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Integrated Management of Woolly Whitefly [*Aleurothrixus Floccusus* (Maskell) Homoptera: Aleyrodidae] on Citrus at Adama, East Shewa Zone, Ethiopia

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ABSTRACT
The woolly whitefly, Aleurothrixus floccusus (Maskell), (Homoptera: Aleyrodidae), is a new invasive alien insect pest of citrus crop recorded in Ethiopia in 2001 in Adama town. Woolly whiteflies are the most destructive pests of citrus in Ethiopia particularly in Central Rift Valley of Ethiopia. It causes tremendous yield loss. In the present study, woolly whitefly management by the integration of fertilizer (DAP), irrigation and sticky gum banding on citrus were investigated in Adama under field condition under natural infestation. The field study was carried out in Adama, East Shewa, Ethiopia in 2011. The experiment was designed in randomized complete block design in three replication in a factorial arrangement where a tree represents one replication. Pre-treatment assessment of woolly whitefly population and weekly assessment after treatment application were done to select the best treatment. The pre-treatment woolly whitefly assessment indicated that 80-100% twig infestation, 60-99% leaf infestation and 35-37% fruit infestation indicating that twig and leaf of the citrus trees are the most preferred plant parts by woolly whitefly, where as low proportion of percent infested citrus plants (0.5% - 2.08%), (0.18% - 1.38%) and (0.56% -1.95%) were recorded in the treated citrus plant in studied area respectively. Significantly low twig infestation, low leaf infestation, low number of woolly whitefly colonies in the twig and leaf, low status of ants and high status of predator (ladybird beetle) and parasitoids (Cales noacki) in the twig and leaf were recorded from citrus plants. Integrated effect of fertilization, irrigation and sticky gum banding effectively increased the yield and quality of citrus fruit. The data obtained indicated that effect of fertilizer; irrigation and sticky gum banding were significant in reducing woolly whitefly infestation on citrus. All infested plant parts were also attended by several ant colonies. However, significant variations were observed among the treatment in fruit yield. From the present study it can be concluded that by providing the citrus plant with appropriate/optimum nutrient and water at the right time which mainly strengthen and help the plant to produce leaves and flowers, and enhance the activity of the natural enemies mainly by disconnecting the symbiotic relationship between the woolly whitefly and ants by using sticky gum banding. As the management of commercial citrus production is very intense the likely problem of woolly whitefly in such a farm is almost nil. Thus, the current technology is fit to small scale citrus production system which has to be extended by the extension agents. Therefore, the use of fertilizer (DAP), irrigation and sticky gum banding could play a vital role in integrated management of woolly whitefly on citrus.
Key words: Citrus, A. floccusus, fertilizer, irrigation, sticky gum banding.

1. INTRODUCTION

Agriculture is the main stay of Ethiopia's economy providing employment to 85% of the population. The sector contributes about 45% of the Gross Domestic Product (GDP) and 63% of total exports with coffee alone accounting for 39.4% of the total export. Furthermore, Agriculture plays a crucial role in providing raw material for industry. Endowed with wide ranging agro-ecological zones and diversified resources, Ethiopia grows all types of crops including different types of citrus crops (CSA, 2004). Located between 4^{O}N-18^{O}N latitude, Ethiopia is able to grow high quality citrus almost year round from orchards and home-gardens in different climatic regions. The major citrus crops grown in Ethiopia are orange, mandarin, grapefruit, lemon and lime (Emana, 2003a & b).

Citrus is an important source of vitamin and minerals, raw materials for local industries and source of foreign currency earnings (Emana, 2003a). Citrus fruits are high value crop in terms of international trade. There are two main markets for citrus fruit: the fresh fruit market and the processed citrus fruits market (mainly juice). According to FAO (2003), fresh orange consumption is declining in developed countries mainly due to shift of preference to orange juice consumption and improvement in transportation and storage of citrus fruits and its products.

Citrus fruits are produced all around the world. According to FAO (2003) data, 140 countries produced citrus fruits. The main citrus fruits producing countries are Brazil, Mediterranean countries, and the United States. These countries account more than two thirds of global citrus production. The world production of citrus fruit has experienced continuous growth in the last decades of the 20 century. Total annual citrus production was estimated at over 105 million tons in the period 2000-2004. Oranges constitute the bulk of citrus fruit production, accounting for more than half of global citrus production in 2004. The rise in citrus production is mainly due to the increase in cultivation areas and the change in consumer preferences towards more health and convenience food consumption and rising incomes. A major development over the last two decades of the 20 century was the growth in trade in small citrus fruits, which include mandarin, lime and lemon at the expense of fresh oranges which is due to the evolution of consumer preferences. Ethiopia is one of the countries in the world where citrus fruits production showed increasing trend despite the increasing insect pest problems mainly due to the heavy pesticide use. For example, the largest citrus plantation in East Africa is found in Ethiopia (Emana, 2003a & b).

The current challenges in the production and trade of citrus is the gap between the demand and availability of organic citrus which is still a niche and makes about 1-2% of the global citrus production. The low availability of organic citrus is mainly due to the use of wide spectrum pesticides mainly for the control of insect pests. In this regard, the alien invasive insect pest receives the highest proportion as this group of insect pest is enemy free which can keep their population in check. In most citrus producing countries of the world, woolly whitefly is causing heavy damage to all citrus crops, some other fruits like guava, coffee and wild flowering plants (Emana, 2003a).

The woolly whitefly, *Aleurothrixus floccusus* (Maskell), first appeared as a citrus pest about 1909 in Tampa, South America. The insect is native to Tropical and Subtropical America and introduced to North Africa and Southern Europe in the 1970's. Currently, the pest is widely distributed in America, Europe, Asia and Africa. In Africa this pest was first recorded in Kenya in 1990, but now exists in Ethiopia, Malawi, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe. In Ethiopia, this pest was first reported by Emana *et al*., (2003) from the Central Rift Valley areas. At the moment, the pest has infested all citrus plants growing in Adama town, Debrezeit town, Zewayi, Arsi-Negele, Sheshemene, Adami Tulu, Meki, and Ambo and their surroundings. Moreover, the big farms of the State Enterprise in the Upper and Middle Awash have been infested by this pest. The expansion and severity of infestation of the pest are very alarming and very high. Fruit crops such as citrus is heavily damaged by insect pests such as fruit flies (*Ceratitis capitata* [Wiedman], *Dacus* spp.), false codling moth [*Cryptophlebia leucotreta* [Meyrick]) and armoured scales (e.g. *Aonidiella aurantii* [Maskell] and *Chrysomphalus aonidum [L.]*) are major insect pests on all citrus farms of Ethiopia (Goossens *et al.*, 1981, Abate, 1981, 1988b).

