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Population dynamics of soybean aphid *Aphis glycines* and its natural enemies in fields

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Abstract Systematic survey and analysis in the fields showed that the peak damage period of *Aphis glycines* was the blooming stage of soybean. The density of soybean aphid reached 18815 per 100 plants and the dwarf rate of soybean plants was 20%. There were 15 species of main natural enemies. The density of natural enemies was 431 per 100 plants during peak period, the dominant natural enemies had 5 species, *Propyloea japonica*, *Sphoerophoria* sp., *Erigonidium gramincola*, *Diaeretiella rapae*, and *Scymnus hoffmanni*. The population dynamic curve of natural enemies resembled to that of *Aphis glycines*, but was delayed by 5-7 d.

Key words *Aphis glycines*, soybean, natural enemy, population dynamics.

Soybean is an important crop in China. Soybean aphid *Aphis glycines* is one of the major pests of soybean, which can cause the rolling of leaves and dwarfing of plants when infected lightly, and give rise to the death of soybean plants and 20-50% of yield loss^[1]. Wang *et al.* studied the soybean aphid as early as 1962. However, few studies have been carried out on the population dynamics of soybean aphid and its natural enemies. The goals of this study are to survey the population dynamics of soybean aphid and its natural enemies, species of natural enemies and relationship between enemy species and soybean aphid, and then to provide the scientific evidence for integrated pest management on soybean aphid.

1. Materials and methods

Cultivar Yan 78-24 was used and sown on June 28th in this study. Surveys were conducted in the field (1 ha) in the Xuchang Institute of Agricultural Science, Henan Province.

Five-spot sampling technique was applied in the survey. Twenty plants per spot for a total of 1000 plants were counted. Sampling started from July 8th (seedling), and ended on August 27th (soybean seed ripe). One survey every 5 d for a total of 11 surveys were performed during the study. Aphids on leaves and plant stems and natural enemies were carefully observed. Alatae, wingless aphids and species and number of natural enemies were recorded, and then the plant number with aphids per 100 plants and that with rolling leaves and dwarf were analyzed.

2. Results and analysis

2.1 Population dynamics of soybean aphids in the fields

Apterous aphids were the main stage feeding on soybean plants, and alatae accounted for less than 16.7 % of the total aphids. Soybean aphid populations started from July 8th to 18th (10 d). July 18th – August 7th was the initial population growth period (20 d), in which the peak density was shown from July 23rd to August 2nd (10 d). The ending growth period occurred from August 7th to 27th (20 d) (see Table 1).

Table 1 Population dynamics of soybean aphids

Date (month-day)	Aphids per 100 plants			Aphids present on plant (%)	Leaf-rolling rate (%)	Soybean development stage
	Total	Apterous Aphids	Alatae			
07-08	76	71	5	16	0	Seedling
07-13	78	65	13	20	0	Seedling
07-18	2611	2601	10	85	0	Seedling
07-23	11786	11761	25	97	6	Seedling
07-28	18815	18424	391	76	8	Vegetative
08-02	6688	6575	113	100	20	Vegetative and blooming
08-07	3193	3151	42	93	3	Blooming
08-12	644	640	4	73	0	Pod ripe
08-17	1067	1060	7	95	0	Pod ripe
08-22	926	922	4	94	3	Pod ripe
08-27	1092	1068	24	82	0	Pod ripe

The alatae and apterous aphids developed simultaneously as shown in table 1. After the aphids invaded the soybean fields, the aphid density was basically stable before July 13th. When the aphids adapted to the habitats of the field, the population developed rapidly. The density of apterous aphids per 100 plants was 2601 on July 18th, but it reached 18424 on August 2nd and the alatae density also increased abruptly from 10 to 391. The density of alatae fluctuated with that of apterous aphids beyond this period. The aphids dispersed quickly as they invaded the soybean fields. The leaf rolling rates were above 80% in the whole soybean development except below 20% before July 13th, and the rates of aphid presence were also high. The leaf rolling and dwarfing plants were under heavy aphid injury, and the change of leaf rolling rate was 5-7 days later than that of aphids. For example, the peak aphid density was 18815 and the leaf rolling rate was 8% on July 28th, whereas the density of aphids declined to 6688 and the leaf rolling rate went up to the maximum 20%. The soybean plants were heavily infested from July 23rd to August 7th based upon the leaf rolling rates. Aphid injury posed a large threat to soybean yield because the vegetative growing and blooming stages were developing during this period. According to a publication ^[1], chemicals need to be applied if the aphid presence rate is over 50% and the aphid density per 100 plants is over 1500. Thereafter, the monitoring and chemical control of aphids is necessary during July 18th-August 7th.

2.2 Natural enemies and their population dynamics

There were 15 species of natural enemies of soybean aphid of which 14 were predacious, 1 was parasitic, and the predacious stage was larva mainly. The dominant enemies were *Propyloea japonica*, *Erigonidium gramincola*, *Diaeretiella rapae*, *Scymnus hoffmanni*, and *Sphoerophoria* sp. The density of natural enemies was over 50 per 100 plants. The dominant enemies started before the soybean seedling (July 28th), but only *Diaeretiella rapae* were visible after the blooming stage (August 2nd) (Table 2).

