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Impact of pH, Nitrogen and Protein Contents in Some Cucurbits on the Population Build-up of Whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae)

MUZAMMIL SATTAR, MOHAMMAD SARWAR AND GHULAM HUSSAIN
Nuclear Institute of Agriculture, Tandojam-70060 (MS, MS) and Sindh Agriculture University, Tandojam-70060 (GH), Pakistan

Abstract.- The most abundant insect pest on cucurbit crops is whitefly *Bemisia tabaci* (Gennadius), which in case of its outbreak causes high yield losses. The existing studies were undertaken to examine the population build-up of whitefly and its correlation with the magnitude of pH, nitrogen and protein contents in leaf extracts of three cucurbit crops viz., watermelon *(Citrullus lanatus* Thanb.), Indian squash *(Citrullus vulgaris* L.) and melon *(Cucumis melo* L.), Analytical response of cucurbit crops under field conditions showed variability in their degree of pH, nitrogen and protein contents and their influence on the population dynamics of whitefly. Population counts on the incidence of whitefly were negatively correlated with increasing concern of these contents in the leaf extracts of the test creepers. Low densities of whitefly (15.04±1.25 per leaf) were associated with a low pH (6.55±0.008), nitrogen (0.394%) and protein (2.462) in watermelon that showed resistance, while, Indian squash (7.30±0.04, 0.526%, 3.29) and melon (7.63±0.01, 0.592%, 3.701) creepers had high contents in their leaves and harboured more pest intensity (24.40±2.03) and (22.30±1.85), respectively and showed susceptibility. Decreases in the activities of whitefly on watermelon indicated that these chemicals were probably directly involved in pest resistance pathways. However, the resistance expressed by watermelon can also be attributed to factors other than described that appeared to be of high significance. The variously occurring percentage of these isolates in all cucurbits tested suggested the need for more durable sources of resistance than those available. Implications of these results for the control of whitefly deserve special attention.

Key words: Cucurbit, whitefly population, nitrogen content of cucurbit, protein content of cucurbit, pH.

INTRODUCTION

The whitefly, *Bemisia tabaci* is widely distributed throughout the northern and western regions of the Indo-Pak sub-continent, particularly, in drier areas (Jackson *et al.,* 1973). There are over 1200 known species of whitefly, but a few species are pests on valuable crops. This is especially true of the sweet potato whitefly *B. tabaci* that was first reported on tobacco. The whitefly was considered as a sporadic pest until 1890, but now due to latest manipulations in agricultural methods and indiscriminate use of agro-chemicals, have set a tread mill of resurgence of minor insect pests to major status (Luo *et al.,* 1989). Furthermore, this insect injects toxic saliva into the host plant affecting normal physiological processes, and is also known to be a vector of viral diseases in a large number of crops. It prefers young and fresh plants to get nutrition and nitrogen contents. As such, the population of the pest varies according to the availability and type of food especially on watermelon, Indian squash and melon (Rahoo, 1999). Mann *et al.* (2002) reported that the whitefly, *Bemisia tabaci*, has recently become a serious pest of agronomically important crops in the world. *Bemisia tabaci* has become a threat in crop growing states of South East Asia due to its high rate of fecundity, mobility and polyphagy. Zhang *et al.* (2004) reported both nymphs and adults of whitefly as obligate phloem feeders which cause chlorosis in infested leaves, excrete honeydew that promotes the growth of sooty mold, and are efficient vectors of plant pathogenic viruses.

The pH of piercing and sucking insect's saliva is dependent upon the pH gradients of the cell sap, they suck from the host body. The pH of the foregut is greatly influenced by food and varies with the diet since there is no appreciable buffering of the foregut contents (Wigglesworth, 1953). With respect to feeding process of insects, these are either phloem feeders, mesophyll feeders or xylem feeders. The

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mechanism whereby the insect was able to reach the phloem, it was concluded that it is depended upon a pH gradient of increasing alkalinity from the cortex to the vascular bundle, the difference being about 1.6 pH units. These experiments have been widely quoted and accepted as a generalization for leafhoppers, but without confirmatory evidence (Carter, 1962). Piercing, sucking insect pests suck more than usual amount of cell sap, because they need nitrogen of nitrogenous foodstuffs.