In citrus growing areas of the world where this pest has been recorded, the management strategy has been skewed towards chemical control because of its devastating nature though the result is not efficient. For the management of woolly whitefly, two control methods are recommended: to give the plant strength by providing sufficient nutrients and optimum water; and use of biological control which could be introduction, conservation and agumentation (Emana, 2003a). In the commercial citrus plantations in Ethiopia as the grower keep the plant strong through the application of fertilizer and optimum irrigation the intensity of woolly whitefly is minimal unlike the individual growers and schools. Under such condition development of integrated pest management (IPM) which involves strengthening of the citrus plant by supplying Nitrogen, Phosphorous and Potassium (NPK) fertilizers and optimum water requirement through irrigation is a necessity. Moreover, making their available natural enemies efficient through the control of ants which keep away the woolly whitefly natural enemies and in turn feed on honey dew. Hence, the current study was meant to develop integrated pest management (IPM) for the control of woolly whitefly mainly under small scale citrus growing conditions. Therefore, the objective of this study was to develop integrated management (IPM) of woolly whitefly on Citrus.

2. MATERIALS AND METHODS

2.1. Description of the study area

The study was conducted on citrus orchard of Kutir Arat School located in Adama town located 100 km away from Addis Ababa at about $8^0$20'N latitude, $39^0$11'E longitude and an altitude of about 1550m above sea level. The area has a mean annual rainfall of 771mm and minimum and maximum day air temperature of 16.4^0C and 30.9^0C, respectively.

2.2. Experimental Design and Procedures

This experiment was conducted beginning from February to May, 2011 on the matured (>8 years old) citrus orchard at Kutir Arat School in Adama town. The orchard was selected for the study because of the heavy woolly whitefly infestation and the field layout is suitable for executing experiments with perfect row and between plants spacing (2.5m). Moreover, the orchard contains a large number of sweet orange citrus plants (about 100 plants) needed for the experiment. Out of 100 plants 36 were randomly selected from the middle of the orchard and tagged to be used for the experiment.

The experiment was laid out in 2x3x2 factorial experiment involving two fertilizer rate [0g/tree and 300g (DAP)/tree/4month) recommended rate 900gDAP/tree/year (Sauls, 2002)], three irrigation frequencies (per week, per two weeks, and per three weeks) and banding of trees with sticky gum at the plant height of 20cm above the ground (with and without it) was used in complete randomized design (CRD). The total treatment combination was 12 (2x3x2). The time of application of treatments such as fertilizer and sticky gum banding was once at the beginning of the experiment. The amount of irrigation per tree was about two bucket (20L) of water, with its micro-catchment area of $1.28m^2$.

2.3. Data Collected

2.3.1. Pre and post treatment application of woolly whitefly infestation assessment

Twig infestation: - Numbers of infested and non infested twigs and/or main branches were recorded on each tagged plant for the experiment and percent twig infestation was calculated.

Leaf infestation: - For leaf infestation two twigs per plant were randomly sampled and the numbers of infested and non infested leaves on each sampled twig were recorded.

Fruit infestation: - Fruit infestation was determined by counting the total fruits per two twigs against the fruits with woolly whitefly infestation.

The number of woolly whitefly colonies: - The number of woolly whitefly colony was recorded by counting the number of woolly whitefly colonies on twigs, leaves and fruit per two twigs on each plant.

Status of predators/parasitoids: -The status of predators was recorded by observing their number on twig and/or main branch, leaf and fruit per two twigs per plant. Infested leaves and twigs were put in insect rearing cage for parasitoids emergence.

Yield: - Fruit yield was recorded by separating marketable and unmarketable fruits per two twigs and put them both in numbers and weight at the time of harvest. Moreover, the number of new shoot emerged and number of flower per two twigs were recorded.

2.4. Data analysis

Data were analyzed using analysis of variance (ANOVA) using SAS computer software (SAS institute, 2002). Before ANOVA data which violate the assumption were transformed using square root ($\sqrt{x+0.5}$ *) transformation (Gomez and Gomez, 1984). Mean comparisons were done using the least significance difference (LSD) at the probability level of 5%.*

3. RESULT AND DISSCUSSIONS

3.1. Weekly Woolly Whitefly Assessment Before and After Treatment Application

3.1.1. Twig infestation

Twig infestation by woolly whitefly pre and post treatment application per two twigs is shown in Table 1. Twig infestation by woolly whitefly was significantly reduced after treatment application with varied levels indicating the effectiveness of the treatments in wooly whitefly management. The effect of the treatments dramatically minimized twig infestation starting from the first week of treatment application on wards which resulted in highly reduced woolly whitefly infestation level after 6^{th} week of treatment application when compared to the untreated check and the pre-treatment application assessment.

Moreover, the interactive effect of fertilizer (DAP), irrigation and sticky gum banding significantly reduced woolly whitefly on citrus twig/main branches by providing the citrus plant with appropriate/optimum nutrient and water at the right time which mainly strengthened and help the plant to produce additional leaves and flowers, and enhanced the activity of the natural enemies mainly by disconnecting the symbiotic relationship between the woolly whitefly and ants by using sticky gum banding. From this result it could be concluded that the integrated effect of fertilizer (DAP), irrigation frequencies and sticky gum banding effectively controlled woolly whitefly population from the citrus twig.

Table 1. Effect of fertilizer, irrigation and sticky gum banding on mean percent woolly whitefly twig infestation of citrus at Adama in 2011.

Mean followed by the same letter(s) with in columns are not significantly different at (LSD, 5%).

Pre-treatment assessment (PTA) and weeks after treatment application (WATA)														
TRT		1WATA	2WATA	3WATA	4WATA	5WATA	6WATA	7WATA	8WATA	9WATA	10WATA	11WATA	12WATA	13WATA
$I_1F_0B_0$	100	93.3^{ab}	90.43^{a}	86.63^{a}	79.70	70.93	60.56^{a}	46.93	44.33	41.20	39.66	38.70	36.16	34.70
$I_1F_0B_1$	100	80.33^{d}	46.66^{e}	22.00^{de}	11.60	6.66	1.04^{f}	1.34	3.75	3.31	2.81	2.50	1.80	1.61
$I_1F_1B_0$	79.66	72.60^{e}	32.66^{g}	23.33^{de}	8.33	3.33	3.96^{def}	2.63	2.33	2.13	2.03	1.88	1.67	1.35
$I_1F_1B_1$	99.33	93.1^{ab}	40.00^{f}	23.33^{de}	6.66	4.33	5.33^{cde}	1.42	0.73	0.73	0.68	0.68	0.59	0.50
$I_2F_0B_0$	90.56	90.83^{b}	89.46^{a}	87.23^{a}	80.33	69.30	58.66^{a}	48.66	42.2	39.70	39.36	37.50	35.33	33.36
$I_2F_0B_1$	99.66	96.43^{a}	80.8b^{c}	18.33^{ef}	27.33	6.33	8.33^{bc}	4.66	3.66	3.13	2.76	2.58	2.12	2.08
$I_2F_1B_0$	90.76	53.33^{g}	55.00^{d}	12.13^{f}	7.66	5.00	4.3c^{def}	4.16	4.20	3.60	3.25	3.13	2.66	2.08
$I_2F_1B_1$	98.33	62.60^{f}	58.33^{d}	28.00^{d}	5.567	1.667	1.547^{ef}	1.42	3.02	2.51	2.31	2.17	1.85	1.61
$I_3F_0B_0$	99.33	95.50^{a}	93.66^{a}	90.53^{a}	82.53	68.53	56.63^{a}	47.70	41.46	39.53	38.53	37.50	35.06	33.53
$I_3F_0B_1$	95.86	84.66^{c}	75.00^{c}	36.66^{c}	15.00	7.40	5.0cd^{ef}	4.33	2.16	2.10	2.10	2.02	1.77	1.25
$I_3F_1B_0$	95.96	94.6^{ab}	82.66^{b}	65.33^{c}	11.62	6.66	6.33^{cd}	4.23	4.00	3.62	3.373	3.08	2.85	1.95
$I_3F_1B_1$	100	92.6^{ab}	43.2^{ef}	72.33^{b}	18.00	15.00	11.00^{b}	9.33	4.00	3.436	3.21	3.05	2.74	2.02
LSD(0.05)		3.86	6.485	7.654	NS	NS	4.10	NS	NS	NS	NS	NS	NS	NS
CV(%)	1.88	2.72	5.86	9.63	15.49	13.75	13.12	13.22	12.94	5.86	5.81	4.50	6.05	5.7

