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Investigation Corn and Soybean Intercropping Advantages in Competition with Redroot Pigweed and Jimsonweed

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Abstract**—**The spatial variation in plant species associated with intercropping is intended to reduce resource competition between species and increase yield potential. A field experiment was carried out on corn (*Zea mays* L.) and soybean (*Glycine max* L.) intercropping in a replacement series experiment with weed contamination consist of: weed free, infestation of redroot pigweed, infestation of jimsonweed and simultaneous infestation of redroot pigweed and jimsonweed in Karaj, Iran during 2007 growing season. The experimental design was a randomized complete block in factorial experiment with replicated thrice. Significant ($P \leq 0.05$) differences were observed in yield in intercropping. Corn yield was higher in intercropping, but soybean yield was significantly reduced by corn when intercropped. However, total productivity and land use efficiency were high under the intercropping system even in contamination of either species of weeds. Aggressivity of corn relative to soybean revealed the greater competitive ability of corn than soybean. Land equivalent ratio (LER) more than 1 in all treatments attributed to intercropping advantages and was highest in 50: 50 (corn/soybean) in weed free. These findings suggest that intercropping corn and soybean increase total productivity per unit area and improve land use efficiency. Considering the experimental findings, corn-soybean intercropping (50:50) may be recommended for yield advantage, more efficient utilization of resources, and weed suppression as a biological control.

Keywords**—**corn, soybean, intercropping, redroot pigweed, jimsonweeed

I. INTRODUCTION

INTERCROPPING, the simultaneous growing of two or more species or cultivars on the same piece of land, is known to increase the size and stability of yields compared to monocropping, especially under low conditions [1]. Among different combinations corn–soybean intercrop systems has been reported to use resources more efficiently and are able to remove more resources than monocrop systems [2], thus decrease the availability of resources for weed production [3] .

Compered with corresponding sole crops, yield advantages have been recorded in many intercropping systems; including corn/soybean [4; 5], soybean/sorghum [6], corn/cowpea [7], etc. In corn/soybean intercropping, Ghafarzadeh *et al.,* [5] found the strip intercropping had 20-24% greater corn yields and 10-15% lower soybean yields in adjacent border rows in the corn/soybean intercropping in Iowa. In pea-barley intercropping, the grain yields of the intercrops were not significantly greater than those of the corresponding sole crops at any of the density; however LER of 0.9-1.2 express resource complementarily in almost all studied intercrops [1]. Hayder *et al.* [8] reported the relative yield total of corn and soybean was greater in intercropping than monoculture, and the highest LER (1.52) were obtain in intercropping. [9] demonstrated the LER value for all the intercropped treatments was greater than unity, indicating yield advantage over mono cropping due to better land utilization. Positive aggressivity values for wheat (0.0025–0.0035) also were recorded under intercropping systems. Relative crowding coefficient values for wheat were greater than one, whereas, it was less than one for chickpea. The products of relative crowding coefficient values were always more than one. In order to re-evaluating intercropping as a management strategy for non-chemical weed control, current experiment focused on yield advantages in corn/soybean intercrop under competition condition with redroot pigweed (AMRE), jimsonweed (DAST) and simultaneous interference of both weed species (AMRE + DAST).

II. MATERIALS AND METHODS

The experiment were conducted in research field, Tehran university, Karaj campus, Iran (35◦34' N; 50◦57' E; 1160 masl). Experiment were conducted during the spring and summer seasons 2007. Each experiment had 20 treatments were arranged factorially in a randomized complete blocks design with three replications. Experimental treatments were five different mixing ratios of corn (*Zea mays* L.) and soybean (*Glycine max* L.) including: 100/0 (P_1), 75/25 (P_2), 50/50 (P_3), 25/75 (P_4) and 0/100 (P_5) (corn/soybean) which planted at four levels of weed infestations: weed free (W_1), infested to redroot pigweed (*Amaranthus retroflexus* L.; AMRE) at 25 plant m^{-2} (W_2), infested to jimsonweed (*Datura stramonium* L.; DAST) at 25 plant m^{-2} (W_3) and mixed stands of AMRE and DAST at total density of 25 plant m^{-2} (W_4). Each plot consisted of six rows with 6.5 m long and 60 cm apart. The seeds of both weed species sowed 15 cm apart in both sides of the crop row at high density in same time with the crop. The weeds were thinned to 15 plants per meter of row (25 plant m^{-2}) at two-leaf stage of each species.The fertilizer schedule was 184 kg N ha^{-1} and 115 kg P_2O_5 for corn. Half of nitrogen (92 kg N ha^{-1}) and the whole amount

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TABLE I
RELATIVE CROWDING COEFFICIENT (RCC) AND LAND EQUIVALENT RATIO OF CORN AND SOYBEAN AND CORN AGGRESIVITY INDEX AGAINST SOYBEAN IN INTERCROPPING

