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RESPONSE OF *Bemisia tabaci* (GENNADIUS) (HOMOPTERA: ALEYRODIDAE) POPULATION TO COTTON WATER STRESS

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ABSTRACT

Cotton plants grown in the greenhouse under natural day length in the summer were watered with four different water regimes (daily, every other day, twice a week and once a week). *Bemesia tabaci* counts (adults and nymphs) were recorded on the whole leaf sample of the lower (abaxial) surface of the cotton leaf for each treatment. Plant physiological characteristics such as leaf water content which represented by Fuel Moisture Content (FMC) and Equivalent Water Thickness (EWT), were calculated from the leaf fresh weight (FW), dry weight (DW) and leaf area (LA) were also recorded. Cotton plant height and soil moisture content (TDR) were also recorded during the watering and drought phase. Plant growth was significantly different at the four watering levels but no significant difference of the mean numbers of *B. tabaci* adult, nymph and insect population (P=0.1354), (P=0.1712) and (P=0.2534), respectively in all levels of watering. However, after the plants were not receiving regular watering during the drought phase (results after day 56) significant differences in the mean numbers of *B. tabaci* adult, nymph and insect population were observed (P =0.0001), (P = 0.0009) and (P =0.0001). Multiple regression analysis reflected that there were significant positive correlations between the mean numbers of the insect population with LA and TDR. Plants that received more water produced more growth and height with small number of insect population with negative correlations. Previous research found that more sticky honeydew sugars reduced whitefly population on non-water-stressed cotton plants compared with the water stressed cotton. Also several studies found that whitefly host prefers water-stressed cotton plants. Results in this study indicated that treatment one (daily watering) was severely affected by the drought impact.

INTRODUCTION

In 1990-1993 growing seasons, *Bemisia tabaci* (Gennadius) populations attained epidemic levels in many cotton-growing areas of Egypt. *B. tabaci* was recorded as one of the main pests in greenhouse in Egypt and has at least 172 host species belonging to different families by Azab *et al.* (1971). Also, since the early 1990s *B. tabaci* (Gennadius) has become a key best of cotton (*Gossypium hirsutum* L. and *G. barbandese* L.) and several other crops in Arizona, California, and the Rio Grande Valley Texas (USDA 1997).The pest damage cotton lint through the deposition of honeydew. Honeydew provides as medium for growth of sooty molds that stain the lint, and also causes fiber stickiness, a critical problem which hinders ginning and textile processing operations (Hector & Hodkinson 1989 and Butler *et al.* 1986). The interaction between whiteflies and host plant is a very critical issue for development of alternate control methods (Van Lenteren and Noldus (1990) Because the first instar is the only form capable of limited movement during immature stage, host selection by the ovipostiting female is critical for the survival of these insects. *Bemisia* species prefer to oviposit on abaxial leaf surfaces, in part because negative geotropic response (Simmons

1994). Yet, factors such as phototropisms (Van Lenteren and Noldus 1990, Chu *et al.* 1995), color and Leaf shape (Butler *et al.* 1986), leaf hairiness (Sippell *et al.* 1987, Kishaba *et al.* 1992), pH (Berlinger *et al.* 1983) and nitrogen content (Bentz *et al.* 1995) also affect oviposition site selection. In a study by Radin *et al.* 1992, irrigation methods were found to have an effect on water stress. The effect of reduced water stress on *B. tabaci* has received some attention in studies. Mor (1987) found that water stress on cotton affected the whitefly nymph population in Israel and suggested that it increased nymphal survival and the highest number of whitefly nymphs was found on water-stressed cotton. Although the effects of water stress on cotton pests were studied in the past (Castle *et al.* 1996, and Mor 1987). Several studies reported that whitefly host prefer water-stressed cotton plants (Flint *et al.* 1996, Skinner 1996). The response of insect feeding depends on the degree of stress. Also water stress in cotton has different effects on whiteflies than in tomatoes. The effect of stress on insects may be related to three main factors: species (plant and insect), type of stress, and the level of stress (Inbar *et al.* 2001). Gencsoylu *et al.* (2003) reported that increasing the irrigation rates in both methods seems to be the most practical way to obtain the lower populations of whitefly associated with reduced water stress. Henneberry *et al.* (2000) indicated that honeydew produced by *B. tabaci* whitefly contains sugar that makes cotton sticky and difficult to process in textile mills. Therefore, more honeydew sugars were produced by *B. tabaci* feeding on non-water-stressed cotton plants compared with the water stressed cotton. So that, *B. tabaci* develop higher populations on water stressed cotton compared with well-watered cotton. Feeding reduced yield and lint contamination with honeydew and associated molds (Gerling *et al.* 1980). Butter and Vir (1989) in India, tested the plant characters. Leaf area, thickness of leaf lamina and *B. tabaci* population relationship. Results revealed that hair density and leaf thickness were positively correlated with the population of *B. tabaci* and positive correlation between the adult population and gossypol glands on stem internodes was obtained. Singh and butler (1988) found that a negative correlation between relative humidity and *B. tabaci* population. The objective of this study is to evaluate the effectiveness of cotton water stress and the resulted changes of physiological characteristics on the whiteflies population.