TRT=treatment, (1-13) WATA=One up to thirteen weeks after treatment application, F_0 =without fertilizer, F_1 =with fertilizer, B_0=without sticky band, B_1= with sticky band, I_1, I_2, I_3=irrigation frequencies. $I_1F_0B_0$**,** $I_2F_0B_0$, and $I_3F_0B_0$ = controls, $I_1F_0B_1$, $I_2F_0B_1$ and $I_3F_0B_1$= Integration of irrigation, without fertilizer and sticky gum banding, $I_1F_1B_0$, $I_2F_1B_0$ and $I_3F_1B_0$= Integration of irrigation, fertilizer and without sticky gum banding and $I_1F_1B_1$, $I_2F_1B_1$ and $I_3F_1B_1$= Integration of irrigation, fertilizer and sticky gum banding. NS=non significant.

3.1.2. Leaf infestation

Leaf infestation by woolly whitefly before and after treatment application per two twigs is shown in Table 2. Leaf infestation by woolly whitefly was significantly reduced due to the treatments application with varied levels. The effect of the treatments significantly reduced leaf infestation starting from first week after treatment application throughout the experimental period after treatment application when almost woolly whitefly infestation become unimportant when compared to the untreated check and the pre-treatment application assessment.

It known that fertilization and irrigation frequencies improved the general health and vigor of citrus plants that also improved the final yield of plants. This study is in agreement with the result of Alva *et al.*, (2006), who reported that the optimal growth, development and yield requires optimal levels of fertigation. From this it can be said the integrated effect of fertilizer (DAP), irrigation frequencies and sticky gum banding found to be effective in significantly reduced woolly whitefly population from the citrus leaf.

Table 2. Effect of fertilizer, irrigation and sticky gum banding on mean percent woolly whitefly leaf infestation of citrus at Adama in 2011.

Pre-treatment assessment (PTA) and weeks after treatment application (WATA)														
TRT		1WATA	2WATA	3WATA	4WATA	5WATA	6WATA	7WATA	8WATA	9WATA	10WATA	11WATA	12WATA	13WATA
$I_1F_0B_0$	94.63	90.06^{a}	87.30^{ab}	83.93^{a}	78.80^{a}	67.83	56.53	45.13	42.23	38.66^{ab}	37.93	36.80^{a}	35.00	31.56
$I_1F_0B_1$	93.63	62.50^{cd}	35.25^{e}	11.60^{e}	6.30^{d}	5.98	0.41	0.72	2.29	2.23^{c}	1.98	1.90^{d}	1.58	1.38
$I_1F_1B_0$	60.33	70.97^{c}	23.90^{f}	10.20^{e}	5.08^{d}	2.84	1.81	0.84	0.75	0.74^{de}	0.66	0.57^{ef}	0.50	0.50
$I_1F_1B_1$	99.33	85.61^{ab}	39.5^{de}	11.60^{e}	4.93^{d}	1.98	1.00	0.88	0.32	0.32^{e}	0.29	0.29^{f}	0.25	0.18
$I_2F_0B_0$	69.30	86.30^{ab}	86.0^{ab}	83.73^{a}	77.56^{a}	67.10	56.76	47.13	40.80	37.86^{b}	36.93	35.00^{c}	33.63	29.83
$I_2F_0B_1$	96.86	83.30^{ab}	81.20^{b}	7.937^{e}	15.53^{b}	5.94	1.22	2.76	1.41	1.10^{cde}	1.01	0.85^{ef}	0.76	0.76
$I_2F_1B_0$	89.66	50.95^{e}	43.30^{d}	6.523^{e}	5.06^{d}	4.11	1.65	1.39	2.15	2.03^{cd}	1.94	1.946^{d}	1.71	1.37
$I_2F_1B_1$	94.97	54.20^{de}	56.59^{c}	21.96^{d}	2.60^{d}	1.02	0.82	0.51	1.08	1.00^{cde}	0.98	0.90^{ef}	0.83	0.83
$I_3F_0B_0$	90.66	90.32^{a}	90.26^{a}	87.40^{a}	79.37^{a}	67.07	53.56	44.90	40.23	39.96^{a}	36.43	35.86^{b}	32.26	31.33
$I_3F_0B_1$	91.67	80.02^{b}	63.59^{c}	26.59^{d}	6.39^{d}	6.36	2.58	0.98	0.67	0.65^{de}	0.62	0.56^{ef}	0.51	0.51
$I_3F_1B_0$	95.16	90.92^{a}	82.21^{b}	57.27^{c}	6.26^{d}	2.39	2.37	1.43	1.13	1.20^{cde}	1.10	1.01^{ef}	0.93	0.77
$I_3F_1B_1$	94.06	82.70^{ab}	35.30^{de}	67.88^{b}	10.61^{c}	1.98	1.42	2.57	1.72	1.60^{cde}	1.53	1.22^{de}	1.07	0.83
LSD(0.05)		8.48	8.04	6.22	4.01	NS	NS	NS	NS	1.41	NS	0.85	NS	NS
CV(%)	1.27	6.51	7.90	9.29	9.56	11.52	12.73	12.26	12.78	7.87	5.31	5.16	8.29	8.66

