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Effect of interplanted and mixed crops of maize and soybean on pest and disease management in soybean

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Abstract- The effect of interplanted and mixed crops of maize and soybean on pest and disease management in soybean was studied in 1993-1995. The results showed that the occurrence of general pests and diseases of soybean in interplanted and mixed crop fields were less severe than in single seeding field. The reduced rate of major pests in interplanted and mixed crop fields was between 11.4%-81.4% and 20.9%-76.0%, respectively. The reduced rate of disease in interplanted and mixed crop fields was between 70%-100% and 56.7%-100% compared with monoculture of soybean, respectively. The increased rates of natural enemies of the former were between 13.0%-86.5%. The economic profits of two cultivation methods increased by 32.9% and 33.7%, respectively, compared with monoculture of soybean.

Key words – interplanted and mixed crops, pests and diseases of soybean, effect

With progress in crop cultivation, yields of interplanted and mixed crops of maize and soybean have also increased significantly. These two methods, together with monoculture of soybeans, make up three major methods in soybean cultivation. In order to define the characteristics of pest and disease in interplanted and mixed crops of maize and soybean, and to discover corresponding pest and disease management methods, field experiments on the effects of interplanted and mixed crops of maize and soybean on pest and disease management in soybean were taken between 1993-1995 in Jiaxiang, Shandong Province.

I. MATERIALS AND METHODS

A. *Experimental field design and varieties*

Soybeans planted by three methods -- monoculture, interplanted and mixed crops of maize and soybean -- were observed. Monoculture was the normal cultivation method. In interplanted cropping fields, spacing between rows was 160 cm; distance between maize plants was 18 cm; 6 rows of soybean were planted with 1 row of maize. In mixed crops fields, spacing between rows was 66 cm; distance between maize plants was 33 cm; 4-5 plants of soybean were planted with 1 plant of maize.

In the experiments, the soybean variety Ludou 4 and the maize variety Yedan 12 were used. The area of each field block was 100 m² (10 m × 10 m). A comparison experiment

was conducted once in 1993-1994, repeated 9 times in 1995, with treatments arranged randomly. There was no protection against pests and diseases during the entire growing season for soybean, permitting all pests and natural enemies to occur naturally.

B. Effect investigation and statistical analysis methods

From seedling stage to harvest stage, soybeans were sampled at 5 points along a diagonal line for every block. The pest and disease situation and natural enemy varieties and populations were observed every 5 days. Yields of maize and soybean were recorded in harvest stages. The characteristics of pests, disease and natural enemies incidence, and economic profits in different cultivation methods were compared. In order to eliminate errors from single investigation results and to improve accuracy, according to the 2-dimensional (time and population) properties of pest and disease, a formula combining population and time property was used to compare pest, disease, and natural enemies incidence. That formula is: $S = \sum DT$, where D is the average population density of the 2 consecutive investigations, also named severity index; and T is the interval between 2 consecutive investigations.

II. RESULTS AND ANALYSIS

A. Effect on soybean pests

Table 1 shows that pests in interplanted and mixed crop fields were fewer than in monoculture soybean, specifically with aphids, *Anomis flava*, *Clanis bilineata walker*, and *Holotrichia parallela* Mtschulsky significantly fewer in the former two methods than those in monoculture fields. The population reductions of aphids were 56.2% and 52.2% respectively. The population reductions of *Anomis flava* were 42.8% and 29.2% respectively. The population reductions of *Clanis bilineata walker* were 53.8% and 56.1% respectively. The population reductions of *Heliothis armigera* Hubner were 25.2% and 26.5%. The population reductions of *Liriomyza stivatae* Blanchard were 81.4% and 76.0%. The population reductions of *Leguminivora glycinivorella* Matsumura were 33.3% and 20.9%. The population reductions of *Holotrichia parallela* Mtschulsky were 11.4% and 35.3%. As observed from the highest pest population density, in interplanted and mixed crops fields, densities of aphids and *Anomis flava* were below economic thresholds (ET: 1500 individuals/100 plants and 50 individuals / 100 plants) in 3a test, while they were above the ET in monoculture soybean fields. Density of *Clanis bilineata walker* was below ET (5 individuals /100 plants) at 1a level in interplanted and mixed crops fields, while it was below ET at 2a level in monoculture fields. Density of *Holotrichia parallela* Mtschulsky satisfied protection index at 2a level (3 individuals / m²) in interplanted and monoculture fields. Results show that *Clanis bilineata walker* and *Holotrichia parallela* Mtschulsky are the major insect pests in interplant sown fields, while *Clanis bilineata walker* is the major insect pests in mixed crops fields.

Table 1 Effect of interplanted and mixed crops of maize and soybean on pest

Year	Cultivation	Aphids		<i>Anomis flava</i>		<i>Clanis bilineata walker</i>		<i>Clanis bilineata walker</i>		<i>Liriomyza stivatae</i> Blanchard		<i>Leguminivora glycinivorella</i> Matsumura		H. parallela
		$\sum DT$	(/100 plants)	$\sum DT$	(/100 p)	$\sum DT$	(/100 p)	$\sum DT$	(/100 p)	$\sum DT$	(/100 p)	$\sum DT$	(/100 p)	(/m ²)
1993	Interplanted	11050	620	947.5	30	0	0	375.0	10	0	0	24.1	1.3	-
	Mixed	13570	460	1432	46	13.0	1	401.0	10	0	0	27.6	2.2	-

