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Major Pests of Maize and Control Measures in Japan

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Abstract
Major pests of maize in Japan include armyworm, oriental corn borer, wireworm, aphid, pink borer, black cutworm, seedcorn maggot, and several species of birds. Among these pests, the first four species and some birds are economically the most important pests. An overall review on the ecological aspects and their control measures indicates that the most promising measure for controlling those pests is an adoption of cultural control methods including use of resistant varieties. The major pests, however, have to be controlled effectively by pesticides in advance to their severe infestations. Further research is needed to develop adequate combinations of cultural and chemicl control measures for effective and low cost management of maize pests.

Discipline: Insect pest
Additional key words: aphid, armyworm, bird, oriental corn borer, wireworm

Introduction

Maize is cultivated in paddy and upland fields throughout the country as one of the most important cereal crops in Japan. Various types of pests including insects, birds, hare, and voles are the main targets of control in maize production. Most of these pests inhabit in paddy as well as in upland fields, which are inseparable locations as their feeding niches. This paper attempts to review ecological characters and managements of the important maize pests in Japan, which have been subjected to intensive studies due to their serious damages on crop production.

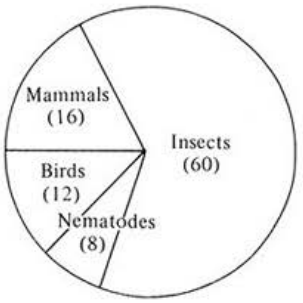

Fig. 1. Maize pests in Japan (96 species)
After Japanese Society of Applied Entomology and Zoology, 1987.

Pests of maize

In a list of the pests contained in the publication issued by the Japanese Society of Applied Entomology and Zoology in 1987, the maize pests in Japan were 96 species in number; consisting of 60 of insects, 8 of nematodes, 12 of birds and 16 of mammals (Fig. 1). Major pests which are economically important are presented in Table 1. Their injuries may be classified broadly by a place of primary damages; i.e., roots; stalks, leaves and ears; and stored grains. Some pests attack maize crop during limited stages in plant growth and some others cause damages during several stages. The major pests of maize and the relevant control measures are described hereafter.

Armyworm

Armyworm, *Pseudaletia separata,* is widely distributed in Asia and Oceania, more specifically in Japan, the Korean peninsula, China, Southeast Asia, Australia, New Zealand, southeast Siberia and some other regions. As far as its presence in Japan is

Table 1. Major pests of maize and their control measures in Japan

Pests	Control measures
Armyworm (*Pseudaletia separata*)	Trichlorfon, Pyridaphenthion Weed control
Oriental corn borer (*Ostrinia furnacalis*)	Resistant varieties Isoxathion, Pyridaphenthion, Cartap, Diazinon, Carbaryl, Phenthoate
Wireworms: (*Melanotus fortimi*, *Agrypnus binodulus*, *Ectinus persimilis*, *Agriotes fusciollis*, *Selatosomus puncticollis*, *Aeoloderma agnata*, *Negastrius quadrillum*, *Dicronychus nothus*)	Isoxathion
Aphids: Corn aphid (*Rhopalosiphum maidis*) Oat bird-cherry aphid (*R. padi*)	Phenthoate
Birds: Carrion crow (*Corvus corone*) Jungle crow (*C. macrorhynchus*) Feral pigeon (*Columba livia*) Rufous turtle dove (*Strepto orientalis*) Common pheasant (*Phasianus colchus*)	Simultaneous seeding in large areas Bird-proof nets Bird reflecting tapes, Sound producers, Razzo, Scarecrows, Window dummies Repellent

concerned, this insect is not a permanent resident in the cold northern districts of the country, i.e., northern Honshu and Hokkaido Island. The fact that the moths are spread and migrate northward by the south wind in spring and southward by the north wind in autumn is confirmed by a marking- and recapture-experiment in China[8]. However, it is not confirmed whether the moths migrate southward from the northern district within Japan. In regard to the outbreaks of the moths in the northern region of Japan, it is presumed that they are caused by mass migrations from eastern China to the northwestern coast of Japan[10]. A justification of this presumption is: the incidence of an outbreak coincides with a mass migration of the moths as well as with a wind condition during the suspected period of their invasion. As a matter of fact, in 1987, an outbreak of armyworm took place in Hokkaido and various field crops were infested by the larvae. The maize area under infestation was approximately 8,000 ha, which accounted for about 20% the total maize area in that region, as shown in Table 2. In this regard, it was confirmed that the outbreak of the first generation resulted from the mass flight of adult moths which had migrated from China[11]. In reference to the wind condition related to that outbreak, an analysis on the 850 mb chart indicated that a most likely route of the migration of the moths had been the low level jet stream over the Japan Sea[4]

The number of generations of the moths varies among the different localities; 2 in northern Honshu and Hokkaido, 3 to 4 in central Honshu, and 4 to 5 in Kyushu, southwestern part of Japan. This variation suggests that growth of the moth be directly influenced by air temperature in the respective regions.