MATERIALS AND METHODS

Cotton (Delta Pine 1517-2000) seeds were germinated on moist paper towels at room temperature. Resulting seedlings were transplanted into 120 ml (4 cm diameter) pots containing Terra-Lite Metro Mix 360. Plants with emerging first true leaf were transplanted into 1.0 L. pots containing Metro Mix 360 and grown in the greenhouse under natural day length in the summer. Plants were watered with four different water regimes (daily, every other day, twice a week and once a week) and there were four replicates of each watering regime. Each pot received 350 ml water and was fertilized weekly. Plants were exposed to whitefly colony 20 days after planting for infestation in sealed insectary in the greenhouse. The plants received water for 8 week after planting and measurements were recorded three times during this period. Water was then withheld for 10 days for all treatments and measurements were recorded three times during this period. Fuel Moisture Content (FMC), and Equivalent Water Thickness (EWT) were also measured. Fuel Moisture Content (FMC) is defined as the ratio between the quantity of water (fresh weight – dry weight) and either the fresh weight or the dry weight (Burgan 1996, Chuvieco *et al.* 1999) FMC = *(FW-DW)/ (FW) or (DW)* * 100 (%). Equivalent Water Thickness (EWT) is the leaf water content per unit leaf area and corresponds to a hypothetical thickness of a single layer of water averaged over the whole leaf area (Danson *et al.* 1992). EWT = *(FW-DW)/A* (g cm $^{-2}$) or (cm) where A is the leaf area. Leaf area (A) measured using a portable leaf area meter (LI-3000A, Li-Cor Inc., Lincoln, Nebraska, USA). These parameters are traditional ways of assessing water stress in plants. Plant height was recorded at all sampling dates for use as a growth indicator.

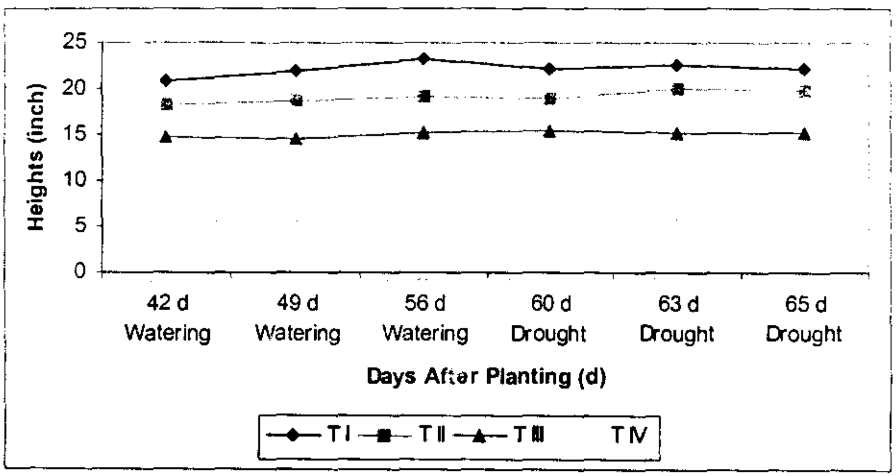
B. Tabaci adult and nymphs were counted weekly using four leaves each plant. *B tabaci* counts (adults and nymphs) were taken on the whole leaf sample on the lower (abaxial) surface of the leaf..