Mean followed by the same letter(s) with in columns are not significantly different at (LSD, 5%). TRT=treatment, PTA=pre-treatment application, (1- 13) WATA=one up to six weeks after treatment application, F_0 = without fertilizer, F_1 =with fertilizer, B_0=without sticky band, B_1= with sticky band, I_1, I_2, I_3=irrigation frequencies. $I_1F_0B_0$**,** $I_2F_0B_0$, and $I_3F_0B_0$ = controls, $I_1F_0B_1$, $I_2F_0B_1$ and $I_3F_0B_1$= Integration of irrigation, without fertilizer and sticky gum banding, $I_1F_1B_0$, $I_2F_1B_0$ and $I_3F_1B_0$= Integration of irrigation, fertilizer and without sticky gum banding and $I_1F_1B_1$, $I_2F_1B_1$ and $I_3F_1B_1$= Integration of irrigation, fertilizer and sticky gum banding. NS=non significant

3.1.3. Fruit infestation

The interactive effect of fertilization (DAP), irrigation and sticky gum banding on fruit infestation of treated and untreated check of citrus plant were compared. The treatment comprised fertilization, irrigation and sticky gum banding and their integration significantly ($p < 0.05$) reduced fruit infestation (Appendix Table 7). The percentage of infested fruit ranged from 0.56% to 1.95% in treated citrus plant, where as in un treated checks (control) of citrus plant ranged from 35% to 37% were infested per two twigs (Fig. 1). Reduction of fruit infestation shows the importance and/or the increment of the fruit yield and fruit quality as well as marketable fruit rather than that of infested and/or unmarketable fruit per two twigs. It was generally observed that integrated effect of fertilization, irrigation and sticky gum banding resulted in significant decrease in fruit infestation as compared with the untreated check (Fig. 1).

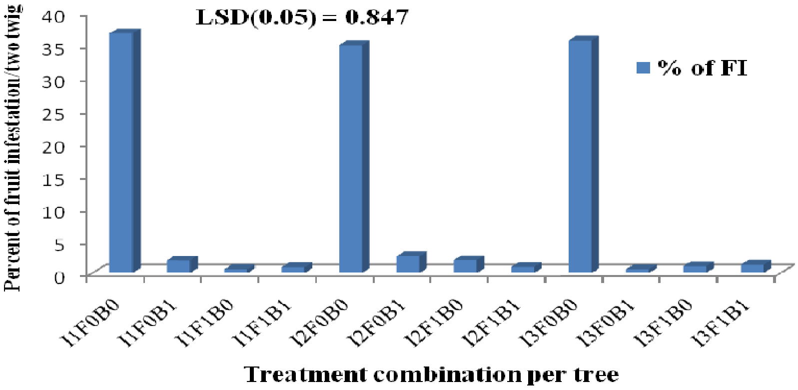

Fig. 1. The mean percent of citrus fruit infestation per two twigs.

3.1.4. The mean number of woolly whitefly colonies on the twigs of citrus

The result of woolly whitefly colonies on the twigs of citrus plants before and after treatment application at Adama is shown in Table 3. The mean number of woolly whitefly colonies per two twigs per plant was significantly reduced due to the treatments application with varied levels but not on fruit throughout the experimental period. The effect of the treatments rapidly minimized the number of woolly whitefly colonies on the citrus twigs starting from first week after treatment application throughout the experimental period when almost the numbers of woolly whitefly colonies on the twigs become un important as compared with untreated check (control) and the pre-treatment application assessment. From this result it could be said the integrated effect of fertilization, irrigation and sticky gum banding effectively reduced woolly whitefly colonies from the citrus twig/main branches.

The colony of woolly whitefly on the twig of citrus covered the main branch of the trees by producing honeydew which collect dust and support the growth of sooty mold; large infestations produced plentiful amounts of honeydew and resulted in the blackening of entire trees that reduced photosynthesis. Honeydew and sooty mold can also contaminate the fruit. This finding related with (Nguyen and Sailer 1979, Sailer *et al*. 1984), who reported that the infestation of woolly whitefly damages citrus twig by sucking sap from the leaves. Also, honeydew excreted is a medium for the growth of sooty mold fungi. The sooty mold can cover the fruit and foliage so that it interferes with photosynthesis, and requires that fruit be washed before marketing.

Table 3. Effect of fertilizer, irrigation and sticky gum banding on mean number of woolly whitefly colonies in the twig of citrus at Adama in 2011.

Pre-treatment assessment (PTA) and weeks after treatment application (WATA)													
TRT		1WATA	2WATA	3WATA	4WATA	5WATA	6WATA	7WATA	8WATA	9WATA	10WATA	11WATA	12WATA	13WATA
$I_1F_0B_0$	46.66	21.66^{b}	17.66^{a}	5.66	5.00^{a}	4.00	4.33^{a}	3.66	3.33	1.87	1.77^{a}	1.67^{a}	1.67^{a}	1.58
$I_1F_0B_1$	26.66	10.00^{ef}	5.00^{bc}	2.33	2.66^{bc}	3.33	2.66^{b}	2.33	2.00	1.46	1.34^{b}	1.22^{b}	1.05^{c}	1.05
$I_1F_1B_0$	15.00	7.00^{fg}	3.66^{c}	2.33	1.00^{d}	1.33	1.00^{e}	1.33	1.00	1.22	1.22^{b}	1.22^{b}	1.05^{c}	0.87
$I_1F_1B_1$	15.00	8.66^{ef}	4.00^{bc}	2.33	1.00^{d}	2.33	2.33^{bc}	2.33	1.33	1.34	1.34^{b}	1.22^{b}	1.05^{c}	0.87
$I_2F_0B_0$	45.00	24.30^{ab}	17.33^{a}	5.66	4.66^{a}	5.33	4.33^{a}	4.00	3.00	1.77	1.77^{a}	1.67^{a}	1.58^{ab}	1.46
$I_2F_0B_1$	22.6	14.00^{cd}	8.66^{b}	2.66	2.66^{bc}	1.66	1.33^{de}	1.33	0.66	1.22	1.22^{b}	1.22^{b}	1.05^{c}	0.70
$I_2F_1B_0$	19.66	11.60^{de}	4.00^{bc}	2.33	2.33^{c}	2.33	1.00^{e}	1.66	1.66	1.46	1.34^{b}	1.22^{b}	1.22^{bc}	1.22
$I_2F_1B_1$	17.00	4.66^{g}	5.00^{bc}	1.33	3.33^{b}	2.33	1.6^{cde}	1.66	1.33	1.34	1.34^{b}	1.22^{b}	1.22^{bc}	0.87
$I_3F_0B_0$	55.00	27.33^{a}	17.00^{a}	3.33	4.33^{a}	5.00	5.00^{a}	2.33	3.66	1.9	1.77^{a}	1.67^{a}	1.58^{ab}	0.87
$I_3F_0B_1$	37.66	17.00^{c}	5.00^{bc}	3.66	2.66^{bc}	2.33	1.33^{de}	1.33	1.00	1.22	1.22^{b}	1.22^{b}	1.05^{c}	1.05
$I_3F_1B_0$	29.66	9.33^{ef}	5.00^{bc}	3.66	2.66^{bc}	2.33	2.66^{b}	0.66	1.00	1.22	1.22^{b}	1.22^{b}	1.22^{bc}	0.70
$I_3F_1B_1$	22.3	11.30^{de}	7.66^{bc}	4.66	2.66^{bc}	2.33	2.01^{bcd}	1.33	1.66	1.46	1.34^{b}	1.34^{b}	1.22^{bc}	1.05
LSD(0.05)		3.66	4.73	NS	0.97	NS	0.93	NS	NS	NS	0.26	0.17	0.36	NS
CV(%)	15.99	15.61	33.70	19.36	19.79	25.15	22.36	34.36	29.19	10.06	11.12	7.61	17.54	22.90