The small larvae of armyworms feed and remain inside of whorled leaves of maize plants. They are not generally noticed until the time when they have fully grown up. In the course of their growing, they consume so many leaves, depending on the size of larval population. In case where it is large enough, the damages may seriously affect the maize yield. It is therefore stressed that an early detection of

Table 2. Outbreaks of first generation of armyworm and damages of crops in Hokkaido, Japan in 1987[a]

Crops	Outbreak area (ha)	Outbreak rate (%)	Area classified based on degree of damages (ha)[b]				
			0	+	++	+++	++++
Rice	3,655	2.5	143,824	3,474	150	30	1
Barley	739	19.4	3,063	379	172	120	68
Spring sowing wheat	6,852	57.1	5,141	1,779	1,746	1,762	1,565
Fall sowing wheat	38,001	36.0	67,452	19,619	8,012	5,934	4,436
Grass	122,679	24.3	382,848	34,235	27,981	26,509	33,954
Corn for vegetables	1,746	13.9	10,796	1,566	116	47	17
Corn for silage	8,148	19.2	34,375	7,028	727	317	76
Total	181,820	21.9	674,499	68,080	38,904	34,719	40,117

a): After Okuyama et al. (1988)[11].
b): Damage degrees in grasses and wheat; + : 1–9, ++ : 10–24, +++ : 25–49, ++++ : over 50 larvae per 1 m^2, Damage degrees in maize and rice; + : 1–9, ++ : 10–29, +++ : 30–100, ++++ : over 100 larvae per 25 stunts.

Table 3. Oviposition of armyworm moths released to the maize fields with and without weeding[a]

Field	No. of moths released	No. of egg mass	No. of eggs	Oviposition sites
With weeding	105	0	0	—
Without weeding	105	97	8,496	Fingergrass

a): After Kanda & Naito (1982)[3].

the occurrence is essential for an effective control of this insect. In addition, it is recommended that the weeds in maize fields be controlled, since the adult moths have a habit of laying their eggs on grasses rather than on maize plants as shown in Table 3[3].

Oriental corn borer

Oriental corn borer, *Ostrinia furnacalis,* is distributed over the whole area of Japan, the Korean peninsula, China, eastern India, Southeast Asia, Australia, and some other regions. European corn borer, *Ostrinia nubilalis*, which is a very important pest of maize in North America, is a different species from the oriental corn borer[9], though these two species have many habitudes similar to each other.

The number of generations of the moth in a year is: 1 in Hokkaido, 2 in the northern and central mountainous districts of Honshu, and 3 in the southern region of Japan. This insect passes the winter in the form of a fully grown worm in stems, ears and stubbles of maize plants, on which it has been feeding. During about a half an year, the larvae are dormant in a diapausing state.

The moths begin emerging in June and continue to come out until September. The moths hide amongst the maize plants in the daytime and fly around mainly during the night. They have a habitude of being attracted by light. An appropriate timing of spraying insecticides can be determined by counting the number of moths in light traps. However, in monitoring the seasonal prevalence of occurrence, use of a sex pheromone in the male moths might be more practical. It is recognized that the sex pheromone of the moth of oriental corn borer is a mixture of chemical compounds which are different from those of European corn borer[1,5].

The females lay their eggs in a mass on the reverse side of maize leaves. Regarding the oviposition site, the moths prefer rampant maize plants[7] and varieties with a taller height[6]. The eggs hatch usually in a week or less. The young larvae feed in the spaces between closely pressed leaves or between ear and stalk, in the tassel or beneath the husks until they are nearly half-grown. In case where maize plants at their late reproductive stage are feeded, the larvae grow very fast[12]. In their mid-growing stage, the larvae begin to get into stalks, ears, or thick leaves and stems, eating these plant parts. They continue feeding in these parts until they are fully grown up.

When heavily infested, the maize stems are easily broken and mechanized operation for harvesting is

seriously hampered. The damages in maize ears cause a low yield and poor quality of the seeds and the silage.

