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A note on the likely areas of establishment of Japanese beetle (*Popillia Japonica, Newman*) in India

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ABSTRACT. A climatological study to delineate the areas favourable for the establishment and multiplication of the Japanese beetle shows that the most favourable meteorological conditions for the beetle would obtain in some parts of north Uttar Pradesh, Himachal Pradesh and Kashmir. A longer activity period from May to August may be expected in India while it is only two months in U.S.A. and European countries. The adult feeding period can extend from April to October and hence several generations can be produced. Thus the pest would pose a serious threat to orchard plantations in northwest India.

1. Introduction

Accidental introdution of exotic pests and disease organisms can lead to virulent infestations on susceptible crops in regions where the climatic conditions are : (*i*) similar to those of their original habitat or (*ii*) are congenial for their survival throughout the year and conducive for their multiplication and spread at some parts of the year. The Japanese beetle (*Popillia Japonica, Newman*) was one such insect which was noticed to be causing heavy damage in eastern coasts of U.S.A. in the 1950s. The insect has, in the beginning of the century, found its way into U.S.A. from Japan. The main source for its initial entry must have been through aircraft as the beetle is a weak flier. The beetles feed on fruits, flowers and foliage of certain kind of plants, particularly in sunny weather and have a preference for grape, raspberry, apple, cherry, sweet corn, maize, rose, horse-chestnut and willow plants. The World Meteorological Organisation had carried out a study in the 1960s on the possibility of establishment of the Japanese beetle in Europe (Bourke 1961). It has been stated (Anonymous 1955) that the pest is probably indigenous to northern India also. Therefore, the need for a climatological study for delineating the areas favourable for its settlement is obvious, to help proper organization of plant protection and quarantine measures to prevent the pest reaching such areas in our country.

2. Life cycle of Japanese beetle

This has been discussed in great detail in relation to environment by Bourke (1961). Salient features are briefly recapitulated here.

Details of the seasonal life cycle of the beetle in Philadelphia, U.S.A. (Flemming 1955) show that adult beetles emerge in mid-June, remain active till mid-August and then gradually disappear. There is repeated mating in this active period. To lay eggs the female burrows about 10 cm into the ground (or a little deeper in drier soil) and about 50 eggs are deposited. Acidic soils are favoured. The grubs hatch out in 2 weeks and move up to feed on fine rootlets. The grub passes through three larval stages. As the soil gets colder, the grubs burrow deeper into the soil and cease feeding when temperature falls below 10°C. When the ground becomes warmer in spring, the grubs again move towards the surface, after 5 days following the favourable changes in temperature. Near the Philadelphia regions the beetles do not emerge till July, in northern areas, while in southern areas emergence occurs in May itself.

3. Favourable environmental conditions

The adult beetle becomes very active as the temperature rises above 20°C on calm, sunny days and are quiet on cool, stormy and cloudy days or when the relative humidity is very high (Flemming 1959). The environmental conditions reported as favourable for the different stages of the life cycle of the Japanese beetle by various investigators on the basis of laboratory studies or empirical methods have been reviewed and summarised by Bourke (1961) to evolve a model of suitable environment for the Japanese beetle.

TABLE 1

Delineation of suitable stations and periods for colonisation and field activity of Japanese beetle (*Popillia Japonica*) in India