Mean followed by the same letter(s) with in columns are not significantly different at (LSD, 5%). TRT=treatment, PTA=pre-treatment application, (1- 13) WATA=one up to six weeks after treatment application, F_0 = without fertilizer, F_1 =with fertilizer, B_0=without sticky band, B_1= with sticky band, I_1, I_2, I_3=irrigation frequencies. $I_1F_0B_0$, $I_2F_0B_0$, and $I_3F_0B_0$ = controls, $I_1F_0B_1$, $I_2F_0B_1$ and $I_3F_0B_1$= Integration of irrigation, without fertilizer and sticky gum banding, $I_1F_1B_0$, $I_2F_1B_0$ and $I_3F_1B_0$= Integration of irrigation, fertilizer and without sticky gum banding and $I_1F_1B_1$, $I_2F_1B_1$ and $I_3F_1B_1$= Integration of irrigation, fertilizer and sticky gum banding. NS=non significant.

3.1.5. The mean number of woolly whitefly colonies on the leaf of citrus

The number of woolly whitefly colonies on the leaf of citrus plants before and after treatment application at Adama is shown in Table 4. The mean number of woolly whitefly colonies on the leaf per two twigs of citrus was significantly reduced due to the treatments application with varied levels. The effect of the treatments considerably minimized the number of woolly whitefly colonies from the citrus leaf starting from first week after treatment application throughout the experimental period after treatment application when almost the numbers of woolly whitefly colonies on the leaf become un important when compared to the untreated check (control) and the pre-treatment application assessment. From this it can be said the integrated effect of fertilization, irrigation and sticky gum banding effectively controlled the number of woolly whitefly colonies from the citrus leaf.

Table 4. Effect of fertilizer, irrigation and sticky gum banding on mean number of woolly whitefly colonies in the leaf of citrus at Adama in 2011.

Pre-treatment assessment (PTA) and weeks after treatment application (WATA)														
TRT		1WATA	2WATA	3WATA	4WATA	5WATA	6WATA	7WATA	8WATA	9WATA	10WATA	11WATA	12WATA	13WATA
$I_1F_0B_0$	4.667	4.33^{a}	4.00	3.00^{a}	2.33	2.66	2.33	1.66^{a}	2.00^{a}	1.46	1.46^{a}	1.34	1.22^{a}	1.22
$I_1F_0B_1$	2.00	1.00^{b}	1.00	1.00^{b}	1.00	1.00	1.00	1.00^{c}	1.00^{bc}	1.22	1.22^{ab}	0.87	0.87^{a}	1.05
$I_1F_1B_0$	1.33	1.00^{b}	1.00	0.33^{b}	1.00	1.00	1.00	1.00^{c}	1.00^{bc}	1.22	1.22^{ab}	1.22	1.05^{a}	0.87
$I_1F_1B_1$	1.00	1.00^{b}	1.00	0.66^{b}	1.00	1.33	1.00	1.00^{c}	1.00^{bc}	1.22	0.87^{c}	1.22	1.05^{a}	0.87
$I_2F_0B_0$	6.00	4.66^{a}	4.00	3.00^{a}	2.33	2.66	2.66	2.33^{a}	1.33^{b}	1.34	1.34^{ab}	1.22	1.22^{a}	1.22
$I_2F_0B_1$	1.00	1.00^{b}	1.00	0.33^{b}	1.00	1.00	1.00	1.00^{c}	0.33^{de}	1.22	1.22^{ab}	1.05	0.87^{a}	0.70
$I_2F_1B_0$	1.33	1.33^{b}	1.00	0.33^{b}	1.00	1.00	1.00	1.00^{c}	1.00^{bc}	1.22	1.05^{bc}	1.05	1.05^{a}	1.22
$I_2F_1B_1$	1.66	1.00^{b}	1.00	0.33^{b}	1.00	1.00	1.00	1.00^{c}	1.00^{bc}	1.22	1.05^{bc}	1.05	1.05^{a}	0.87
$I_3F_0B_0$	5.33	4.66^{a}	3.33	3.00^{a}	2.33	2.66	2.66	1.66^{b}	2.00^{a}	1.46	1.46^{a}	1.34	1.22^{a}	0.87
$I_3F_0B_1$	2.66	1.00^{b}	1.00	1.00^{b}	1.00	1.00	1.00	1.00^{c}	0.66^{cd}	1.22	1.22^{ab}	1.22	1.05^{a}	1.05
$I_3F_1B_0$	2.66	1.00^{b}	1.00	0.66^{b}	1.00	1.00	1.00	0.33^{c}	0.00^{e}	1.22	0.87^{c}	0.87	0.87^{a}	0.70
$I_3F_1B_1$	1.66	1.00^{b}	1.33	1.00^{b}	1.00	1.00	1.00	1.00^{c}	1.00^{bc}	1.22	1.22^{ab}	1.22	0.87^{a}	1.05
LSD(0.05)		0.397	NS	0.486	NS	NS	NS	0.56	0.4865	NS	0.33	NS	0.43	NS
CV(%)	36.10	19.16	13.68	33.40	21.65	23.07	20.78	28.57	28.08	8.07	16.91	18.39	24.94	23.28

Mean followed by the same letter(s) with in columns are not significantly different at (LSD, 5%). TRT=treatment, PTA=pre-treatment application, (1- 13) WATA=one up to six weeks after treatment application, F_0 = without fertilizer, F_1 =with fertilizer, B_0=without sticky band, B_1= with sticky band, I_1, I_2, I_3=irrigation frequencies. $I_1F_0B_0$, $I_2F_0B_0$, and $I_3F_0B_0$ = controls, $I_1F_0B_1$, $I_2F_0B_1$ and $I_3F_0B_1$= Integration of irrigation, without fertilizer and sticky gum banding, $I_1F_1B_0$, $I_2F_1B_0$ and $I_3F_1B_0$= Integration of irrigation, fertilizer and without sticky gum banding and $I_1F_1B_1$, $I_2F_1B_1$ and $I_3F_1B_1$= Integration of irrigation, fertilizer and sticky gum banding. NS=non significant.