Obtained data were statistically analyzed using proc. ANOVA Corr. And Reg. in SAS (SAS Institute 1988). Mean separations were conducted using Duncan multiple range test in the same program.

RESULTS AND DISCUSSION

The growth of the cotton plants was clearly related to the amount of water that they received as indicated by the plant heights that resulted from the different watering regimes (figure 1).

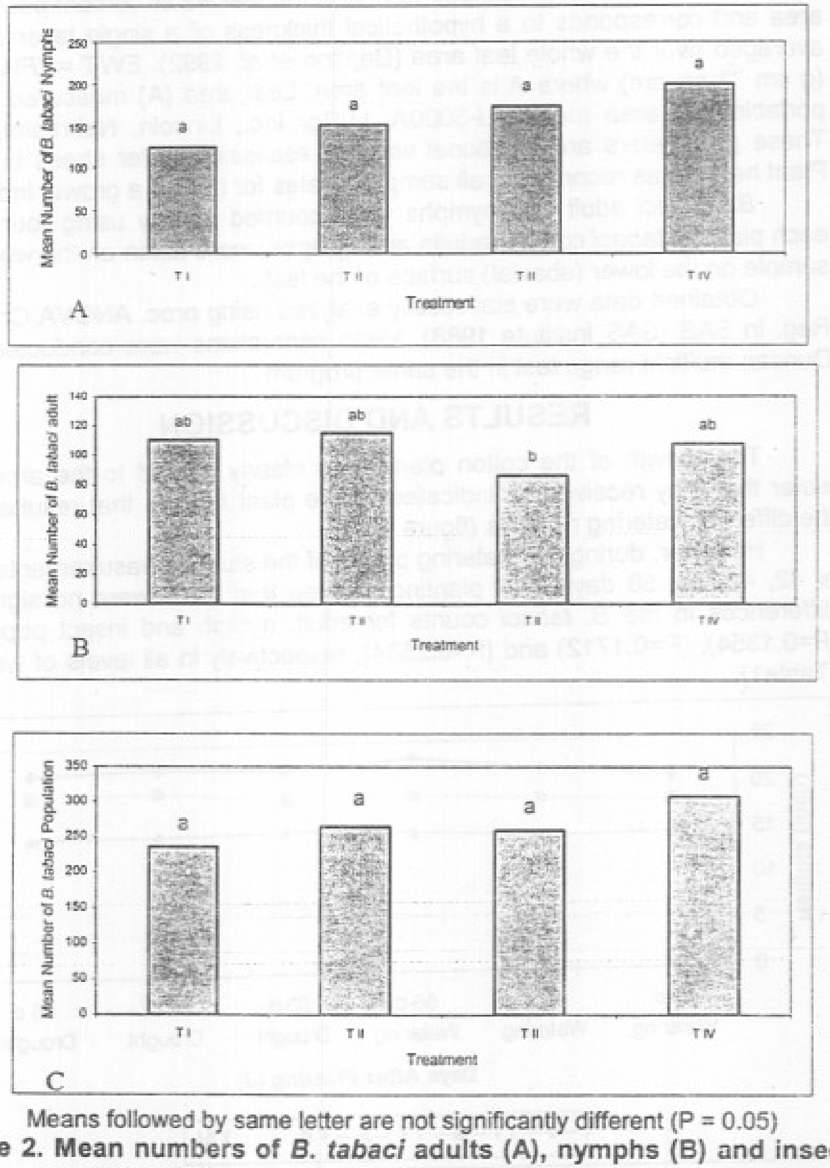
However, during the watering phase of the study, measujrements taken at 42, 49 and 56 days after planting showed that there were no significant differences in the *B. tabaci* counts for adult, nymph and insect population (P=0.1354), (P=0.1712) and (P=0.2534), respectively in all levels of watering (Table1).