Table 2 Natural enemies of soybean aphids*

	Natural enemies	Predacious / parasitic stage	Aphids predated (per day)	Development scale	Starting date(month -day)
Predators	<i>Propyloea japonica</i>	Adult, larva	80	++++	07-23
	<i>Sphoerophoria</i> sp.	Larva	50	+++	07-23
	<i>Erigonidium gramincola</i>	Adult, larva		+++	07-08
	<i>Scymnus hoffmanni</i>	Adult, larva		+++	07-28
	<i>Nabis sioferus</i>	Adult, nymph		++	07-28
	<i>Lschiodon scutellaris</i>	Larva		++	08-07
	<i>Epistrophe balteata</i>	Larva	120	++	08-07
	<i>Syrphus serarius</i>	Larva		+	
	<i>Chrysopa sinica</i>	Adult, larva	513	+	
	<i>Chrysopa septempunctata</i>	Adult, larva	2400	+	
	<i>Coccinella septempunctata</i>	Adult, larva	90	+	08-02
	<i>Harmonia axyridis</i>	Adult, larva	100-200	+	08-02
	<i>Deraeocoris punctulatus</i>	Adult, nymph		+	
	<i>Geocoris pallidipennis</i>	Adult, nymph		+	
Parasite	<i>Diaeretiella rapae</i>	Stay in aphids until emerge		++++	08-02

Notes: “+”, “++”, “+++”, and “++++” indicate the total number of natural enemies is less than 20, 21-50, 51-70, and more than 70 per 100 soybean plants, respectively.

The curve of population dynamics is shown in Fig 1. Only a few enemy species were present in the early soybean stages. *Erigonidium gramincola* was the only species in early July. Five enemy species were visible from late July to early August. The enemy species reached the maximum 15 in early-middle August. The natural enemies decreased gradually in middle-late August.

The dominant enemy species were as follows: *Erigonidium gramincola* was the main species in the seedling stage; *Diaeretiella rapae*, *Sphoerophoria* sp., *Harmonia axyridis* and *Erigonidium gramincola* accounted for 67.5%, 38.2%, 29.6% and 26.4%, respectively, in vegetative and blooming stages; *Diaeretiella rapae* was the main species after the pod ripe stage and it accounted for 85.2% on August 17th.

* Note from translator: Wrong species names of natural enemies were corrected.

Density of natural enemies

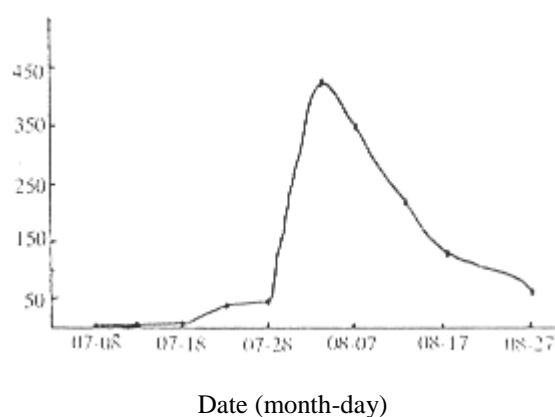


Fig 1 Development of main natural enemies of soybean aphid

The natural enemies increased rapidly from July 28th to August 2nd (see Fig. 1) and the density of enemies remained high until it peaked on August 12th. The natural enemies showed a good control of aphids in this period.

2.3 Control effects of natural enemies on soybean aphids

The natural enemies peaked at 431 on August 2nd, and there were over 135 natural enemies on August 17th. The aphids decreased rapidly as natural enemies increased. The aphid density declined from 18815 on July 28th to 644 on August 12th, and the ratios of aphids to natural enemies decreased from 310.2 to 10.4. This fact indicated that the growth of natural enemies played an important role in controlling the rapid growth of aphids.

The parasitism rate here was ratio of mummies to total aphids surveyed. The parasitism rates were 24.4% on August 12th and 9.5% on August 22nd. The natural enemies had made a contribution to control the aphids during the middle and late seasons (see Table 3). The aphids peaked on July 28th, but the natural enemies peaked on August 2nd. This difference showed that the growth of natural enemies had a 5-7 d delay to that of aphids. The aphids were the food resource of natural enemies, therefore the density of natural enemies fluctuated with the dynamic change of aphids. The population dynamic of aphids was close to the results by Wang *et al.* [2].

Table 3 Population dynamics of natural enemies and their control effects on soybean aphids

	Survey date (month-day)										
	07-08	07-13	07-18	07-23	07-28	08-02	08-07	08-12	08-17	08-22	08-27
Natural enemies per 100 plants	1.0	1.0	7.0	38.0	43.0	431.0	348.0	219.0	135.0	115.0	60.0
Aphids/natural enemies	76.0	78.0	373.0	310.2	437.6	167.2	26.4	10.4	53.4	34.2	136.5
Parasitism rate (%)	0	0	0	0	0	5.8	7.1	24.4	10.8	9.5	4.8

3. Discussion

The soybean aphid is a migrating pest with intermediate host [2]. It is an important pest in the soybean fields in Henan, Hubei, and other provinces. This study elucidated the development of soybean aphids in the fields with the analysis of soybean growth stages, and gained the scientific basis for the monitoring, prediction, and integrated management of soybean aphids. The systematic survey clarified the species, development time, density, and population dynamics of natural enemies, and thus

provided certain knowledge for employing natural enemies to control soybean aphids. The growth and decline of migrating soybean aphids correlated intensively to the corresponding climatic conditions and intermediate host. Therefore, further studies on the comprehensive analysis of soybean development stages, climatic factors and intermediate host are very important while studying the population dynamics of soybean aphid and its natural enemies.

References

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