3.1.7. Status of predators in the twig and leaf of citrus

The population of predators in twig and leaf of citrus plant per two twigs before and after treatment application at Adama is shown in Table 6. Numerous predators attack the citrus woolly whitefly from this ladybird beetle was observed on twig and leaf of citrus during experiment but not on fruit. Accordingly, status of ladybird beetle in the twig and leaf of citrus significantly increased in number and reduced citrus woolly whitefly population due to the treatments application with varied levels. The effect of the treatments enhances the status of ladybird beetle in the twig and leaf starting from six week after treatment application throughout the experimental period when almost the status of ladybird beetle become at hand on citrus plant as compared with untreated check and the pre-treatment application assessment. From this it can be said the integrated effect of fertilization, irrigation and sticky gum banding effectively increased the status of ladybird beetle in the twig and leaf of citrus plant.

Fertilization (DAP), irrigation frequencies and sticky gum banding effectively increased the number of ladybird beetle on twig and leaf of citrus plant to feed on the egg and immature stage of woolly whitefly and reduced twig and leaf woolly whitefly population. This study has confirmed the results of earlier worker (Obrycki and Kring 1998, Yigit *et al*., 2003), who reported as over fifty species of coccinellidae attack eggs and immature stages of woolly whitefly pests. There is remarkable variation in the predatory behavior of these polyphagous coccinellids; some are mobile, seeking out prey, and others are sedentary, and complete preimaginal development on one twig/leaf (Obrycki and Kring, 1998).

Table 5. Effect of fertilizer, irrigation and sticky gum banding on the mean status of predator in the twig and leaf of citrus in Adama, 2011.

Pre-treatment assessment (PTA) and weeks after treatment application (WATA)														
TRT		1WATA	2WATA	3WATA	4WATA	5WATA	6WATA	7WATA	8WATA	9WATA	10WATA	11WATA	12WATA	13WATA
$I_1F_0B_0$	2.00	2.33	2.00^{b}	2.66	1.66	1.66	1.33^{c}	2.00^{e}	1.00^{e}	1.33^{d}	1.33	2.33^{def}	2.66	2.33^{g}
$I_1F_0B_1$	1.61	1.87	2.50^{ab}	2.81	3.66	3.00	1.34^{c}	1.37^{e}	6.00^{a}	2.66^{c}	2.66	2.33^{def}	5.33	11.00^{c}
$I_1F_1B_0$	1.35	1.67	1.88^{b}	2.03	2.33	2.33	2.63^{c}	3.96^{d}	4.66^{b}	2.33^{c}	1.00	3.66^{cd}	4.00	7.00^{e}
$I_1F_1B_1$	0.57	0.59	0.68^{c}	1.33	2.00	2.33	1.42^{c}	5.33^{cd}	4.66^{b}	4.66^{a}	1.00	7.00^{b}	2.66	9.00^{d}
$I_2F_0B_0$	1.66	2.00	2.33^{ab}	2.33	1.00	1.00	1.33^{c}	1.00^{cd}	1.33^{e}	1.33^{d}	1.33	1.33^{f}	3.00	2.66^{g}
$I_2F_0B_1$	2.08	2.08	2.58^{ab}	2.76	3.00	3.66	4.66^{b}	8.33^{b}	4.66^{b}	3.66^{b}	2.66	11.00^{a}	6.00	14.00^{a}
$I_2F_1B_0$	2.08	2.66	3.13^{a}	3.25	3.33	3.00	4.16^{b}	4.30^{d}	5.00^{b}	2.66^{c}	2.33	3.33^{de}	5.00	12.66^{ab}
$I_2F_1B_1$	1.61	1.85	2.17^{b}	2.70	2.33	3.00	1.42^{c}	1.54^{e}	2.33^{d}	2.33^{c}	2.66	3.00^{de}	4.00	5.33^{f}
$I_3F_0B_0$	1.33	2.00	2.33^{ab}	2.66	1.00	1.33	1.33^{c}	1.66^{e}	1.33^{e}	1.33^{d}	1.33	2.00^{ef}	2.33	1.66^{g}
$I_3F_0B_1$	1.25	1.77	2.01^{b}	2.10	1.66	2.33	4.33^{b}	5.00^{cd}	3.66^{c}	4.66^{a}	2.66	5.00^{c}	5.00	12.00^{bc}
$I_3F_1B_0$	1.95	2.85	3.08^{a}	3.37	3.66	3.33	4.23^{b}	6.33^{c}	2.33^{d}	2.66^{c}	2.66	8.00^{b}	5.33	8.00^{de}
$I_3F_1B_1$	2.01	2.74	3.05^{a}	3.21	3.33	3.33	9.33^{a}	11.00^{a}	2.66^{d}	2.66^{c}	2.66	7.66^{b}	3.66	12.33^{bc}
LSD(0.05)		NS	0.80	NS	NS	NS	1.36	1.68	0.97	0.97	NS	1.53	NS	1.61
CV (%)	20.67	12.60	20.60	21.41	22.87	27.18	25.96	23.20	17.46	21.42	25.99	19.33	18.70	11.72

Mean followed by the same letter(s) with in columns are not significantly different at (LSD, 5%). TRT=treatment, PTA=pre-treatment application, (1- 13) WATA=one up to six weeks after treatment application, F_0 = without fertilizer, F_1 =with fertilizer, B_0=without sticky band, B_1= with sticky band, I_1, I_2, I_3=irrigation frequencies. $I_1F_0B_0$, $I_2F_0B_0$, and $I_3F_0B_0$ = controls, $I_1F_0B_1$, $I_2F_0B_1$ and $I_3F_0B_1$= Integration of irrigation, without fertilizer and sticky gum banding, $I_1F_1B_0$, $I_2F_1B_0$ and $I_3F_1B_0$= Integration of irrigation, fertilizer and without sticky gum banding and $I_1F_1B_1$, $I_2F_1B_1$ and $I_3F_1B_1$= Integration of irrigation, fertilizer and sticky gum banding. NS=non significant.

3.1.8. Status of parasitoids in the twig and leaf of citrus

Status of parasitoids on twig and leaf of citrus plant per two twigs before and after treatment application at Adama is shown in Table 7. Infested leaves and twigs were put in insect rearing cage for parasitoids emergence. After rearing for two days the pupal parasitoid, *Cales noacki* was emerged on the twig and leaf of citrus plant during field experiment. Accordingly, status of a pupal parasitoid, *Cales noacki* in the twig and leaf significantly improved in number and reduced citrus woolly whitefly population due to the treatments application with varied levels. The effect of the treatments enhances the status of *Cales noacki* in the twig and leaf of citrus plant all over the experimental period. Commencing this it can be said the integrated effect of fertilization, irrigation and sticky gum banding effectively increased the status of *Cales noacki* in the twig and leaf of citrus plant.