TI=daily watering, TII=every other day, TIII twice a week and TIV=once a week

Figure 1. Cotton plant heights measured with the different water regime during the study period.

The highest mean number of *B. tabaci* adult was (114.92) recorded in treatment two (three days a week watering), while the lowest mean number of adult was (86.42) recorded in treatment three (two week watering). On the other hand, results indicated that the other two parameters highest mean number of nymphs and mean number of insect population were occurred in treatment four (once a week watering) 200.25 and 308.17, respectively. While the lowest mean number occurred in treatment one (daily watering) were 125.17 and 235.17, respectively (Figure 2).



Means followed by same letter are not significantly different (P = 0.05)

Figure 2. Mean numbers of *B. tabaci* adults (A), nymphs (B) and insect population (C) per cotton leaf in each watering treatment during the watering phase.

This suggests that the plants growth may be limited by the amount of water they received but, even though the plants were smaller, they were healthy and no water stress was indicated and no significant differences in whitefly counts have been recorded.

After the plants were not receiving regular watering drought phase (results after day 56) significant differences in the *B. tabaci* adult, nymph and insect population were observed (P =0.0001), (P = 0.0009) and (P =0.0001), respectively (Table 2).

The average number of whitefly adult, nymph and insect population per plant was greater in treatment four (once week watering) 59.417, 75.917 and 135.33, respectively and there were a significant differences between treatment four and all other treatments (Figure 3). The plants that had received daily watering were the first to show significant changes in the *B. tabaci* population compared with the other treatments. Accordingly, the highest mean number of adult, nymphs and insect population were occurred in treatment four (once a week watering) 59.417, 75.917 and 135.33, respectively. While, the lowest mean number of whitefly adult, nymph and insect population per plant recorded in treatment one (daily watering) 24.417, 45.5 and 69.92, respectively (Figure 3).

Results showed a great impact was recorded in whitefly population in the daily watering treatment, which recorded the lowest mean numbers of population during the drought phase. Increasing the water rates seems to be the most practical way to obtain the lower populations of whitefly associated with reduced water stress. This results agreed with Mor (1987) reported that the highest number of whitefly nymphs was found on water-stressed cotton. Also similar finding was reported by (Mattson and Haack 1987) found that avoidance of water stress on cotton is the main cultural practice necessary to reduce whitefly population. In the drought phase, regression analysis of insect population with cotton plant physiological characteristics such as Plant Height, Dry Weight (DW), Leaf Area (LA), Fuel Moisture Content (FMC), Equivalent Water Thickness (EWT) and Soil Moisture (TDR) showed that the slopes of regression lines for all parameters were significantly correlated (Figure 4 and 5).

Regression analysis indicated that there were a strong correlation between TDR, EWT, LA & DW and the whiteflies population. Plants that received more water produced more growth and height with small number of insect population with negative correlations. Results agreed with Henneberry *et al.* (2000) found that more sticky honeydew sugars reduced whitefly population on non-water-stressed cotton plants compared with the water stressed cotton. Therefore, our results indicated that treatment one (daily watering) was severely affected by the drought impact. Remarkable impact of daily watering plants occurred when the plants experienced the drought which observed as a quick dryness of the leaves, lead to unsuitable habitat to whiteflies. In agreement with these results, several studies reported that whitefly host prefers water-stressed cotton plants (Flint *et al.* 1996, Skinner 1996). The response of insect feeding depends on the degree of stress.

