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Optimum Chilli Density Inter-planted with Maize in Relation to Aphid Population and Incidence of Virus Diseases on Chilli

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Abstract: The study was conducted to determine the most effective chilli density inter-planted with maize to reduce the population of the aphid, *Aphis gossypii* and incidence of virus diseases on chilli. The treatments were MCMCMCM, MCCMCCM, MCCCCCM and CCCCCCC (M, Maize; C, Chilli). Results showed that the number of alate aphids caught per day and number of apterous aphid per plant was significantly different among treatments ($P < 0.05$). The number of apterous aphid per plant was found to be higher in plots where higher number of chilli plants were inter-planted with maize. However, there were no significant differences ($P > 0.05$) in the number of apterous aphid in treatments of MCMCMCM and MCCMCCM or in treatment of MCCCCCM and CCCCCCC. The number of apterous aphids per plant and counts of alate aphids per treatment were significantly ($P < 0.05$) more abundant in the monoculture plots than in other treatments. The number of apterous aphids was also found to be significantly different ($P = 0.001$) at different level of strata. The numbers were higher in lower than in upper stratum. Results showed that there was a significant correlation ($r = 0.96$, $P < 0.05$) between percent virus diseases and treatments, days after transplanting (DAT) and numbers of apterous and alate aphids. Incidence of virus diseases was only correlated with treatments and DAT after subjected to a stepwise elimination regression analysis. This suggests that the incidence of virus diseases were influenced by the number of chilli plants inter-planted with maize and duration of chilli plants exposed in the field. The cumulative percent of cucumber mosaic virus (CMV) incidence was significantly lower ($P = 0.001$) than chilli veinal mottle virus (CVMV) in all the treatments. However, there was no significant difference ($P > 0.05$) in the percent of CVMV incidence among the treatments. It was found that percent virus disease incidence significantly correlated ($r = 0.45$) with the rainfall. Result of this study suggests that the chilli-maize inter-cropping system of MCCMCCM could reduce the population of aphid and hence incidence of virus diseases on chilli.

Key words: *Aphis gossypii*, virus diseases, inter-cropping, chilli, maize

Introduction

The melon aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), a polyphagous in nature (York, 1992), is the major aphid species causing serious damage and yield loss on chilli (*Capsicum annum*) (Hussein and Samad, 1993). Up to date it has been the only aphid species infesting chilli in Malaysia. Most of damage is mainly due to virus diseases that it transmits. Although *A. gossypii* is able to vector 50 plant viruses world wide in the non-persistent manner (Blackman & Eastop, 1984), the Chilli Veinal Mottle Potyvirus (CVMV) and Cucumber Mosaic Cucumovirus (CMV) are the most prevalent and devastating viruses that it transmits (Mohamad Roff & Ong, 1992). Insecticides are commonly used for controlling aphid and virus diseases (Thresh, 1983), but they could kill non-target organisms, pollute environment and lead to resistant development.

The cultural practices such as intercropping (system effects) could limit pest mobility, reduce immigration or increase emigration rate of herbivore insects whilst simultaneously attracts predators and parasitoid to regulate the pest population (Pimentel, 1961; Kareiva, 1983; Nordlund *et al.*, 1984). In addition, the secondary compound emitted by the certain companion crops (crop effects) could repel the infestation of insect pests and increase percent parasitism by their parasitoids (Bach & Tabashnik, 1990). There have been evidences that intercropping could be used as an effective method of controlling insect pests and insect-borne diseases (Sharma & Sharma, 1987; Davis and Pedigo, 1990).

In Malaysia, intercropping chilli with maize was found to reduce aphid population abundance and virus diseases incidence (Idris *et al.*, 1999). However, the density of chilli and maize was at one to one ratio, and this is really do not reflecting chilli as the main crop. So the objective of study was to find out the optimum number of chilli plants interplanted with maize that have the lowest *A. gossypii* population but favour natural enemies action. It is hope that the finding would help growers in overcoming virus diseases problem of chilli and reduce an insecticide dependency attitude among the growers.

Materials and Methods

This study was conducted at MARDI Station Jalan Kebun, Klang, Selangor from June to November 1999. Chilli variety MC 11 was used because it houses relatively less number of *A. gossypii* (Idris *et al.*, 1999), while the maize used was a sweet corn of Taiwanese variety.

Experimental layout: Chilli was sowed in July in netted and insect proof greenhouse and transplanted to a field on 9th September 1999. The plants were planted in line on the raised bed. The beds were covered with silver plastic mulch to reduce weed problems, and a compound fertilizer NPK (12:12:17.2) was applied at 30 g/plant at 4 split applications at monthly interval. The planting distant was 0.6 m or 25 cm between chilli or maize plants and 1.0 m between chilli and maize. The treatments were MCMCMCM (M, maize; C, chilli), MCCMCCM, MCCCCCM and CCCCCCC. Experiment was arranged following a RCBD with three replicates per treatment (each replicate or plot is measure at 113.6 x 6 m^2 and separated from each other by 2.0 m). No pesticide was sprayed throughout the experimental period except herbicide, glyphosate isopropylamine (ECOMAC®), to control weeds. A circular yellow pan trap half filled with soap water was placed in the middle of the plot to collect alate aphid. Traps were supported with a wooden stakes and adjusted to just above of chilli canopy level from time to time.