	Relative crowding coefficient			Corn aggresivity index	Land Equivalent Ratio		
Weed infestation	Kc	Ks	RCC		RYc	RYs	LER
Weed free (W_1)	3.585	0.284	2.09	0.60	1.112	0.221	1.33
	11.845	0.255	26.41	0.56	1.029	0.203	1.23
	10.589	0.263	1.78	0.54	1.033	0.208	1.24
infestation of redroot pigweed (W_2)	4.696	0.238	4.86	0.47	0.928	0.192	1.12
	6.767	1.029	36.11	0.73	0.865	0.501	1.37
	1.962	0.898	10.14	0.41	0.662	0.458	1.12
infestation of jimsonweed (W_3)	3.736	0.632	6.32	0.80	0.787	0.387	1.17
	3.459	0.576	10.30	0.82	0.775	0.365	1.14
	4.099	0.865	2.77	1.35	0.577	0.721	1.30
infestation to both weeds (W_4)	2.738	0.845	7.93	0.96	0.477	0.712	1.19
	3.280	1.116	2.82	1.06	0.522	0.770	1.29
	2.215	1.115	1.95	0.68	0.425	0.762	1.19

of ammonium phosphate were applied as basal and remaining nitrogen was top dressed at 6-8 leaf stage of corn. Soybean received the total amount of N, (23 kg ha^{-1}) and P_2O_5 (69 kg ha^{-1}), as basal in strip banding. At the end of growing season, all plants in 2 m of 4 rows were harvested in each plot; to evaluate the crop yield. Plant samples to determining dry weight were oven-dried at 70 ◦C temperature to a constant weight. Land equivalent ratio (LER), Relative crowding Coefficient (RCC) and Aggressivity (A) was calculated according to Willey, [10]. Data collected for two years studies were subjected to the analysis of variance (ANOVA). The significant differences between treatments were compared with the critical difference at 5% level of probability, using Duncan's multiple range tests.

III. RESULT AND DISCUSSION

A. Crop yields

Mixing ratios of corn/soybean and weed infestation had significant effects on corn and soybean yield ($P<0.001$) (data not shown). Appearance of each weed species increased competition efficiency for light reception and had reduced corn and soybean grain yield.

The highest corn yield (10875 Kg ha^{-}) was obtained in 75/25 (corn/soybean) and weed free treatment (Fig. 1). In legume/grass, intercropping, higher yield compare to mono cropping may mainly is due to capturing resources, which decreased weed growth and increased yield or due to using resources [11] which is not available by weeds.

Results indicated that in all weed treatments, soybean monoculture had higher yield than intercropping treatments (Fig. 1) which was due to higher density. Soybean has less competitive ability than corn in intercropping systems.

B. Relative Crowding Coefficient (RCC)

The RCC value was significantly greater (6.97) in 50:50 (corn/soybean) in weed free over all other treatments (Table 1). The lowest RCC (1.02) was recorded in 25:75 (corn/soybean) in weed free (Table 1). There was no any RCC lesser than 1 which shows sometimes, differences in growth patterns of the intercrops also improve light interception pattern, leaf area index and leaf area duration [12]. The accompanying crops in mixtures ought to be planted in such a way as to minimize competition for light and other resources, and manipulating spatial arrangement is one way of attaining this.

With deeper observation in Table 1, soybean was dominated, which had lower RCC in almost all treatment. This result could be attributed to differences in morphology and physiology of these two crops.

C. Aggressivity Index (A)

Table 1 reveals that the value of aggressivity of corn was positive for all combinations, although the aggressivity index of soybean was not shown, but soybean was considered as the less-dominant crop in the system. Positive value of aggressivity indicates to corn, as dominant crops in the present study. So in corn/soybean intercropping, soybean growth associated with a tall grass like corn can be a dominated crop. Aasim *et al.,* [13] revealed the aggresivity of cotton was the dominant species with positive values in the intercropping systems over the cowpea and sorghum which had negative values.

D. Land Equivalent Ratio (LER)

Yield advantage in terms of LER varied from 1.12 to 1.37. These results indicate that 12 to 37%, greater area would be required by a sole cropping system to recover the yield of intercropping system [14]. The higher the LER and RCC value, the greater is the yield advantage. Although in intercropping, crops were infested with weeds, but can conquer the weeds with better utilizing resources.

Neighboring of C_4 (corn) and C_3 (soybean) species in all parts of growth stages not only decreased competition, but also increased facilitative mechanism (Table 1). In stress condition like weed infestation, all mixing ratios had higher LER than 1, which shows intercropping advantages. The advantages accrued from intercropping systems, as evident from competitive functions, is due to better utilization of growth resources under cereal–legume intercropping system [15].

IV. Conclusion

It is concluded that intercropping can be used as a tool to improve competitive ability of a canopy with good suppressive characteristics. According to yield advantages in corn and soybean intercropping, it could be a management strategy for weeds suppression and alternation tool to reduce the reliance of weed management to chemical herbicides.

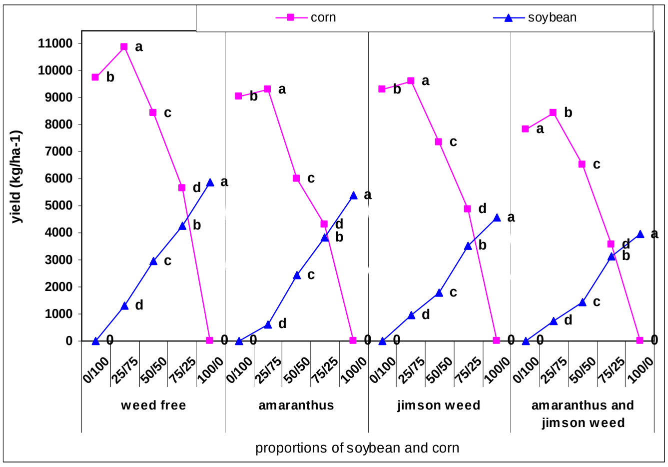

Fig. 1 Interaction effect of mixing ratios * weed infestation on corn and soybean yield on 2006

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