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Integrated Control of the White Mango Scale Through Tree Management and Soil Drenching with a Systemic Insecticide in Western Ethiopia

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ነጭ የማንጎ ስኬል ሰይንሳዊ መጠሪያው Aulacaspis tubercularis (Hemiptera: Diaspididae) ሲሆን እ.ኤ.አ. በ2010 ዓ.ም. ተከስቶ ኢትዮጵያ ውስጥ የማንጎ ምርትን አደጋ ላይ የጣለ ተባይ ነው። በመላው አገሪቱ በአጭር ጊዜ ተሰራጭቶ የማንጎ ምርትና ጥራት እንዲቀንስ አድርጓል። ተባዩን ለመቆጣጠር ከሚወሰዱ ርምጃዎች ውስጥ፤ ፀረ-ተባይ መጠቀም፣የተክል አያያዝን ማሻሻልና በጥገኛ ነፍሳት በመጠቀም በሥነ-ሕይወታዊ መንገድ መቆጣጠር ይገኙበታል። በማንጎ ተክል ውስጥ ተሰራጭቶ የሚሰራ ፀረ-ተባይን በአንድ ሊትር ውሀ በጥብጦ በተክሉ ዙሪያ ማጠጣትና የማንጎን ቅርንጫፎች መግረዝ (የተክል አያያዝን መጠቀም) ነጭ የማንጎ ስኬል ተባይን ለመቆጣጠር ያለውን ፍቱንነት ለመመርመር እ.ኤ.አ. በ2018 እና 2019 ዓ.ም. በምዕራብ ኢትዮጵያ በሚገኙ ሁለት አካባቢዎች ለተከታታይ ሁለት ዓመታት የመስክ ሙከራ ተካሄዶ ነበር። ለሙከራው በሶስት ድግግሞሽ የተሰራ ራንደማይዝድ ኮምፕሊት ብሎክ የተባለ ዲዛይን ጥቅም ላይ ውሏል። በውጤቱም የተባዩ ድምር ቁጥር በሁለቱም ዓመታትና በሁለቱም አካባቢዎች ማለትም ኡኬ እና ባኮ ላይ ውጤታማ በሆነ መልኩ ሊቀንስ ችሏል። ኡኬ ላይ የማንጎ ተክል ቅርንጫፎችን መግረዝና ቲያሜቶክሳም 25በመቶ WG 18ግራም በአንድ የማንጎ ተክል ዙርያ በአንድ ሊትር ውኃ በጥብጦ መርጨት በመጀመሪያው ዓመት የመጀመሪያ ርጭት ወደ ዝቅተኛ የተባዩ ቁጥር (42.23 በቅጠል) ሲያወረደው በዚያው ዓመት ሁለተኛው ዙር ርጭት ወደ 27.83 በቅጠል አድርሶታል። ይህንኑ ፀረ-ተባይ በተመሳሳይ ሁኔታ በ12 ግራም መጠን መስጠት ደግሞ የተባዩን ቁጥር በመጀመሪያ ዙር ርጭት 86.83 በቅጠል እንዲሆን ሲያደርገው በሁለተኛው ዙር ርጭት ወደ 61.0 በቅጠል እንዲቀንስ አድርጎታል። ለማወዳደሪያ ምንም ርጭትም ሆነ መግረዝ ያልተደረገባቸው የማንጎ ተክሎች በመጀመሪያው ዙር ርጭት 334.32 ተባይ በቅጠል እንዲሁም በሁለተኛው ዙር ርጭት 591.29 ተባይ በቅጠል የሆነ ከፍተኛ ቁጥር ታይቶባቸዋል። ባኮ ላይም የተካሄደው ሙከራ ተመሳሳይ ውጤት አሳይቷል።ይህ ምርምር ከላይ የተጠቀሰውን ዘዴ መጠቀም ተባዩን ለመቆጣጠር ተስፋ ሰጪ ውጤት ያስገኘ መሆኑን አመላክቷል። ይህንኑ ዘዴ ከሌሎች ማለትም ጥገኛ ነፍሳትን በመጠቀም በሥነ-ሕይወታዊ መንገድ መቆጣጠር ዘዴዎች ጋር ማቀናጀት ያለውን ጠቀሜታና ፀረ-ተባዩ በማንጎ ፍሬ ይዘት ላይ ያለውን ተፅዕኖ በቀጣይ ማጥናት ያስፈልጋል።

Abstract

The white mango scale insect, **Aulacaspis tubercularis** (*Hemiptera: Diaspididae*) *is a recent threat to mango production in Ethiopia which was introduced in 2010. It has spread to all mango producing areas of the country within a short period of time reducing the production and quality of mangos. Control measures taken against the white mango scale include use of chemical insecticides, cultural practices and biological control using parasitoids and predators. Field experiments were conducted in western Ethiopia in two locations for two consecutive years in 2018 and 2019 to evaluate the efficacy of integrated application of a systemic soil drenching pesticide and tree management (pruning) for the control of the white mango scale. Randomized complete block designs with* *three replications were used for the experiments. The total number of WMS life stages varied significantly among the different treatments throughout the two years and application seasons at both Uke and Bako sites. At Uke Thiamethoxam 25% WG at 18g/tree + pruning treated trees showed the minimum mean number of WMS life stages per leaf (42.23) and (27.83) followed by Thiamethoxam 25% WG at 12g/tree + pruning treated trees (86.83) and (61.0) in the first and second application seasons respectively. Control trees showed highest (334.33) and (591.29) number of WMS life stages in the first and second application seasons respectively. Similar trends were observed at Bako. The study has shown that the integrated use of the systemic soil drenching insecticide and tree management can significantly reduce the WMS life stages on infested mango trees indicating that it is a promising approach to the control of the WMS. Integration of these approach with other management components such as biological control agents and the effect of the systemic insecticide on the content of the edible fruit deserves further study.*

