production systems. The cover crops develop a physical barrier on the soil surface so that sufficient light for germination and growth of weeds is not provided. Forage legumes such as clover and vetch due to rapid establishment and high growth capacity in field conditions are more suitable and effective for weed control.

These plants also increase the available nitrogen for attendant plants through nitrogen fixation and hence have an important role in the alteration of competitive relations between crop and weed and resulting in improvement of the competitiveness of the crop over the weeds (Teasdale *et al.*, 2007). Cover crops can affect weed establishment and density through effects on the radiation and chemical environment of weed and inhibit weed emergence by physically impeding the progress of seedlings from accessing light (Teadale and Mohler, 2000) as well as releasing phytotoxins that inhibit seedling growth (Blackshaw *et al.*, 2001).

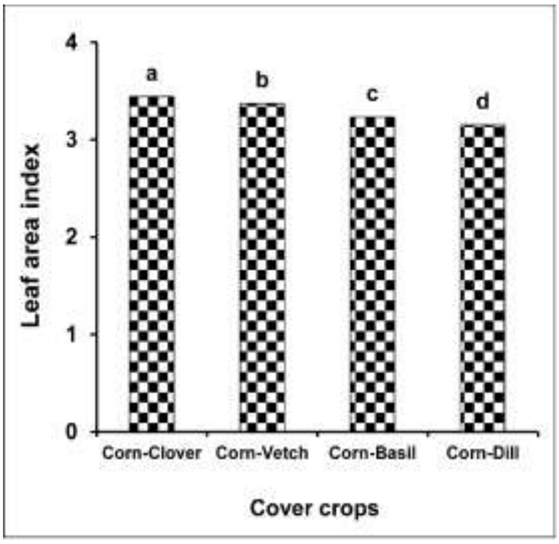

Fig. 2. Means of leaf area index of corn affected by different cover crops Different letters indicate significant difference at p≤ 0.05 (Duncan test).

Received light percentage

Received light by canopy significantly influenced by cover crops species and planting time of these plants. However, interaction of cover crops × planting time was not significant for this trait (Table 4). Among the various cover and medicinal plants species, dill caused highest adverse impact on received light percent (Fig. 3). This can be due to presence of weeds and greater height of dill compared with other studied cover crops. Received light percentage by corn canopy in corn-clover intercropping was higher than other intercropping treatments (Fig. 3) which can lead to better utilization of the absorbed light and increase forage yield in these conditions.

Although height of the most weeds is lower than corn, even without creating shade on corn plants, weeds influence corn growth via the radiation reflected by them. Plants absorb red light radiation (660-670 nm) and reflect far-red radiation (730 to 740 nm). The FR/R ratio plays an important role in the induction of many morphological changes in plant architecture (stem elongation, apical dominance, thinner leaves, leaf area distribution, etc.) (Ballaré, 1999). Cover crops increase corn yield not only by reduction of weed biomass and density (yeganehpoor *et al.*, 2015), but also by increment of competitiveness of corn against weeds at any given biomass through an improved capture of nutrients and water in cover crop system (Clark *et al.*, 1995). Delayed planting of cover crops, 15 days after corn planting, significantly reduced received light compared with synchronic cultivation of tested cover crops with corn (Table 5). The leaf area index, plant height, vertical leaf area distribution and leaf angle distribution are factors that play key role in evaluating of competition for light in mixed canopies (Lindquist and Mortensen, 1999). Leaf area index have a close relation with percentage of the received light by the canopy in monoculture and intercropping systems. Cover crops as Living mulches through change in quality and quantity of light and soil temperature can negatively affect seed germination (Gallagher *et al.*, 1999) and growth of weeds.