Data collection and analysis: Data collections were commenced on the 14 October 1999 (25 days after transplanting, DAT) and ended on 27 November 1999 (66 DAT). Data collected were the total numbers of apterous aphid per plant per season, total number of apterous aphid per plant stratum per season, number of alate aphid per week or per season, number of virus (cucumber mosaic virus, CMV and chilli veinal mottle virus, CVMV) disease-infected plants per week and abiotic data (rainfall, relative humidity, temperature and light intensity). The abiotic data were collected by the weather station of MARDI, Jalan Kebun, Klang, Malaysia.

A one-way analysis of variance (one-way ANOVA) was used to analyze the differences in the total numbers of alate and apterous aphid per season among treatments. The total number of apterous aphid per plant stratum per season was analyzed using two-way ANOVA. When ANOVA was significant the means were separated by LSD at $\alpha = 0.05$. The cumulative percent of virus disease incidences were calculated as percentage by dividing the total number of chilli plant infected at the time of sampling in a treatment with the total number of plants in a treatment and multiplied by 100. A multiple regression was used to analyze the relationship between cumulative percent of virus disease incidence and treatments, DAT and number of alate and apterous aphids. The influences of abiotic factors (rainfall, light intensity, relative humidity and temperature) on the cumulative percent of virus disease incidence were tested using multiple correlation analysis. Data were analyzed using the MINITAB Statistical Software (MINITAB Version 13.3, 2000).

Results and Discussion

Alate aphid: The numbers of alate aphid caught per plot were significantly different ($F = 6.9$; df = 3, 28; $P = 0.001$) among treatments (Fig. 1A). The numbers of aphid caught were significantly higher ($P < 0.05$) in plot where chilli planted alone (monoculture) than in other treatments. This is tends to agree with the 'resource concentration hypothesis' proposed by Root (1973) in which aphid populations aggregated in plot with most abundance resource (chilli plants). When the populations are too high the effect crowding may stimulate alate aphid production (Jasson & Smilowitz, 1985) and that explain why significantly more alate aphid were caught in chilli monoculture plots. Although aphid numbers were lowest in the plot of MCMCMCM, there was no significant difference in the number of alate aphids in MCMCMCM and MCCMCCM. This indicates that planting a single row of maize for every two rows of chilli can significantly lower the number of alate aphid on chilli plants. The maize plants were reported to act as the barrier to visual chemical cues of aphid and that aphid could not identify and locate their preferred habitat (Mohamad Roff & Ho, 1991; Haase & Litsinger, 1981; Perrin & Phillips, 1978). In addition, aphids also do not prefer homogenous habitat (Minks & Harrewijn, 1989) like the MCMMCMCM and MCCMCCM plots. The numbers of alate aphid caught were varied significantly ($F = 7.4$, df = 7, 84; $P < 0.05$) with days after transplanting (DAT). Number of alate aphid caught was significantly higher ($P < 0.05$) in mid-season (43 – 55 DAT) than in the early or late season (Fig. 1B). This indicates that a high rate of emigration during mid-season as compared with the early and late season. This is probably due to crowding effect of an apterous aphid that resulted in frequent body contact between individuals during the mid-season. Frequent body contact was reported to stimulate the production of alate individuals (Jasson and Smilowitz, 1985). The decrease in the nutritional value of the host plant as the season progress may also indirectly promote alate production (Way and Cammel, 1970; Kennedy & Fosbrooke, 1973; Jasson and Smilowitz, 1985). The gradually increase in the number of alate aphid from 25 to 43 DAT indicating the attractiveness of plants to flying aphids is generally enhanced if their background provides a contrast (Smith, 1976). In contrast, Fatimah (1998) reported that the alate aphid population in five different chilli varieties were highest in the 3rd week after transplanting ($\approx$37 DAT) and declined from this time on ward.

Apterous aphid: The numbers of apterous aphid per plant were significantly different among treatments ($F = 8.6$; df = 3, 84; $P<0.05$) (Fig. 2A). The numbers of apterous aphid in MCMCMCM and MCCMCCM were not significantly different ($P<0.05$) but differed significantly ($P<0.05$) with that of MCCCCCM and chilli CCCCCCC. The trend of apterous aphid population was somewhat similar to the alate aphid population (Fig. 1A). This was indicated by the significant and positive relationship ($r = 95.3$; $F = 21.6$; df = 1, 2; $P < 0.05$) between the number of alate aphid and apterous aphid per treatment. As such, this result tends to agree with that of 'resource concentration hypothesis' proposed by Root (1973). There was no significant difference in the number of aphid in MCCCCCM and CCCCCCC plots. This suggests that the present of single row of maize at the edge of the plot was not able to act as the physical barrier to alate aphid movement (Hasse and Litsinger, 1981) that have direct influence in reducing apterous aphid population. On the other hand, high apterous aphid population in treatments with less maize plants could be explained by the 'Push and Pull Strategy' proposed by Pyke *et al.* (1987). According to this theory, maize plants may be emitted complexes of volatile compound capable of preventing aphid from colonizing chilli plants and at the same time attract more aphid's natural enemies such as the lady bird and lace wing (Mohamad Roff and Idris, 1999) to chilli plants.