The use of resistant cultivars is the most effective means of controlling insect pests of cucurbit crops. To date, some resistant and tolerant cucurbits cultivars have been introduced as a result of breeding studies. Transferring research findings to farmers is as important as gathering results. Trials conducted on farms in the country can be very much helpful to transfer resistant varieties to farmers. As such, with emerging importance of this insect, the experiments were carried out on the effect of pH, nitrogen and protein levels as basis of resistance, for population development of whitefly on some cucurbit crops i.e., watermelon, Indian squash and melon at the experimental area of Sindh Agriculture University, Tandojam. Agro-ecological parameters are considered to be the safe weapons to combat against pest menaces in agrarian control measure. The key for the control of some unpredictable insects is to monitor their population and forecast their pest-densities for future control strategies. The one such unpredictable insect pest to combat with is whitefly, *Bemisia tabaci.*

MATERIALS AND METHODS

The present study to note down the effect of pH, nitrogen and protein levels for origin of resistance on population development of whitefly on some cucurbit crops was conducted at the experimental field, Faculty of Crop Protection, Sindh Agriculture University, Tandojam, during May to July 1999. Three cucurbit crops *viz.,* watermelon *(Citrullus lanatus* Thanb.), Indian squash *(Citrullus vulgaris* L.) and melon *(Cucumis melo* L.) were selected for sowing on an area measuring one acre.

Field observations

After two-weeks of sowing of the crops, these vegetables (creepers) were observed randomly at weekly intervals and pest scouting was made around 8.00 AM and continued from May to July. Sixty leaves from 30 randomly selected plants (10 plants from each replicate) were observed to record the occurrence of adult whitefly *Bemisia tabaci.* The population of whitefly on watermelon, Indian squash and melon were counted by direct visual counts on the third and fourth nodes of the creepers, both on upper and lower surfaces of leaves. For recording the population of whitefly nymphs (crawlers) on leaves, 60 leaves from 30 randomly selected plants (10 plants from each replicate) were checked. The counting was carried out with the help of a metal frame measuring 2.5 cm^2, placed at the center of the underside of leaf, and to record nymphal population, it was counted with the help of magnifying lens.

Determination of pH

For determination of pH, 500 g of fresh green leaves each of watermelon, Indian squash and melon were grinded with water separately in a grinder (Commercial Blender), and the ground materials were strained through fine muslin cloth. Fifty m1 of this extract was pipetted in a clean g1ass beaker and pH was recorded by using a pH meter. To confirm observations, five samples of each crop were processed and observations were recorded three times.

Determination of nitrogen contents

To determine the nitrogen level in each crop, 10 leaves (from 5 plants) each of watermelon, Indian squash and melon were washed with distilled water, the test leaves of each crop were placed in separate envelopes and dried for 25 days at 68°C. At 100% dryness, leaves were ground, put in the small plastic bags and placed again in oven for 10 days. The ground powder of each sample was digested in a mixture of $CuSO_4$, K_2SO_4 and Selenium in the ratio of 10:1:1 @ 11 g and 12.5 ml of H_2SO_4 per test tube was added and placed in fuming hood for one hour at 400°C in digestion plate. After that, the digested plates were put in the distilled water for cooling.

For distillation, two drops of concentrated solution of Tashiro were put in the flask and 50 ml of NaOH solution was added to separate the molecules in crystal form. The mixture was put in the Kjeldhal Flask. The temperature of Kjeldhal Flask was kept at 400°C. After heating, 60 ml of the mixture from the flask was taken and titrated with HCl.

To obtain protein percentage in watermelon, Indian squash and melon, the formula described by Harold (1969) was applied. Data recorded was transformed into mean values and subjected to statistical analysis. The mean population of adults, nymphs and total population (nymphs plus adults) were analyzed with the help of Paired Students Test.

RESULTS AND DISCUSSION

White fly population

Table I shows the nymphs and adults populations of whitefly that were counted separately on cucurbit creepers (watermelon, Indian squash and melon). The results showed that at the initial growth stage of crops, population density of whitefly per leaf was at lower level. The initial population was less on watermelon, Indian squash and melon or it was at zero (0) level at plant emergence. Later on, as the crop proceeded toward maximum growing stage, pest population increased rapidly. Thereafter, it increased slowly and population density rose gradually. Subsequent\y, it declined slowly and reached to 0 as the crop fully matured. The population trend of whitefly on Indian squash and melon creepers showed that the population was more or less similar except on watermelon ranging from 15.04±1.25 to 24.40±2.03 per leaf. The mean nymphal population of whitefly per leaf was 10.51±1.90, 15.44±1.63 and 16.08±1.75 on watermelon, Indian squash and melon, respectively. There was a significant difference between watermelon-Indian squash, and Indian squash-melon but non-significant difference between watermelon, Indian squash-melon (Table I).

The adult's population results showed that there was a significant difference between watermelon-Indian squash and non-significant difference between Indian squash-melon, and watermelon-Indian squash-melon. The average adult population of whitefly per leaf was 4.53±0.58, 08.95±0.81 and 06.22±1.21 on watermelon, Indian squash and melon, respectively. These population variations could be due to chemical constituents (pH, nitrogen and protein) as well as factors other than these described which appeared to be of high significance that fluctuated in adult's whitefly population.