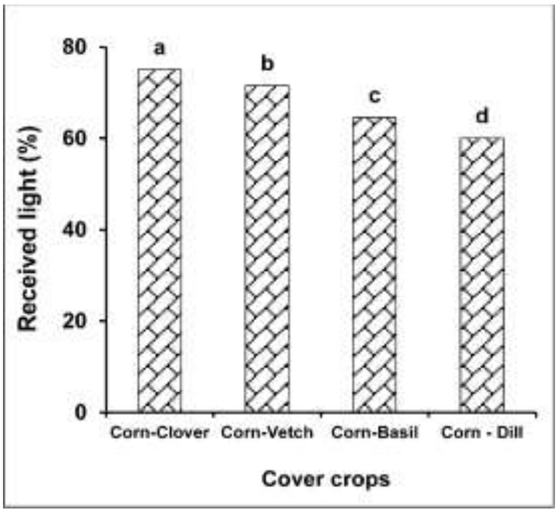

Fig. 3. Changes in received light by corn canopy affected by cover crops Different letters indicate significant difference at p ≤ 0.05 (Duncan test).

Fresh forage yield

The results of the analysis of variance showed that companion crops and planting date (synchronic and 15 days after corn planting) had significant effects on the corn forage yield (Table 4). Fresh forage yield of corn intercropped with red clover was higher than other cover crops (Fig 4). Delayed planting of cover crops in corn field led to 23.6% reduction in corn forage yield compared with their simultaneous cultivation with corn (Table 5). According to Yeganehpoor *et al.* (2015), red clover had highest positive effect in suppressing weeds. So that lowest weeds biomass (13.75 g m^{-2}) has been recorded for synchronic cultivation of corn with clover due to rapid growth and high competitiveness of clover in the early stages of growth. The highest weed biomass has been also achieved with dill cultivation 15 days after corn planting (60.2 g m^{-2}). Chlorophyll content (Fig. 1), leaf are index (Fig. 2) and received light by corn canopy (Fig. 3) in corn-clover intercropping were higher than other treatments which lead to better absorbance and utilization of light, and improvement of photosynthesis rate and forage yield in this conditions. Clover can stimulate corn growth and yield through availability of nitrogen, better distribution of light in middle and upper parts of corn canopy and weed control. Also, corn forage yield under synchronic planting was more than those under planting of cover crops 15 days after corn planting (Table 5).

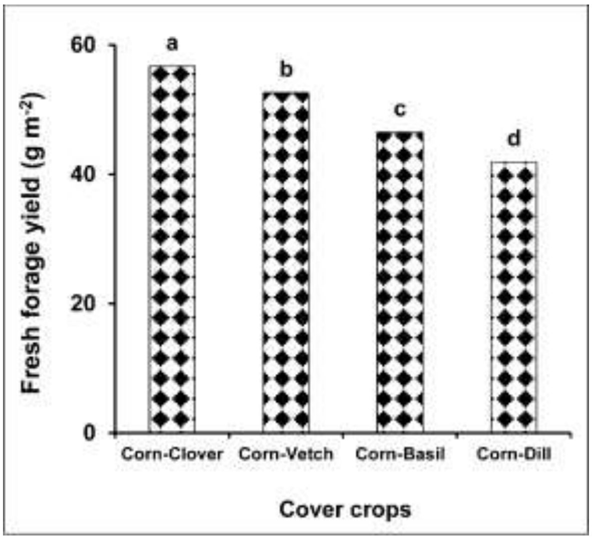

Fig. 4. Means of forage yield of corn affected by cover crops Different letters indicate significant difference at $p \leq 0.05$ (Duncan test).

Earlier emergence and growth of weeds in field can diminish vegetative growth and forage fresh yield of corn due to higher density and better utilization of environmental resources (Cavero *et al.*, 1999).

One reason for the reduction of weeds by cover crops is the intensive competition for light, water, space and nutrients (Bezuidenhout *et al.*, 2012). Cover crops intercropped with crops can improve soil nitrogen status (Chalk, 1998) and conserved soil moisture and increased crop yields (Kue and Jellum, 2002).

