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Assessment of yield and yield components of corn (*Zea mays* L.) under two and three strip intercropping systems

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Abstract

Intercropping can be described as the growing of two or more crops simultaneously on the same field. In order to investigate the effects of three spices (corn, soybean and sunflower) strip intercropping on yield and yield components of corn (*Zea mays* L.) a field experiment was carried out as randomized complete block design (RCB) with three replications in 2011. Results showed that the chlorophyll content of corn significantly affected by neighboring of soybean and sunflower. The maximum chlorophyll content of corn leaves was obtained at intercropping of corn-soybean, additive corn-soybean, corn-soybean-sunflower and corn-soybean-sunflower-soybean while, minimum chlorophyll content of this cultivar was showed at pure culture of corn. The effect of different intercropping on number of leaves, height of plant and diagonal of ear and biological yield of corn was not significant. The most ear length, number of rows in ear, number of grain in row, grain weight, grain yield and harvest index of corn were showed at intercropping of corn-soybean and corn-soybean-sunflower-soybean. The neighboring of sunflower by beside of corn significantly inhibited yield and yield component of this cultivar as the lowest yield of corn was obtained at intercropping of corn-sunflower.

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Introduction

Maize as a third cereal product of the world has been recognized as a common component in most intercropping systems. Intercropping has been traditionally practiced in many parts of world (Anil *et al*., 2000; Karadag, 2004) and has some advantages over monocultures (Anil and Phipps, 1998; Karadag, 2004). Intercropping supplies efficient resource utilization, reduces risk to the environment and production costs, and provides greater financial stability, making the system more suitable particularly for labor-intensive, small farmers (Anil and Phipps, 1998).

In conventional farming and monoculture systems, although high yield per unit area is been able to provide the nutritional needs of growing populations in some areas, but these systems requires direct and indirect to abundant costs and energy that arise from fossil fuels. In terms of ecology and environment, monoculture has been caused a series of serious problems.

There is an urgent need to develop cropping systems that are highly productive, sustainable and use local grown crops. Intercropping of sunflower-maize has been studied mostly in tropical areas and Singh (1982), Bakht and Shah (1989), Fagbayide *et al*., (1997), Galal (1998) and Robinson (1984) found no advantages in total yield production in respect to maize alone. However, Nyakatawa and Nyati (1998) found total yield increasing when maize and sunflower were grown together.

Intercropping of two or more crops establish a plant community which may use the resources more efficiently for growth as dry matter production and therefore may improve the quality and quantity of yield. This systems influence yield variables of the component crops, such as harvest index, hundred seed weight, number of reproductive organs and number of seeds, within each reproductive unit (Knudsen *et al*., 2004). Therefore multi-species intercropping of corn with other crops could be effective for resources utilization and also increasing the biodiversity lead to sustainability in corn cropping systems. So the objective of the study was to evaluate the productivity of corn with soybean and sunflower in strip intercropping.

Material and methods

Site description

This study was carried out at the Research Farm of Tabriz University, Tabriz, Iran (latitude 38.05 ^{o}N, longitude 46.17 ^{o}E, Altitude 1360 m above sea level) in 2011. The climate is characterized by mean annual precipitation of 245.75 mm, mean annual temperature of 10 ^{o}C, mean annual maximum and minimum temperature were 16.6 ^{o}C and 10^{o}C, respectively.

Experimental design

A randomize complete block design (RCB) with three replication was arranged. In this study three crops, corn (*Zea mays* L.), sunflower (*Helianthus annuus* L.) and soybean (*Glycine max* L.) strip intercropped in different systems were included three species in pure culture sunflower, corn and soybean crop species, including sunflower and corn ratio of 3:3 and a 3:4 ratio of corn and soybean, an additive corn and soybean 100: 20 and three species of sunflower - soybean - corn ratio of 3:4:3, and sunflower - soybean - corn - soybean ratio will be 3:4:3:4.

Seeds of corn, sunflower and soybean were treated with 2 g kg^{-1} Benomyl and then were sown by hand in 5 cm depth of a sandy loam soil. Seeding densities of maize, sunflower and soybean were 10, 8 and 60 seeds m^{-2}, respectively. All plots were irrigated immediately after sowing and after seedling establishment, plants were thinned. Subsequent irrigations were carried out on the basis of 70 mm evaporation from class A pan up to maturity stage. Hand weeding of the experimental area was performed as required.

Data collection

In flowering stages of corn leaf chlorophyll content of upper, middle and lower leaves were measured. Leaf sunflower was directly measured by a chlorophyll

meter (SPAD 502). At maturity, the plants in 1 m^2 of each plot were harvested and number of leaves, plant height, diagonal of ear, length of ear, number of rows in ear, number of grain in each row, number of grain in plant, 100 grain weight, grain yield, biological yield and harvest index were determined.

Data analysis

Analysis of variance was performed using MSTATC and SPSS-16 software. The means were compared using the Duncan multiple range test at the 5% probability level.

Results

Analysis of variance showed that chlorophyll content, length of ear, number of row in ear, number of grain in plant, 100 grains weight, grain yield and harvest index were significantly affected by different intercropping pattern. In contrast, the effect of different crops neighboring by beside of corn on number of leaves, plant height, diagonal ear and biological yield was not significant (Table 1).

Table 1. Analysis of variance of chlorophyll content, yield and yield component of corn at different types of strip intercropping.