There were prominent differences between total population of whitefly (*i.e.*, nymphs and adults) recorded on individual cucurbit plant, significantly more on Indian squash as compared to melon and watermelon. To determine difference between mean population densities on test crops, these were analyzed by combining the values of both stages of creature with the help of Student's Paired Test. The results proved that there was highly significant difference between watermelon and Indian squash than melon and also significant difference between watermelon and melon ($P<0.05$), but non-significant difference ($P<0.05$) was found between Indian squash and melon. There was a significant difference between watermelon Indian squash-melon.

This increase and decrease in pest population may be attributed due to different factors (variability in pH, nitrogen and protein contents) of tested creepers that influenced the population dynamics of whitefly. Similar findings were reported by Ohnesorge and Rapp (1981) that population of *B. tabaci* increased and declined due to age and chemistry of the host leaf. This difference may be due to the less percentage of nitrogen in watermelon than Indian squash and melon. Berlinger (1986), reported that external features, physical characters of leaf surface *i.e.*, sticky glandular trichomes and internal chemistry of the leaf and also pH of the leaf cell sap and nitrogen level play decisive roles in population build-up. Furthermore, the adults had a clear preference for media with pH values of 6.0-7.25 (Tunc *et al.,* 1983).

pH, nitrogen and protein content

Table II shows leaf pH, nitrogen and protein levels. The Table shows differences between leaf pH, nitrogen and protein levels, which were more or less similar in Indian squash (7.30±0.04, 0.526%, 3.29% and melon (7.63±0.01, 0.592%, 3.701), creepers, respectively. Whereas, in watermelon pH

Table I.- Mean nymphal, adult and total population of *Bemisia tabaci* on different cucurbit crops.

Population	Watermelon	Indian squash	Melon	Water melon: Indian squash	t-value	
					Indian squash: Melon	Watermelon: Indian squash: Melon
Nymphs	10.51±1.90	15.44±1.63	16.08±1.75	4.36 (P<0.001)	2.59	P<0.05
Adult	4.53±0.58	8.95±0.81	6.22±1.21	5.31 (P<0.001)	N.S.	N.S.
Adult nymphs	15.04±1.25	24.4±2.03	22.3±1.85	7.41 (P<0.001)	N.S.	2.43 (P<0.05)

Table II.- pH values, Nitrogen (%) and Protein contents of leaves of various cucurbit crops.

Crop host	pH	nitrogen (%)	protein (%)
Watermelon	6.55±0.008	0.394	2.462
Indian squash	7.30±0.04	0.526	3.29
Melon	7.63±0.01	0.592	3.701

(6.55±0.008), nitrogen (0.394%) and protein (2.462) were less. Population counts on the incidence of whitefly were negatively correlated with increasing concern of these contents in the leaf extracts of the test creepers. Low densities of whitefly (15.04±1.25 per leaf) were associated with a low pH (6.55±0.008), nitrogen (0.394 %) and protein (2.462) in watermelon that showed resistance, while, Indian squash (7.30±0.04, 0.526 %, 3.29) and melon (7.63±0.01, 0.592 %, 3.701) creepers had high contents in their leaves and harboured more pest intensity (24.40±2.03) and (22.30±1.85), respect1ve\y and showed susceptibility.

Due to variations among these factors whitefly showed varying degree of preference for these creepers. As watermelon possessed least abundance for these ingredients, the incidence of whitefly was the least, while, the reverse was true in case of Indian squash and melon where amount of these substances were higher, and consequently, pest invasions were additional. The activities of whitefly on susceptible cultivars (Indian squash and melon) were higher than on resistant cultivar (watermelon) indicating that these chemicals were probably directly involved in pest resistance, pathways. Our findings are in line of Moreno *et al.* (1993). These researchers observed that pH and nitrogen percentage of the plant were responsible for population development of insect pests. Butani (1974) showed that nitrogenous components increase pest infestation. Rustamani *et al.* (1999) studied that higher doses of nitrogen favoured the multiplication of insect pests, Elizabeth *et al.* (2000) reported that diet pH did not significantly affect egg hatch. Developmental response was variable, but pH 6.5 and 8.0 diets supported the highest percentage of nymphs to the 3rd and 4th instars. pH of 5.0 failed to support development to the 3rd or 4th instar. It was found that in adult whiteflies the optimum pH for ingestion of a 20% sucrose diet was between 6.5 and 7.5, in a tested range of 4.5 to 8.5.

It is concluded that the population differences between creepers for insect resistance might be due to the various differences between their morphological characters, chemical nature and natural site conditions. The resistance in cucurbits was due to accumulation of pH, nitrogen and protein contents in all these crops studied. But correlation between accumulations of these contents to the degree of insects' resistance is further needed to be observed. The use of resistant cultivars is the most effective means of controlling whitefly as a result of breeding studies. However, just now researched finding along with some agronomically acceptable characters and constituents are expected to be utilized in vegetable growing areas. Transferring research findings to farmers is as important as gathering results.

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