	Monoculture	35960	1560	1574	58	53.0	2	448.0	15	7.5	1	32.9	2.8	-
1994	Interplanted	10790	480	400.5	13	98.5	4	184.5	7	132.0	5	10.8	1.2	1.0
	Mixed	13530	700	393.5	12	78.0	4	197.0	7	171.0	6	14.1	1.3	0.8
	Monoculture	24210	1520	685.5	19	137.5	6	294.0	10	308.0	12	21.1	1.8	1.1
1995	Interplanted	6965.6	320	114.7	3.7	137.4	6.3	87.2	3.9	11.7	1.7	14.1	0.9	3.8
	Mixed	6197.8	315.6	138.3	4.3	104.2	5.0	71.6	3.2	15.0	1.7	16.2	1.2	2.5
	Monoculture	12418.9	526.7	216.0	6.2	205.8	6.2	111.18	4.3	90.8	8.3	18.6	1.3	4.4
	Variance analysis	23.99**	-	6.31*	-	4.67*	-	2.14	-	2.23	-	2.47	-	15.00**
Reduction (%) compared with monoculture	Interplanted	56.2	-	42.8	-	53.8-	-	25.2	-	81.4	-	33.3	-	11.4
	Mixed	52.2	-	29.2	-	56.1-	-	26.5	-	76.0	-	20.9	-	35.3

** [no footnote provided in original]

B. Effect on soybean pests and diseases

3a test showed that average severity indices of soybean mosaic virus in interplanted and mixed crop fields were 0.9 and 1.3 respectively. Compared with 3.0 severity index of monoculture field, they were reduced by 70.0% and 56.7%. The severity indices of soybean root rot disease were 0 for the former two cultivation methods, but 2.5 for monoculture soybean field. Results showed that disease infection in interplanted and mixed crop fields is much lighter than in monoculture soybean.

C. Effect on soybean natural enemies

1) Natural predators

From Table 2, the population of natural predators in interplanted and mixed crop fields was higher than in monoculture fields. Population of beetles in interplanted and mixed crop fields increased by 84.0% and 86.5% compared with monoculture fields. Lacewing flies increased by 58.9% and 80.6% respectively. Spiders increased by 41.3% and 52.3% respectively. Syrphus flies in interplanted and mixed crop fields were also significantly more than those in monoculture fields. *Propylaea japonica* Thunberg and *Harmonia axyridis* Pallas were the major varieties of beetle, each making up 62.4% and 10.3% respectively. *Chrysopa sinica* Tjeder was the major variety of lacewing fly, making up 57.9%. *Epistrophe balteata* De Geer and *Syrphus corollae* Fabricius were the major varieties of Syrphus fly, making up 56.3% and 31.6% respectively. *Erigonidium graminicolum* Sandevall and *Misumenops tricuspidatus* Fabricius were the major varieties of spider, making up 33.8% and 26.2% respectively.

2) Natural parasites

The population of natural parasites in interplanted and mixed crop fields was much higher than those in monoculture fields (Table 2). *Trioxys auctus* Haliday was the major species of Aphid, and its population in interplanted and mixed crop fields increased by 23.9% and 29.9% respectively. *Trichogramma dendrolimi* Matsumura was the major species of *Clanis bilineata walker's* egg masses, increasing by 13.0% and 20.05% respectively. *Casinarina nigripes* Gravenhorst and *Apanteles ruficrus* Haliday were the major species of *Argyrogramma agnata* Staudinger's larvae, making up 45.0% and 23.0% respectively. Their population increased by 18.7% and 25.3% respectively.

Table 2 Natural enemies situation in different cultivation methods

Cultivation methods	Natural preyer (\sum_{DT})				Natural parasites (%)		
	Beetle	Lacewing fly	Syrphus fly	Spider	Aphid	<i>Clanis bilineata walker's</i> spawn	<i>Argyrogramma agnata</i> Staudinger's larvae
Interplant	150.0	98.5	46.5	265.0	14.5	11.3	23.5
Mixture	152.0	112.0	42.5	285.5	15.2	12.0	24.8
Monoculture	81.5	62.0	0.0	187.5	11.7	10.0	19.8

D. Economic profits in different cultivation methods

The economic profits of interplanted and mixed crop fields were higher than those of monoculture fields (Table 3), with a mean increase of 32.9% and 33.7% respectively.

Table 3 Economic profits of different cultivation methods

Cultivation methods	Soybean		Maize		Economic profits (yuan/hm ²)	Rate of increase (%)
	(kg/hm ²)	(yuan/hm ²)#	(kg/hm ²)	(yuan/hm ²)#		
Interplant	1082.0	3462.4	4366.2	6112.7	9575.1	32.9
Mixture	664.1	2125.1	5363.8	7509.3	9634.4	33.7
Monoculture	2252.0	7206.4	0	0	7206.4	-

yuan: unit of Chinese currency RMB

III. DISCUSSION

Maize and soybean are both important crops in China. Interplanted and mixed crops of maize and soybean methods can effectively solve their competition for land. Moreover, these two cultivation methods yield higher economic profits. They are highly profitable cultivation methods. Since these two methods help natural enemies growth, restrain pest and disease infection, consequently, pest and disease incidence are within the range of economic threshold. Promotion of interplanted and mixed crops of maize and soybean methods, cooperated with interplanted or mixed crops of wheat, vegetable, and cotton, will help form a favorable niche for natural enemies. This action will play an important role in improving natural protection capability in Northern China.

IV. REFERENCE

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