This study, fertilization, irrigation frequencies and sticky gum banding found to be effective in significantly increased the number of *Cales noacki* on the twig and leaf of citrus to feed on the egg and immature stage of woolly whitefly and reduced the twig and leaf woolly whitefly population. In addition, *Cales noacki* is a specific entomophagous parasitoid of the woolly whitefly, which is one of the most important citrus pests. This finding is related with (Miklasievicz and Walker, 1990; Delbene and Gargani, 1991; Vivas, 1992; Barbagallo *et al*., 1993; Katsoyannos *et al.,* 1997), who reported that *C. noacki* is the most effective known natural enemy of woolly whitefly, and has been used successfully in many countries for the biological control of woolly whitefly. On the other hand, Katsayannos *et al*. (1997) reported that after releasing *C. noacki* in Greece, the parasitoid despite having some natural enemies appeared to be the main contributor to an observed reduction of woolly whitefly. Moreover, Emana (2007) reported *Cales noacki* from Ethiopia.

Table 6. Effect of fertilizer, irrigation and sticky gum banding on the mean status of parasitoids in the twig and leaf of citrus in Adama, 2011.

Pre-treatment assessment (PTA) and weeks after treatment application (WATA)														
TRT		1WATA	2WATA	3WATA	4WATA	5WATA	6WATA	7WATA	8WATA	9WATA	10WATA	11WATA	12WATA	13WATA
$I_1F_0B_0$	1.00	1.00^{bc}	1.00^{bcd}	1.66	1.00	1.00	1.00^{bc}	1.33^{cd}	1.33^{bc}	1.00	1.33	1.66^{cde}	1.00^{b}	1.00^{bc}
$I_1F_0B_1$	1.38	1.58^{a}	1.90^{a}	2.00	2.10	1.33	0.71^{c}	1.00^{d}	2.33^{a}	2.00	1.00	1.00^{e}	1.66^{ab}	0.71^{b}
$I_1F_1B_0$	0.69	0.50^{d}	0.57^{de}	1.00	1.33	1.33	0.84^{bc}	2.00^{abc}	1.00^{c}	1.33	1.00	2.33^{abc}	2.00^{a}	0.84^{bc}
$I_1F_1B_1$	0.73	0.24^{e}	0.29^{e}	1.00	1.00	1.00	0.88^{bc}	2.66^{a}	2.00^{ab}	2.00	1.00	2.66^{ab}	1.33^{ab}	0.88^{bc}
$I_2F_0B_0$	1.00	1.00^{bc}	1.00^{bcd}	1.66	1.00	1.00	1.00^{bc}	1.00^{d}	1.00^{c}	1.33	1.00	1.00^{e}	1.66^{ab}	1.00^{bc}
$I_2F_0B_1$	0.76	0.76^{c}	0.85^{cd}	1.33	1.33	1.66	2.76^{a}	2.66^{a}	2.00^{ab}	2.00	1.00	3.00^{a}	1.33^{ab}	2.76^{a}
$I_2F_1B_0$	1.50	1.71^{a}	1.94^{a}	2.33	2.15	1.33	1.39^{b}	2.00^{abc}	2.00^{ab}	1.33	1.00	2.00^{cde}	1.66^{ab}	1.39^{b}
$I_2F_1B_1$	0.8	0.83^{bc}	0.90^{bcd}	1.00	1.00	2.00	0.50^{c}	1.00^{d}	1.33^{bc}	1.66	1.00	1.33^{de}	2.00^{a}	0.50^{c}
$I_3F_0B_0$	1.00	1.00^{bc}	1.33^{b}	1.66	1.00	1.00	0.66^{c}	1.33^{dc}	1.00^{c}	1.33	1.00	1.66^{cde}	1.33^{ab}	0.66^{c}
$I_3F_0B_1$	0.70	0.51^{d}	0.56^{de}	1.66	1.30	1.00	0.91^{bc}	1.66^{bcd}	2.33^{a}	2.00	1.00	1.66^{cde}	1.66^{ab}	0.91^{bc}
$I_3F_1B_0$	0.79	0.93^{bc}	1.01^{bcd}	1.33	1.28	1.66	1.43^{b}	2.33^{ab}	1.66^{abc}	1.00	1.00	3.00^{a}	1.33^{ab}	1.43^{b}
$I_3F_1B_1$	1.00	1.07^{b}	1.22^{bc}	1.66	1.31	1.66	2.57^{a}	2.66^{a}	1.66^{abc}	2.00	1.00	2.66^{ab}	2.00^{a}	2.57^{a}
LSD(0.05)		0.253	0.48	NS	NS	NS	0.58	0.74	0.68	NS	NS	0.888	0.794	0.584
CV (%)	26.43	16.14	27.20	28.34	29.73	30.61	28.33	24.42	24.91	29.77	16.21	26.35	29.77	28.33

Mean followed by the same letter(s) with in columns are not significantly different at (LSD, 5%). TRT=treatment, PTA=pre-treatment application, (1- 13) WATA=one up to six weeks after treatment application,

F_0 = without fertilizer, F_1 =with fertilizer, B_0=without sticky band, B_1= with sticky band, I_1, I_2, I_3=irrigation frequencies. $I_1F_0B_0$, $I_2F_0B_0$, and $I_3F_0B_0$ = controls, $I_1F_0B_1$, $I_2F_0B_1$ and $I_3F_0B_1$= Integration of irrigation, without fertilizer and sticky gum banding, $I_1F_1B_0$, $I_2F_1B_0$ and $I_3F_1B_0$= Integration of irrigation, fertilizer and without sticky gum banding and $I_1F_1B_1$, $I_2F_1B_1$ and $I_3F_1B_1$= Integration of irrigation, fertilizer and sticky gum banding. NS=non significant.

3.2. Number of new shoot emerged, flower and fruit yield

The number of new shoot emerged; number of flower and fruit yield per two twigs, marketable and unmarketable fruit yield (fruit yield were graded based on size, shape and weight) are presented in Table 8. The number of new shoot emerged and the number of flower per two twigs were significantly increased after treatment application with varied levels. Significant difference in number of new shoot emerged and number of flower per two twig were observed for treated citrus plant when compared to untreated check of citrus plant and pre-treatment application assessment. It may be attributed to the fact that the experimental citrus trees were under stress with very less leaf age and due to interactive effect of fertilization (DAP), irrigation and sticky gum banding, the leaf age was increased that helped provide improved plant health, leaf life and flower initiation, resulting in better fruit growth, development and improved fruit quality. Overall, fertilization, irrigation and sticky gum banding were the best treatments with respect to fruit quality. The results are in agreement with Hussain and Ali (1972) and Jeelani (1994) who reported that there was appreciable change in fruit number by irrigation and fertilizer application.