Oil, starch and protein yields

Cover crops and sowing time of these plants had significant effects on yields of oil, starch and protein of corn seeds. However, interaction of cover crops × sowing time was not statistically significant for these traits (Table 4). The highest and the lowest oil, starch and protein yields were obtained from corn-clover and corn-dill intercropping, respectively (Table 6). Delayed sowing of cover crops resulted in reduction of oil, starch and protein yields of corn seeds (Table 5). Delayed sowing of cover crops resulted in availability of soil and environmental resource and niche for weed emergence and growth and ultimately reduction of qualitative parameters of corn seeds. Red clover and hairy vetch due to rapid establishment and high growth capacity in filed compared with medicinal plants such as basil and dill are more suitable and effective for weed control. In fact basil and dill because of low growth rate and establishment especially in early growing season cannot compete with weeds as well as forage plants.

The changes in yields of oil, starch and protein of corn seeds due to intercropping of cover crops are related to changes of their percentage and corn seed yield per unit area. Since the highest seed yield (Yeganehpoor *et al.*, 2015) and oil, starch and protein contents of corn seeds (Yeganehpoor *et al.*, 2013) were obtained from synchronic cultivation of companion crops with corn, especially red clover, corn plants cultivated simultaneously with clover had also higher oil, starch and protein yields. Cover crops have a great suppressive effect on all stages of weed life cycle (Teasdale *et al.*, 2007).

There is often a negative correlation between cover crop and weed biomass (Sheaffer *et al.*, 2002). Cover crops generally create unfavorable radiation environment for germination, emergence and growth of weeds, absorb red light and reduce the red to far-red ratio sufficiently to inhibit phytochrome-mediated seed germination (Teasdale and Daughtry, 1993), compete for light, water and nutrients and release allelochemicals that inhibit or retard germination, emergence and early growth of them (Teasdale, 2003).

Table 6. Means of yields of oil, starch and protein of corn seeds affected by cover crops intercropping.

Treatment	Seed oil yield	Seed starch yield	Seed protein yield
Corn - Clover	169.50 ^{a}	280.33 ^{a}	122.10 ^{a}
Corn - Vetch	154.46 ^{b}	251.50 ^{b}	112.05 ^{b}
Corn - Basil	138.19 ^{c}	209.75 ^{c}	100.71 ^{c}
Corn - Dill	130.37 ^{d}	196.14 ^{d}	85.88 ^{d}

Different letters at each column indicate significant difference at $p \leq 0.05$ (Duncan test).

Correlation between studied physiological parameters in corn

According to Table 7, leaf area index, chlorophyll content index and received light had high significant and positive correlation with forage yield of corn (r = 0.75, r = 0.43 and r = 0.41, respectively). These results show that high chlorophyll content, expanded leaves and rapid expansion of canopy green cover through better light absorbance and ultimately improvement of plant photosynthesis could lead to the production of higher forage yield in corn. The correlation between oil, starch and protein percentages with forage yield was also significant and positive (Table 7). Corn leaf area was also significantly and positively correlated with chlorophyll content (r = 0.73) and received light (r = 0.65).

Table 7. Correlation coefficients between some physiological parameters in corn.

Traits	1	2	3	4	5	6	7
1. Forage yield	1						
2. Leaf area index	0.75^{**}	1					
3. Leaf chlorophyll content	0.43^{**}	0.73^{**}	1				
4. Received light	0.41^{**}	0.65^{**}	0.75^{**}	1			
5. Seed oil yield	0.25^{*}	0.25^{*}	0.09^{ns}	0.05^{ns}	1		
6. Seed protein yield	0.15^{*}	0.02^{ns}	0.27^{*}	0.02^{ns}	0.01^{ns}	1	
7. Seed starch yield	0.39^{**}	0.45^{**}	0.30^{*}	0.08^{ns}	0.06^{ns}	0.01^{ns}	1

ns, *,**: No significant and significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Conclusion