Table 1: Mean numbers of *B. tabaci* adult, nymph and insect population during the watering phase of cotton plant

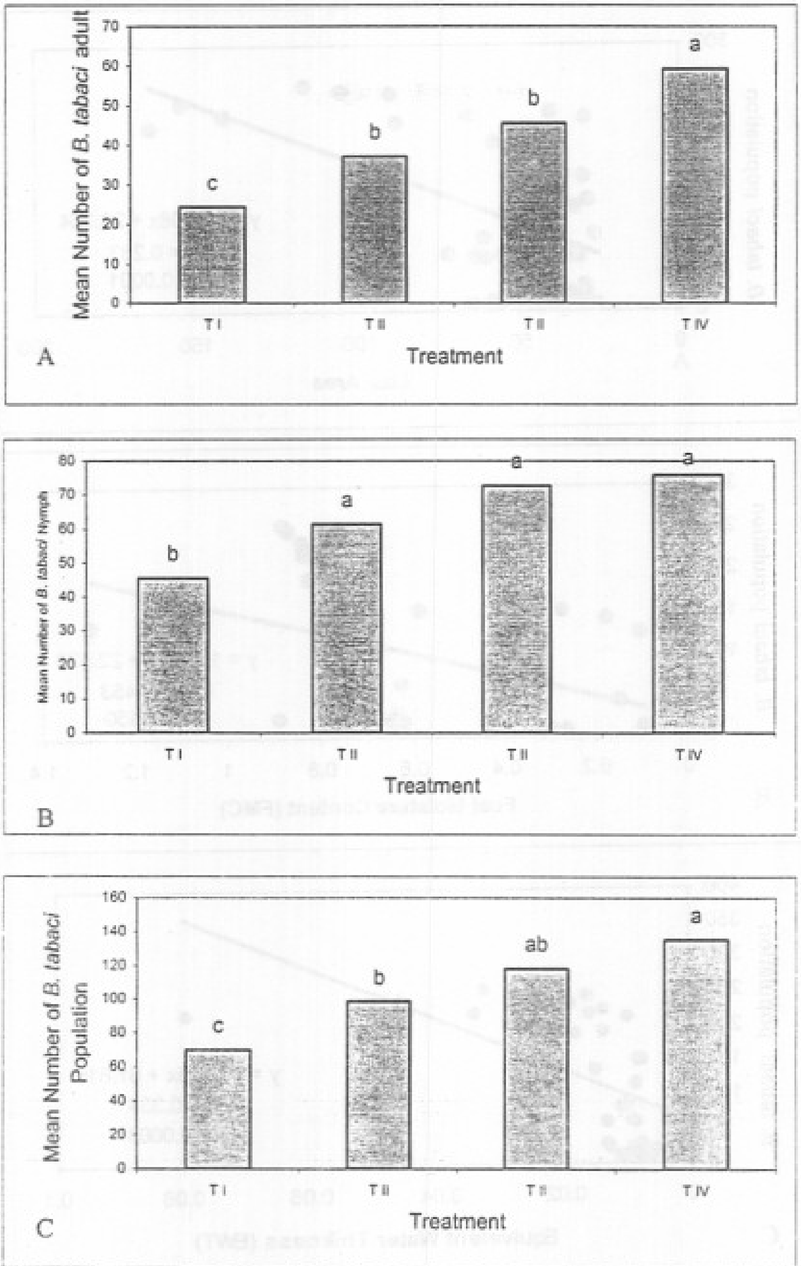
	Treatment	42 d	49 d	56 d	Mean	DF	SS	MS	F value	Pr>F
Adult	I	10±2.94	168.25±31.83	152.75±35..04	110.3	3	5767.063	1922.354	1.96	0.1354
	II	6.75±2.22	172.25±27.11	165.75±29.60	114.9					
	III	9.25±2.87	164.25±33.98	85.75±47.86	86.42					
	IV	11.25±3.86	180.5±9.26	132±56.03	107.9					
Nymph	I	7.75±2.75	163.5±14.39	204.25±43.45	125.17	3	37142.06	12380.69	1.75	0.1712
	II	10.75±3.30	163.75±21.96	276.75±116.73	150.4					
	III	10.75±4.11	177.5±16.18	333.5±195.55	173.9					
	IV	11±4.69	175.75±18.55	414±156.57	200.25					
Insect Pouplation	I	17.75±3.77	331.75±33.69	357±75.35	253.17	3	32804.67	10934.89	1.41	0.2534
	II	17.5±3.11	336±26.70	442.5±114.80	265.3					
	III	20±4.76	341.75±34.03	419.25±198.94	260.3					
	IV	22.25±8.54	356.25±27..66	546±178.88	308.17					