Statistically significance difference in fruit yield was observed for treated citrus plant when compared to untreated check of citrus plant at Adama. It is apparent that the interactive effect of fertilizer (DAP), irrigation and sticky gum banding significantly increased the total yield per two twigs as compared to control. Total fruit yield was maximum (188 fruit/two twig) at which the marketable (169 fruit/two twig) and unmarketable (24 fruit/two twig) fruit yield was obtained from treated citrus plant respectively, where as less number of fruits (48 fruit/two twig) were recorded in untreated check. And weight of maturity showed significant variation on marketable fruit yield, where as insignificant effect on the weight of unmarketable fruit yield of citrus plant. At the treatment combination level $I_3F_0B_1$ the number of flower is greater than that of fruit per two twigs per plant because for the period of recording the number of flower, it was not initiated completely on this plant when compared with that of other experimental citrus trees that transport the variation on the number of flower and fruit.

It was generally observed that the interactive effect of fertilization, irrigation and sticky gum banding effectively increased the yield and quality of citrus fruit and also increased the number of citrus fruit per two twig as well as quality of marketable fruit and reduced the number of unmarketable fruit per two twigs. It also indicated that fertilization, irrigation frequencies and sticky gum banding improved the general health and vigor of citrus plants that also improved the final yield of plants. In this study, also the integrated effect of fertilization, irrigation frequencies and sticky gum banding found to be more efficient which involves strengthening of the citrus plant by the use of Nitrogen, Phosphorous and Potassium (NPK) source fertilizers and optimum water requirement through irrigation and increased the performance of natural enemies to reduce woolly whitefly infestation. These findings are in lined with the finding of (Embleton *et al*., 1986; Smith, 1998), who reported that nitrogen is the nutrient most likely to limit yield and quality of citrus, and is the nutrient used in the highest amounts for citrus production. In addition, adequate supplies of N are necessary to optimize yield of young citrus trees. Optimal growth and yield requires optimal levels of N and irrigation. This finding is also lined with (Davies & Albrigo, 1994; Tucker *et al*., 1995; Alva *et al.*, 2006), who reported that better yield of good quality citrus fruits can be achieved by the adequate supply of fertilizer at critical stage of fruit commencement and development.

Table 7. Effect of fertilizer, irrigation and sticky gum banding on the mean number of new shoot emerged, flower and fruit yield (marketable, unmarketable and its weight) per two twig at Adama, East Shewa, Ethiopia.

	Post treatment application assessment					
TRT	NNS/2twig	NF_L/2twig	NF_R/2twig	MR/2twig	Wt(kg)	UMR/2twig	Wt(kg)
$I_1F_0B_0$	244.33^{i}	55.667^{e}	51.00^{d}	27.41^{e}	4.42^{e}	40.25^{a}	5.00
$I_1F_0B_1$	537.67^{g}	180.00^{bc}	149.33^{bc}	127.94^{bc}	18.42^{bc}	21.39^{bc}	2.32
$I_1F_1B_0$	570.67^{f}	193.33^{ab}	149.33^{bc}	124.32^{bcd}	17.48^{bcd}	25.34^{bc}	3.36
$I_1F_1B_1$	682.67^{d}	200.00^{a}	157.00^{b}	133.71^{b}	18.82^{b}	23.28^{bc}	2.83
$I_2F_0B_0$	241.33^{i}	57.00^{e}	47.66^{d}	20.26^{e}	3.34^{e}	37.07^{a}	4.58
$I_2F_0B_1$	1024.33^{b}	179.66^{bc}	159.66^{b}	131.20^{b}	18.96^{b}	28.46^{b}	3.52
$I_2F_1B_0$	622.67^{e}	174.66^{cd}	138.66^{c}	114.93^{d}	16.45^{d}	23.06^{bc}	2.80
$I_2F_1B_1$	780.00^{c}	174.33^{cd}	146.66^{bc}	122.45^{bcd}	18.00^{bcd}	24.21^{bc}	3.06
$I_3F_0B_0$	300.67^{i}	63.66^{e}	61.66^{d}	31.52^{e}	5.16^{e}	44.14^{a}	5.46
$I_3F_0B_1$	1022.67^{b}	161.00^{d}	187.66^{a}	168.95^{a}	23.69^{a}	18.71^{c}	2.49
$I_3F_1B_0$	699.00^{d}	184.66^{abc}	138.66^{c}	118.63^{cd}	16.93^{cd}	20.03^{c}	2.52
$I_3F_1B_1$	1457.67^{a}	180.66^{bc}	148.00^{bc}	121.30^{bcd}	17.50^{bcd}	26.69^{bc}	3.25
LSD(0.05)	23.549	18.484	14.28	12.50	1.826	8.206	NS
CV	2.05	7.29	6.62	7.168	7.25	17.56	18.25

Mean followed by the same letter(s) with in columns are not significantly different at (LSD, 5%). TRT=treatment. $I_1F_0B_0$, $I_2F_0B_0$, and $I_3F_0B_0$ = controls, $I_1F_0B_1$, $I_2F_0B_1$ and $I_3F_0B_1$ = Integration of irrigation, without fertilizer and sticky gum banding, $I_1F_1B_0$, $I_2F_1B_0$ and $I_3F_1B_0$ = Integration of irrigation, fertilizer and without sticky gum banding and $I_1F_1B_1$, $I_2F_1B_1$ and $I_3F_1B_1$ = Integration of irrigation, fertilizer and sticky gum banding. NNS/2twig = number of new shoot emerged per two twig, NF_L/2twig = number of flowering per two twig, NF_R/2twig = number of fruit per two twig, MR/2twig= marketable fruit per two twig, UMR/2twig = unmarketable fruit per two twig, Wt (kg) = weight of its matured fruit in kilo gram. NS=non significant.

4. CONCLUSIONS

The present study showed that effect of fertilizer; irrigation and sticky gum banding were significant in reducing woolly whitefly infestation on citrus. All infested plant parts were also attended by several ant colonies. However, significant variations were observed among the treatment in fruit yield. From the present study it can be concluded that by providing the citrus plant with appropriate/optimum nutrient and water at the right time which mainly strengthen and help the plant to produce leaves and flowers, and enhance the activity of the natural enemies mainly by disconnecting the symbiotic relationship between the woolly whitefly and ants by using sticky gum banding. As the management of commercial citrus production is very intense the likely problem of woolly whitefly in such a farm is almost nil. Thus, the current technology is fit to small scale citrus production system which has to be extended by the extension agents. The result of this study revealed that the use of fertilizer (DAP), irrigation and sticky gum banding have a potential role in reducing citrus infestation by woolly whitefly. From the current trial treated citrus plant showed almost nil infestation to woolly whitefly as compared to untreated check and the pre-treatment application assessment. Hence, farmers in the Central Rift Valley of Ethiopia can obtain economic advantage by integrating fertilizer, irrigation and stick gum banding on citrus to control woolly whitefly infestation. Thus, integration should be considered as one option for woolly whitefly management.

Therefore, the integration of fertilizer (DAP), irrigation and sticky gum banding can be recommended in managing woolly whitefly infestation on citrus.

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