The results indicated that the lack of weed control in sole cropping of corn led to significant reduction of chlorophyll content index, leaf area index, received light, oil, protein, starch and ultimately forage yields of corn. The simultaneous cultivation of corn-cover crops, especially red clover, considerably improved all evaluated traits compared with delayed planting of cover crops. High chlorophyll content and leaf area index in corn-clover intercropping had a positive effect on received and absorbed light percentage, photosynthesis rate and ultimately forage yield. The high forage yield in synchronic cultivation of corn with clover can be due to rapid growth and high competitiveness of this forage legume in the early stages of growth. In general, simultaneous cultivation of corn with legume cover crops can considerably reduce weeds growth and establishment, leading to reduction of weed interference and increment of corn yield.

References

Abdin OA, Zhou XM, Cloutier D, Coulman DC, Faris MA, Smith DL. 2000. Cover crop and inter row tillage for weed control in short season maize (*Zea mays*). European Journal of Agronomy **12,** 93-102.

Anwar P, Juraimi AS, Puteh A, Selamat A, Man A, Hakim A. 2011. Seedling method and rate influence on weed suppression in aerobic rice. African Journal of Biotechnology **10,** 15259-15271.

Argenta G, Ferreira da Silva PT, Sangoi L. 2004. Leaf relative b-chlorophyll content as an indicator parameter to predict nitrogen fertilization in maize. Ciencia Rural Santa Maria **34,** 1379-1387.

Azhar N, Hussain B, Ashraf MY, Abbasi KY. 2011. Water stress mediated changes in growth, physiology and secondary metabolites of desi ajwain (*Trachyspermum ammi* L.). Pakistan Journal of Botany **43,** 15-19.

Ballaré CL. 1999. Keeping up with the neighbours: phytochrome sensing and other signaling mechanisms. Trends in Plant Science **4(1),** 97-102.

Banik P, Midya A, Sarkar BK, Ghose SS. 2006. Wheat and chickpea intercropping systems in an additive experiment. Advantages and weed smothering. European Journal of Agronomy **24,** 325-332.

Bayer C, Mielniczuk J, Amado TJC, Martin-Neto L, Fernandes SV. 2000. Organic matter storage in a sandy clay loam Acrisol affected by tillage and cropping systems in southern Brazil. Soil and Tillage Research **54,** 101-109.

Belel MD, Halim RA, Rafii MY, Saud HM. 2014. Intercropping of corn with some selected legumes for improved forage production: A Review. Journal of Agricultural Science **6(3),** 48-62.

Bezuidenhout SR, Reinhardt CF, Whitwell MI. 2012. Cover crops of oats, stooling rye and three annual ryegrass cultivars influence maize and *Cyperus esculentus* growth. Weed Research **52,** 153-160.

Blackshaw RE, Lemerle D, Mailer R, Young KR. 2002. Influence of wild radish on yield and quality of canola. Weed Science **50,** 334-349.

Blackshaw RE, Moyer JR, Doram RC, Bosweell AL. 2001. Yellow sweet clover, green manure, and its residues effectively suppress weed during fallow. Weed Science **49,** 406-413.

Campiglia E, Paolini R, Colla G, Mancinelli R, 2009. The effects of cover cropping on yield and weed control of potato in a transitional system. Field Crop Research **112,** 16-23.

Cavero J, Zaragoza C, Suso ML, Pardo A. 1999. Competition between maize and *Datura stramonium* in an irrigated field under semi-arid conditions. Weed Research **39,** 225-240.

Chalk PM. 1998. Dynamics of biologically fixed N in legume-cereal rotations: a review. Australian Journal of Agricultural Research **49,** 303-316.

Clark AJ, Decker AM, Meisinger JJ, Mulford FR, McIntosh MS. 1995. Hairy vetch kill date effects on soil water and corn production. Agronomy Journal **87,** 579-585.

Evans SP, Knezevic SA, Lindquist JL, Shapiro CA. 2003. Influence of nitrogen and duration of weed interference on corn growth and development. Weed Science **51(3),** 456-566.