There was no significant interaction ($F = 0.4$; df = 6, 84; $P > 0.05$) between the treatments and plant strata in influencing the number of apterous aphid caught. However, there was a significant difference in the number of apterous aphid recorded among plant strata ($F = 5.2$; df = 2, 84; $P < 0.05$) (Fig. 2B). In general, the numbers of apterous aphids were significantly higher at the bottom than at the middle or top plant stratum in all treatments ($P<0.05$). This suggests that inter-planting maize in chilli ecosystem, irrespective of chilli to maize ratio, does not affect the behavior of an aphid that normally prefers feeding at the lower stratum of the host plants. This may be due to favorable microhabitat or environment in the lower than in other plant strata. High relative humidity and being protected from heavy rainfall, gusty wind and its natural enemies at the lower stratum might be the main reason *A. gossypii* preferred the lower stratum especially leaves close to the ground than the upper plant's strata (Dickkson *et al.* 1956). Aphid preferred the lower plant stratum may also because of high nitrogen and amino acids content in leaves at lower than at the upper strata (Jansson & Smilowitz, 1985). Heathcote (1958) reported that the water trap at placed at lower plant stratum caught more alate aphids than the traps placed at the upper plant strata, indicating of high apterous aphid population at the lower than at the upper plant strata.

Virus diseases incidence: There was a significant different (F

Fig. 1: Mean total number of alate aphid per treatment (A) and per week (day after transplanting, DAT) M and C stand for maize and chilli plant respectively.

Fig. 2: Mean total no. of *A. gossypii* per treatment (A) or per plant stratum per treatment (B). C = chilli, M = maize

Fig. 3: Cumulative percent of virus disease incidence per treatment (A) and percent CVMV or CMV per week

= 7.06; df = 3, 28; P = 0.001) in the cumulative percent of CMV among treatments (Fig. 3A). Percent CMV disease was significantly higher ($P < 0.05$) in chilli monoculture than the other treatments. Percent CMV in MCCMCCM and MCMCMCM was significantly lower than that in MCCCCCM, suggesting that a single row of maize per two row of chilli significantly reduce CMV disease. However, the cumulative percent of CVMV among treatments were not differed significantly (F = 1.9; df = 3, 28; P = 0.153). The mean cumulative percent of CMV incidence was significantly lower (t = 4.5, df = 7, P = 0.001) than CVMV in all the treatments (Fig. 3A). This indicates that CMV is the most damaging virus disease to chilli industry in Malaysia irrespective of chilli planting systems.

Although CVMV seemed to be less damaging than CMV (both are vectored by *A. gossypii*) (Ong *et al*., 1978), it may enhance the CMV infectivity if the two viruses are present in the plants (Harris and Maramorosch, 1977). Percent virus diseases incidence per week in all treatments increased with DAT (Fig. 3B). As for the mean cumulative percent of virus diseases, the percent of diseases incidence per week was comparatively higher in treatments with less maize plants (Fig. 3 A & B).

Results of multiple regression analysis showed that there was a significant relationship (r = 0.96, F = 81.24; df = 5, 26; $P < 0.05$) between the percent virus disease incidences and the treatments, days after transplanting (DAT), and numbers of apterous and alate aphids. However, result of the stepwise elimination regression indicated that only the DAT and treatments had significant and positive relationship (r = 0.58 & r = 0.76; $P<0.05$) with the percent virus disease incidence. This suggests that the incidence of virus diseases increased with the number of chilli plants per plot and season progress (Fig. 3A & B). As the season progress, the development state of the plant that related to plant quality favor disease development (Jansson & Smilowitz, 1985; Gill, 1970). This may be further enhanced by the favourable weather condition (especially wind) that permits alate aphid production (Wallin and Loonan, 1971; Welling and Dixon, 1987).

Result of multiple correlation analysis indicated that there was a significant correlation between abiotic factors (temperature, rainfall, light intensity and weed speed) (r = 0.67; F = 3.04; df = 5, 26; P = 0.027) and the percent of virus disease incidences per week. However, after a stepwise elimination correlation was done it was found that only rainfall had a negative and significantly correlated (r = 0.45; F = 7.67; df = 1, 30; P = 0.01) with the virus disease incidence. In contrast to what was reported in the temperate region (Welling & Dixon, 1987; Swenson, 1968), the temperature seemed to be not a factor to influence the disease incidence. Result of this study suggests that the chilli-maize inter-cropping system of MCCMCCM could reduce the population of aphid and hence the incidence of virus diseases on chilli. However, further study need to be initiated whether or not at this chilli-maize inter-cropping system could yield similar or more farm produces than by the chilli monoculture. Because of virus diseases were detected as early as at the 40 DAT for MCCMCCM one or two spray of selective insecticide is needed to kill the emigrated alate aphids, and this would delay the onset of the disease incidence. By the time the disease the start to establish the plant have already tolerance to the virus diseases.

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