Source	df	Chlorophyll content	Ear length	Row per ear	Grain per row	Grain per plant	Grain weight	Grain yield	Harvest index
Block	2	0.715	0.578	0.016	7.951	1494.982	0.201	963344.703	0.000001
Cropping system	5	71.589**	1.767*	0.105**	10.472*	3071.319**	4.160**	2284835.29**	0.005**

Sole cropping of corn had the least chlorophyll content, while in all intercropping treatments especially when corn was in neighboring of soybean, chlorophyll content of corn significantly increased.

As the most chlorophyll content in leaves of corn was recorded in intercropping of corn-soybean, additive corn-soybean, corn-soybean-sunflower and corn-soybean-sunflower-soybean (Fig. 1).

Table 2. Yield and yield components of corn at different types of strip intercropping.

Treatments	**Length of ear**	**Row number per ear**	**Grain number per rows**	**Grain number per plant**	**100 grain weight**	**Grain yield**	**Harvest index**
Pure corn	13.59 b	14.67 bc	29.71 bc	43.58 bc	22.27 b	9718.71 bc	0.54 b
Corn-Sunflower	13.27 b	14.47 c	27.85 c	40.27 c	21.83 bc	8820.42 c	0.5 c
Corn-Soybean	15.03 a	14.93 a	32.07 ab	47.89 a	22.97 ab	11003.84 a	0.6 a
Additive corn-Soybean	15.12 a	14.87 ab	33.06 a	49.19 a	20.67c	10173.44 ab	0.59 a
Corn-Soybean-Sunflower	13.97 ab	14.67 bc	31.71 ab	46.29 ab	23.13 ab	10714.79 a	0.59 a
Corn-Soybean-Sunflower-Soybean	14.56 ab	14.93 a	30.78 ab	45.96 ab	24.07 a	11081.85 a	0.6 a

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

Minimum length of ear was showed in pure corn and intercropping of corn-sunflower. In all intercropping pattern that utilized of sunflower in neighboring of corn the length of ear was reduced. In contrast, maximum ear length was obtained from corn that cultured by beside of soybean (additive corn-soybean and corn-soybean) (Table 2). Row number of ear at intercropping of corn-sunflower was the lowest in compared to other traits. But, there was no significant difference between this culture system with pure corn and corn-soybean-sunflower. The most of this trait was showed at intercropping of corn-soybean, increase of corn-soybean and corn-soybean-sunflower-soybean (Table 2).

Corn plant under intercropping of corn-sunflower had lower grain number of row in ear, number of grain in plant, grain yield and harvest index than that of other culture systems. Similarly intercropping of corn-soybean, additive corn-soybean, corn-soybean-sunflower and corn-soybean-sunflower-soybean have the higher of these traits in comparison to pure corn and corn-sunflower systems. Maximum loss in 100 grain weight was observed under intercropping of increase of corn -soybean. In contrast, the highest grain weight was recorded under intercropping of corn-soybean, corn-soybean-sunflower and corn-soybean-sunflower-soybean (Table 2).

Discussion

Sole cropping of corn has least chlorophyll content, yield and yield component in compared to two and three intercropping with sunflower and especially soybean (Table 2 and Figure 1). One possible explanation for the higher yields of intercrops is ability of the component crops to exploit different soil layer without competing with each other. There is probably better use of resource such as I: light, because the presence of maize ensured good early interception of light in above layer of canopy and legume in below layer of canopy intercept diffused light as stated (Eskandari *et al*., 2009), II: water and nutrient (Knudsen *et al*., 2004).

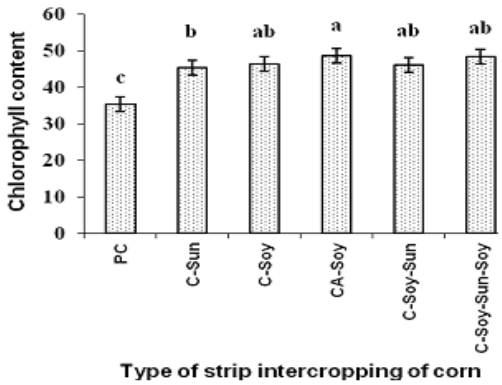

Fig. 1. Changes in chlorophyll content of corn (C) and corn additive (CA) at two and three strip intercropping with pure culture (PC) of corn, soybean (Soy) and sunflower (Sun). Different letter in each treatment indicate significant difference at $p \leq 0.05$.

In contrast, some of researcher indicated that intercropping was caused the reduction in yield, as, Lesoing and Francis (1999) in corn-soybean intercrop, where the sole crop components yielded higher than the corresponding crops in intercropping situation. Yunusa (1989), Odo (1991) and Pal *et al.,* (1993) had earlier reported yield reductions in intercropped cereal/legume compared to sole cereal and legume. However yield reduction due to intercropping often depended on the crop component ratios, which in part reflect the effects of decreased population density on the yield of component crops.

In the present study, soybean has beneficially effect on yield and yield component of corn, however, sunflower has adverse effect on corn yield (Table 2). This is in agreement with the results reported by Robinson (1984), Fagbayide *et al*., (1997) and Galal (1998). There are several possible benefits of intercropping legumes with non-legumes. This may be the resulting of allelopathic effect of sunflower that inhibited growth, development and consequence yield of corn (Andrew and Kassam, 1976).

The results of the present study can serve as a guiding index in the use of row arrangements for obtaining higher grain yield stability of corn when intercropped with soybean and this indicated strip intercropping of three species is the best system for increasing corn yield.

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