Gallagher RS, Fernandes ECM, McCallie EL. 1999. Weed management through short-term improved fallows in tropical agroecosystems. Agroforestry Systems **47,** 197-221.

Ijoyah MO, Jimba J. 2012. Evaluation of yield and yield components of maize (*Zea mays* L.) and okra (*Abelmoschus esculentus*) intercropping system at Makurdi, Nigeria. Journal of Biodiversity and Environmental Sciences **2(2),** 38-44.

Jhala AJ, Knezevic SZ, Ganie ZA, Singh M. 2014. integrated weed management in maize. In: Chauhan BS, Mahajan G, Eds. Recent Advances in Weed Management, Springer Science, Business Media, New York 177-196.

Knezevic SZ, Evans SP, Blankenship EE, Van Acker RC, Lindquist JL. 2002. Critical period of weed control: the concept and data analysis. Weed Sciences **50,** 773-786.

Kremer RJ. 2004. Weed control. In: Smith CW, Betran J, Runge ECA, Eds. Corn: origin, history, technology and production, Wiley Hoboken 717-752.

Kruidhof H, Bastiaans ML, Kropff MJ. 2008. Ecological weed management by cover cropping: effects on weed growth in autumn and weed establishment in spring. Weed Research **48,** 492-502.

Kue S, Jellum EJ. 2002. Influence of winter cover crop and residue management on soil nitrogen availability and corn. Agronomy Journal **94,** 501-508.

Lindquist JL, Mortensen DA. 1999. Ecophysiological characteristics of four maize hybrids and *Abutilon theophrasti*. Weed Research **39(4),** 271-285.

Sarrantonio M, Gallandt ER. 2003. The role of cover crops in North American cropping systems. Journal of Crop Production **8,** 53-73.

Sheaffer CC, Gunsolus JL, Grimsbo Jewett J, Lee SH. 2002. Annual Medicago as a smother crop in soybean. Journal of Agronomy and Crop Science **188,** 408-416.

Teasdale JR, Brandseater LO, Calegari A, Skora-Neto F. 2007. Cover crops and weed management. In: Upadhyaya MK, Blackshaw RE, Eds. Non-chemical Weed Management: Principles, Concepts, and Technology. Wallingford, UK, CAB International 49-64.

Teasdale JR, Daughtry CST. 1993. Weed suppression by live and desiccated hairy vetch. Weed Science **41,** 207-212.

Teasdale JR, Mohler CL. 2000. The quantitative relationship between weed emergence and the physical properties of mulches. Weed Science **48,** 385-392.

Teasdale JR. 1996. Contribution of cover crops to weed management in sustainable agricultural systems. Journal of Production Agriculture **9,** 475-479.

Teasdale JR. 2003. Principles and practices of using cover crops in weed management systems. In: Labrada R, Ed. Weed Management for Developing Countries, Chapter 3.1, Food and Agriculture Organization of the United Nations, Rome, Italy 169-178.

Thayamini HS, Brintha I. 2010. Review on maize based intercropping. Journal of Agronomy **9(3),** 135-145.

Yeganehpoor F, Zehtab-Salmasi S, Abedi G, Samadiyan S, Beyginiya V. 2015. Effects of cover crops and weed management on corn yield. Journal of the Saudi Society of Agricultural Sciences **14,** 178-181.

Yeganehpoor F, Zehtab-Salmasi S, Ghassemi-Golezani K, Valizadeh M, Moeinirad A. 2013. Effect of weeding and by forage and medicinal plants as companion crops on some of quality traits of Corn (*Zea mays*). International Journal of Farming and Allied Sciences **2(20),** 821-825.

Zaefarian F, Bagheri M, Bicharanlou B, Asadi GA, Akbarpour V. 2012. Leaf chlorophyll of corn, sweet basil and borage under intercropping system in weed interference. World Academy of Science, Engineering and Technology **6,** 09-24.