TI=daily watering, TII=every other day, TIII twice a week and TIV=once a week

Table 2. Mean numbers of *B. tabaci* adult, nymph and insect population during the drought phase of cotton plant

	Treatment	60 d	63 d	65 d		DF	SS	MS	F value	Pr>F
Adult	I	44.75±9.18	21±7.26	7.5±3.87	24.4	3	7777.563	2592.521	1 4.57	0.0001
	II	79±5.16	23.25±5.62	9.5±3.11	37.2					
	III	81.75±21.79	46±11.69	9.25±2.22	45.6					
	IV	103.75±11.67	61.75±13.70	12.75±3.86	59.4					
Nymph	I	93.5±3.11	37.5±12.77	5.5±4.12	45.5	3	6809.396	2269.799	6.61	0.0009
	II	135±8.52	45±14.62	4.25±2.22	61.4					
	III	152±16.99	60.25±15.17	6±4.08	72.7					
	IV	119±22.42	96±17.91	12.75±1.71	75.9					
Insect ouplation	I	138.25±11.50	58.5±9.75	13±6.88	69.9	3	28436.5	9478.833	14.8	0.0001
	II	214±7.35	68.25±12.61	13.75±4.79	98.6					
	III	233.75±18.19	106.25±24.76	15.25±5.85	118.4					
	IV	222.75±25.40	157.75±22.63	25.5±4.65	135.3					

TI=daily watering, TII=every other day, TIII twice a week and TIV=once a week



Means followed by same letter are not significantly different (P = 0.05)

Figure 3. Mean numbers of *B. tabaci* adults (A), nymphs (B) and insect population (C) per cotton leaf in each watering treatment during the drought phase.