Station	Months with temperature range		Three consecutive months of activity with av. rainfall more than 250 mm (Egg laying)	Months with clouds more than 5 Octa for 15 days or more (Adults inactive)	Months with mean R. H. 90% or more (Adults inactive)
	8°-31°C (non-hibernation)	15°-31° C (Activity)			
(1) Mussoorie	A M J J A S O	M J J A	M J J : J J A	Aug	J A S
(2) Dalhousie	M A M J J A S O	M J J A S	M J J : J J A : J A S	J A	Aug
(3) Dharamsala	F M A M J J A S O N	A M J J A S O	M J J : J J A : J A S : A S O	J A	—
(4) Simla	A M J J A S O	M J J A	M J J : J J A	J A	Aug
(5) Mukteswara	A M J J A S O	M J J A	M J J : J J A	Aug	J A S
(6) Srinagar	M J J A S	J A	—	J F M D	—
(7) Nainital	A M J J A S O	M J J A S	M J J : J J A : J A S	J A S	—
(8) Banihal	A M J J A S	J J A	J J A	—	—
(9) Qazigund	M J J A	J J A	J J A	J F M A	Jul
(10) Joshimuth	A M J J A S O	J J A S	J J A : J A S	J A	Aug
(11) Dibrugarh	Jan to Dec	M A M : J J A S O N	N A M : A M J : M J J : J J A : J A S : A S O	M A M J J A	—
(12) Dhubri	Jan to Dec	M A M J J A S O N	M A M : A M J : M J J : J J A : J A S : A S O	J J A S	—
(13) Shillong	M A M J J A S O	M J J A S	M J J : J J A : J A S	M J J A S	—
(14) Cherrapunji	Feb to Dec	A M J J A S O	A M J : M J J : J J A : J A S : A S O	A M J J A S	J J A
(15) Kalimpong	Feb to Dec	A M J J A S O	A M J : M J J : J J A : J A S : A S O	J J A	J A S
(16) Abu	Jan to Dec	M A M J J A S O	M J J : J J A : J A S : A S O	J A	J A
(17) Marmugao	Jan to Dec	Jan to Dec	A M J : M J J : J J A : J A S : A S O : S O N	J J A S	—
(18) Coonoor	F M A M J J A S O N D	M J J	M J J	J A S O N	—
(19) Kodaikanal	J F M A M J J A S O N D	A M J	A M J	M J J A S O N D	—
(20) Balehannur	Jan to Dec	F M A M J J A S O N D	M A M : A M J : M J J : J J A : J A S : A S O : S O N : O N D	M J J A S	J J A S
(21) Mercara	Jan to Dec	F M A M J J A S O N	M A M : A M J : M J J : J J A : J A S : A S O : S O N : O N D	J J A S	J J A S
(22) Mahabaleshwar	Jan to Dec	M A M J J A S O	A M J : M J J : J J A : J A S : A S O	J J A S	J J A S
(23) Aijal	Jan to Dec	J J A S O	J J A : J A S : A S O	J J A S	J J A S
(24) Harnai	Jan to Dec	Jan to Dec	A M J : M J J : J J A : J A S A S O : S O N	J J A S	—
(25) Ootacamund	M A M J J A S O N	A M	M A M	J J A S O	J A

As per this model the average soil temperature at 5 or 10 cm depth should lie in the range 20°-28°C, the total rainfall for 3 consecutive months should be more than 250 mm for laying eggs and the lowest soil temperature at 5 or 10 cm should be above –2°C. Regarding the lower limit, Marlatt (1931) had observed that hibernating larvae may survive temperatures as low as –10°C. Regarding the upper temperature limit Fox (1939) points out that while a constant temperature of 28°C is quite lethal to the grubs, exposure during larval development of grubs, to a temperature regime of the order of 20°–25°C help them to withstand the high temperatures better.

4. Delineation of favourable regions in India

From the foregoing discussion the soil temperature (S.T.) regime at 5 or 10 cm and the rainfall pattern during the favourable regimes of soil temperatures emerge as the most important factors for the establishment and colonisation of the beetle. An examination of the S.T.'s at 5 and 15 cm depths for the representative months of January, April, July and October showed that favourable soil temperature conditions would be found only in some parts of north Uttar Pradesh, Himachal Pradesh and Kashmir. As S.T. data are not available for the above areas the difference between the mean minimum and maximum air temperature fields from the S.T. regimes at the min. epoch (0700 LMT) and maximum epoch (1400 LMT) were ascertained. It was seen that except in summer the 5 cm S.T. is (*i*) higher than min. by 2.5°C at 0700 LMT and (*ii*) higher than max. at 1400 LMT by 2.5°C in north and 5°C in south. At the 15 cm depth the 0700 hr soil temperature is greater than min. by 5°C in winter and monsoon period while in summer and post monsoon season the difference could go upto 7.5°C. However, at 1400 hr the 15 cm S.T. is 2.5° –5.0°C less than the max. in north and 0°–2.5°C less than max. in south. In the light of this a diurnal air temperature range of 18° C min. and 26° C max. could lead to a S.T. regime of 20°-28°C at 5 cm depth. At 15 cm depth the above temperature conditions would result from an air temperature regime of 15°C min. and 31°C max. In light of the above the stations and months in which min. air temperatures were greater than 15°C and max. air temperatures were less than 31°C were noted (Table 1). The months of favourable meteorological conditions for various activities of the pest for such stations are also given in Table 1.

The stations in Table 1 are suitable for completion of the full life cycle of the beetle. However, non-availability of their preferred foods, make their incidence less risky in west Peninsular and northeast India.

5. Conclusions

From the study of the climatic situation in our country and the conditions required for completing life cycle, activity and mortality of this pest, the following conclusions are drawn:

(1) A higher activity period in India may be expected during the period May to August (whereas it is only two months in U.S.A. and European countries).

(2) During August most of the days are cloudy with R. H. $\geqslant$ 90 per cent. This period is not conducive for the activity of the pest but the period is favourable for egg laying.

(3) The adult feeding period can extend from April to October in some places which may produce several generations in a year in India.

(4) The rate of spread and the extent of damage by this pest would pose a serious threat to orchard plantations in hilly areas of northwest India. The possibility of damage in northeast India also exists.

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