Corn borer injuries in maize could be effectively controlled with a profit, if resistant cultivars and pesticides are properly used, as shown in Table 1. Use of the varieties resistant to corn borer is strongly recommended for reducing pest damages. Some dent corn cultivars tested in the field showed a significant difference in regard to their resistance to corn borer, especially to its first generation. Some of the F_1 hybrid cultivars, introduced to Japan in the early 1950s such as Takanewase, G4553, and GSA2222, expressed high resistance to the first generation of corn borer. However, in the second generation, less clear differences were observed among the cultivars tested. It should be added that no distinct relationship could be seen between the dates of tassel heading and the infestations of corn borer, which had been so far one of the important indexes in identifying characteristics of maize cultivars.

Wireworms

As presented in Table 1, eight species of wireworms attacking maize are identified in Japan (Japanese Society of Applied Entomology and Zoology, 1987). Wireworm is one of the most difficult maize insects to control, widespread in many other crops as well. Damages caused by this insect are very destructive. All the species of wireworms, especially their larvae, attack maize plants at the two stages, including seed germination and seedling growth. Wireworms live underground for 2 to 6 years. If attacked by this insect, maize plants may not germinate well, or even though starting well, they may wither or die as the worm easily bore into the underground part of the stems.

Effective control with cultural practices is rather difficult in managing wireworms in the fields, because this insect has a relatively long life-cycle. Seed treatment with isoxathion prior to seeding is an effective measure for control.

Aphids

Among the various aphids of maize, the most serious are corn leaf aphid, *Rhopalosiphum maidis,* oat bird-cherry aphid, *Rhophalosiphum padi,* and *Sitobion akebiae.* The corn leaf aphid is a widespread pest that is distributed throughout Japan. This aphid attacks maize, oat, barnyard millet, foxtail millet, sorghum and some other crops. The aphid infests the upper leaf and the tassel of maize plants. Under a heavy infestation of aphids, sweet corn is seriously hindered in its growth as well as in grain quality. The oat bird-cherry aphid is also a widespread insect pest that is distributed over the whole areas of Japan. As far as the host crops of the aphids are concerned, maize is only one of their intermediate hosts; the main hosts are apple trees and some other crops such as barley and wheat. The aphids attack leaves, tassels and ears of maize plants.

Birds

Table 4 shows some statistical data as of 1984 reported by the Plant Protection Division of the Ministry of Agriculture, Forestry and Fisheries on the occurrence of damages in crops caused by birds in Japan. The damaged area by sparrows is the most extensive, while the damaged amount by crows is the greatest. Sparrows attack mainly forage crops with small grains, such as foxtail millet and millet, damaging their seed grains. Birds that attack maize plants include carrion crows, jungle crows, feral pigeons, rufous turtle doves and common pheasants. In the last ten years, the areas grown to soybean and forage crops increased in Japan as the converted crops from rice. This conversion has caused increased damages by pigeons and crows, subsequently. It is generally recognized that the damages by these birds are very difficult to control.

Table 4. Damages in crops caused by birds in Japan (1982)[a)]

Birds	Damaged area (ha)	Damaged amount (t)	Main crops damaged
Sparrow	85,682	8,455	Rice, Forage crops
Crows	28,743	26,492	Vegetables, Forage crops
Mallard	19,589	1,777	Rice
Gray starling	7,897	3,886	Fruits
Bulbul	7,892	5,100	Vegetables, Fruits
Dove	16,367	8,916	Beans, Forage crops
Pheasant	643	253	Forage crops
Others	4,799	2,299	
Total	171,612	57,178	

a): After Plant Protection Division of MAFF, Japan, 1984.

Some measures for bird control are shown in Table 1. Among the cultural control methods, simultaneous seeding in large areas is recommended. Deep sowing of maize seeds, i.e., planting at a depth of 6 to 9 cm, is an effective means to protect maize seedlings from damages of crows[2]. Bird-proof nets are the most reliable method for bird control, though they could not be made available for large fields of maize. Physical and mechanical control methods, including bird reflecting tapes, sound producers, Razzo, scarecrows, and window dummies, are also used in maize fields. Seed treatment with a repellent is another method to protect maize seedlings from the harmful birds.

Conclusion

As far as the members contained in the maize pests and their ecological characters in Japan are concerned, no difference exists among the pests of sweet corn for vegetables and dent corn for silage, although the economic significance is completely different between them. The necessity of the pest control is determined on the basis of its economic return. Application of pesticides to control the pests of dent corn for silage has not been well developed in Japan, because cattle farmers find insecticides extremely expensive. In addition, since the dent corn is utilized directly for feeding of dairy cows and beef cattle, use of insecticides is requested to be minimized for safety reason.

The promising measures for controlling maize pests would therefore be an adoption of cultural methods, including the use of resistant varieties. The most important pests, however, have to be controlled effectively by pesticides prior to their severe infestations. In this regard, further ecological research is required to develop adequate combinations of cultural and chemical control measures for effective and low cost management of maize pests.

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