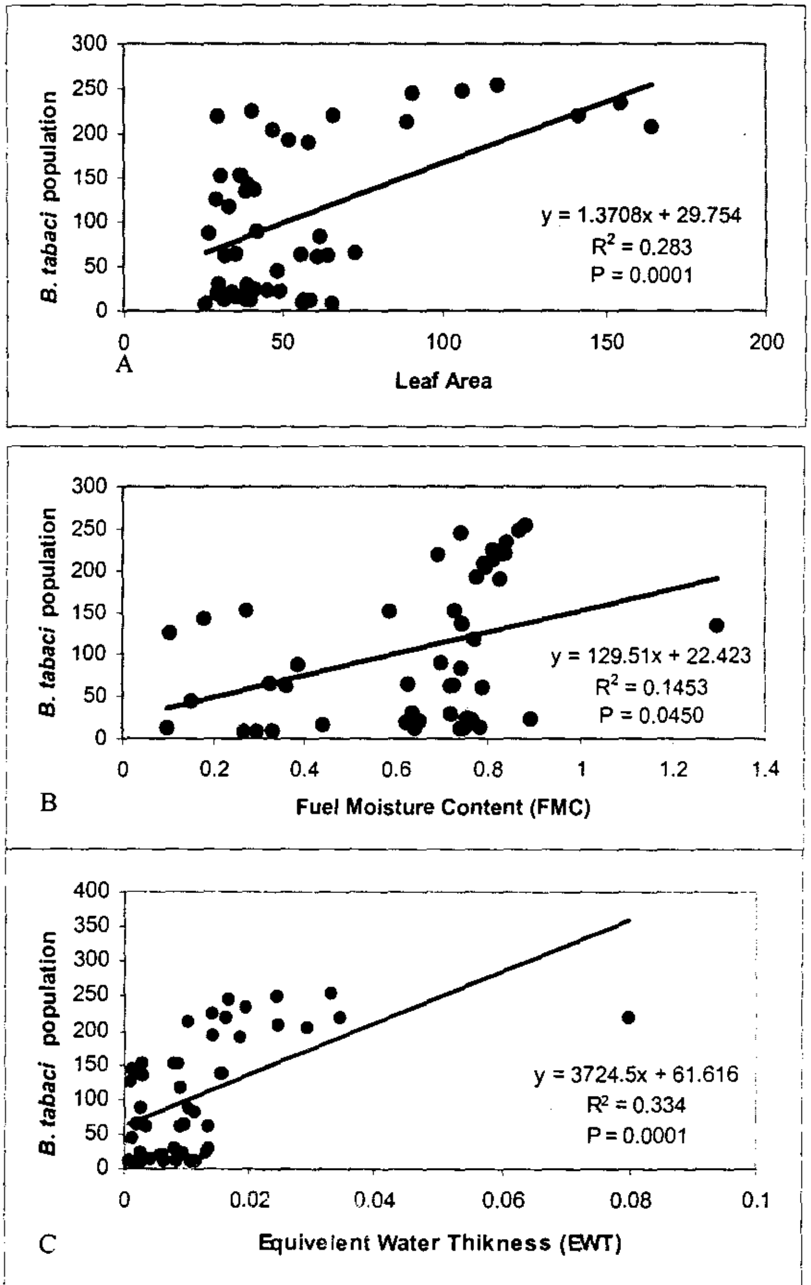


Figure 4. Correlation between mean number of *B. tabaci* population and Leaf Area (A), FMC (B) and EWT (C) in the drought phase.

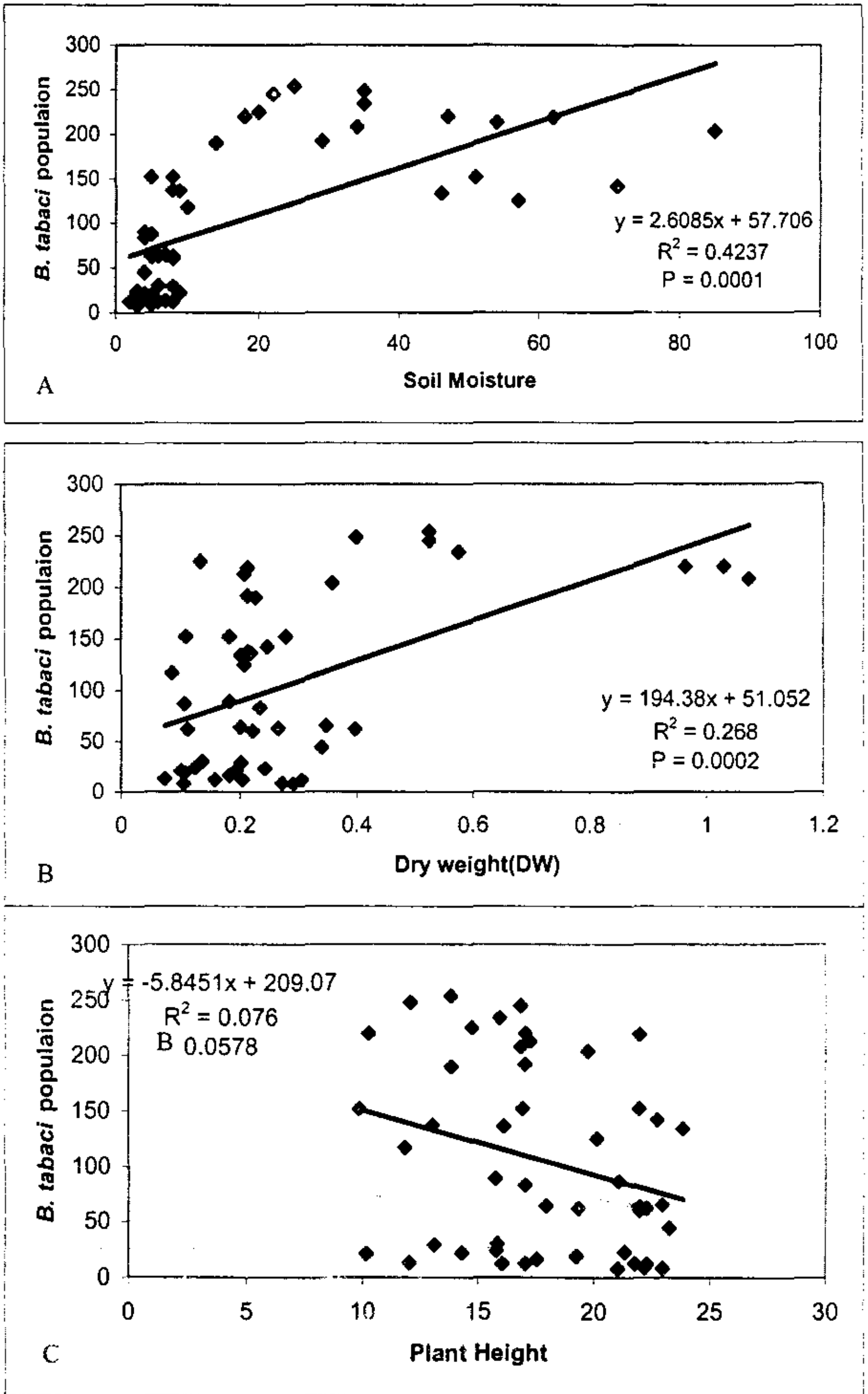


Figure 5. Correlation between mean number of *B. tabaci* population and Soil moisture (A), Plant height (B) and Dry weight (C) in the watering phase.

Also water stress in cotton has different effects on whiteflies than in tomatoes. The effect of stress on insects may be related to three main factors: species (plat and insect), type of stress, and the level of stress (Inbar *et al.* 2001).

Multiple regression analysis reflected that there were significant positive correlations between the mean numbers of the insect population and LA, and TDR. On the other hand, negative correlation observed between the mean number of insect population and Plant height, DW, and FMC. Generally, whitefly populations were not affected by the water regime, while a great impact was recorded in whitefly population due to the drought effect. In conclusion, low irrigation rates can be used in cotton fields in order to conserve water in an area with limited water supply, and it is a necessary to implicate the suitable control approach to reduce the whitefly population in water stressed cotton.

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إستجابة تعداد الذبابة البيضاء *Bemisia tabaci* (Gennadius) (Aleyrodidae : Homoptera) للاجهاد المائى لنبات القطن

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قسم وقاية النبات - كلية الزراعة - جامعة الأزهر - القاهرة

لقد تمت تربية نباتات القطن تحت ظروف الصوبة مع الاضاءة الطبيعية فى موسم الصيف وتم رى نباتات بأربع معدلات رى كما يلى : كل يوم ، يوم بعد يوم ، مرتان ثم مرة واحدة اسبوعيا وكان لكل نظام رى أربع مكررات. تم عد الحشرات البالغه والحوريات وتسجيلها من على السطح السفلى لأوراق النبات لكل معاملة. تم تقدير السمات الفسيولوجية للنبات مثل المحتوى المائى للورقة والذى تم بواسطة مقياس المحتوى الرطوبى للورقة (FMC) وسمك الماء المكافىء للورقة (EWT) وذلك لحساب الوزن الرطب والوزن الجاف ومساحة سطح الورقة، علاوة على ذلك ، فقدج تم قياس طول النبات فوق سطح التربة وكذلك رطوبة التربة (TDR) فى مرحلة معدلات الرى المختلفة ومرحلة التعرض للجفاف . أظهرت النتائج أن هناك اختلافاً معنوياً فى نمو النبات بين معدلات الرى الأربعة فى حين أنه لم يكن هناك فروق معنوية لتعداد حشرات الذبابه البيضاء فى معدلات الرى السابقة . عند تعرض النباتات للجفاف وذلك بعدم ريها جميعا لمدة عشرة أيام أوجد فروقا معنويه فى تعداد الحوريات والحشرات البالغه للذبابة البيضاء. أظهرت النتائج كذلك أن النباتات التى تم ريها يوميا كانت أكثر النباتات تأثرا بالجفاف مصحوبا باعداد أقل من الذبابة البيضاء نتيجة الاصفرار والجفاف السريع للأوراق مما اظهر ارتباطا احصائيا سالبا ، وقد توافقت هذه النتائج المتحصل عليها من دراسات سابقة والتى أوضحت أن الذبابة البيضاء تفضل نباتات القطن التى تعرضت للاجهاد والجفاف .