Keywords: WMS, *Aulacaspis tubercularis*, Thiamethoxam, systemic insecticide, soil drenching

Introduction

The white mango scale insect, *Aulacaspis tubercularis* Newstead, (Hemiptera: Diaspididae) is a recently introduced pest of mango which is currently threatening mango production in Ethiopia. The pest was first reported in east Wellega zone in August, 2010 at a private farm called Green Focus Ethiopia Ltd. (Mohamed *et al*., 2012). It has been spreading fast ever since then to almost all mango producing regions in the country causing high losses on mango production and threatening the emerging fruit production and processing industry. Several surveys (Temesgen, 2014; Gashawbeza *et al*., 2015; Ofgaa *et al.,* 2019) have confirmed its spread to different parts of the country. The insect attacks the mango plant at all the growth stages from seedling to maturity and leaves, twigs and fruits are attacked and die back is observed (Ofgaa *et al*., 2016). It causes defoliation, poor blossoming, and decreased fruit bearing, reduced juice in fruits and can cause death of the whole plant if infestation occurs at seedling stage (Abo- Shanab, 2012). The white mango scale infestation can cover about 33% of the mango canopy when severe (Mohamed *et al*., 2011) and thus deprives the plant of active photosynthetic leaf area by causing yellowing and blackening of the leaves. It also causes pink blemishes and yellowing of mature and ripe fruits rendering them unfit for both local and international markets (USDA, 2006). The scales of the insect are blown by wind and cause nuisance and allergic reactions to farmers (Belay, Personal observation).The white mango scale is known to lower productivity in mangos (Blackburn, 1984; Miller, 1990). It has caused serious damages to mango production in many countries (SRA, 2006; Germain *et al*., 2010; Abo-Shanab, 2012) and become an important mango pest in Africa, North America, South America and the Caribbean Islands (El-Metwally *et al*., 2011;

Nabil *et al*., 2012). Once fertilization takes place, the white mango scale crawlers hatch out and attach to the plant part to suck the plant saps (Louw *et al*., 2008; Goble *et al*., 2012). Host range and geographic distribution studies have confirmed that the white mango scale is present in 69 countries, has a polyphagous nature and attacks more than 30 genera of crops belonging to over 18 families including citrus, papaya, avocado, ginger, cinnamon and pumpkins (Malumphy 2014; García, 2016).

Control measures taken against the white mango scale include use of chemical insecticides, cultural practices and biological control using parasitoids and predators (Daneel and Joubert, 2009; Abo-Shanab, 2012; Gashawbeza *et al*., 2015). However, use of foliar insecticides against the WMS is less practical as most of the varieties grown in the homesteads of small holder farms are up to 20m tall (Temesgen, 2014) and difficult to reach by ordinary spray equipment. Moreover, use of foliar insecticides in homestead mangos entails health hazards to humans and domestic animals. The objective of this study was therefore to evaluate the efficacy of integrated application of a systemic soil drenching insecticide and tree management in controlling the white mango scale.

Materials and Methods

The experiments were conducted in western Ethiopia in two locations for two consecutive years in 2018 and 2019. The first site is located in East Wellega Zone of Oromia region at a commercial mango orchard called Raj Agro-industry Ltd. The second site is located in West Shoa Zone of Oromia region at Bako Agricultural Research Center experimental fruit orchard. In the first experiment conducted at Raj Agro-industry orchard, a site containing six years old mango trees of Tommy Atkins variety having similar sizes was purposively selected. The distance between the mango trees in the orchard was six meters in all directions. A randomized complete block design with three replications was used. The distance between each block was one row of mango trees. There were eight treatments and thus each block contained eight mango trees. Thiamethoxam 25% WG (a neonicotinoid insecticide registered in Ethiopia for the control of the WMS) at 6, 12 and 18g/tree with and without pruning (tree management) were used as treatments together with pruning only and a control which received irrigation only. Trenches of approximately 10 cm depth were dug around each tree at one meter distance from the trunk. Each dose of Thiametoxam 25% WG was dissolved in one liter of water. Drenching was done by pouring the dissolved chemical around the trench after irrigating each tree adequately using tractor mounted water tanks at Uke. The trenches were covered with soil after treatment application. Drenching was done twice in a season. The first and second treatment applications of first season were conducted on January 26, 2018 and April 26, 2018 respectively. Similarly, first and second applications of second cropping season were conducted on January 23, 2019 and April 25, 2019 respectively. The treatment application times coincided with early flowering and fruit setting periods of the mango trees. Similar treatments and application methodology were used in the second experiment site at Bako Agricultural Research Center except that the varieties used were different (Tommy Atkins, local varities, Kent, Keit and Apple). Since there was no regular irrigation schedule in Bako site, drenching was done after irrigation of each tree using watering cans for 5 consecutive days to sufficiently moisten the soil around the root zone in January. For this site, the first and second treatment applications of first season were conducted on January 24, 2018 and April 27, 2018 respectively while first and second treatment applications of second cropping season were conducted on January 20, 2019 and April 19, 2019 respectively. Tree management activities i.e. Pruning of old branches, twigs and diseased leaves was done to open the canopy of the mango trees using ordinary wood saw after data collection and before treatment application at each of the sites. Estimation of the initial mean leaf infestation level by WMS (white mango scale) life stages (male, females, crawlers) before treatment applications in each of the sites in the respective years was done by visual estimation of the proportion of leaf samples infested with WMS on whole tree basis.

Data collection and analysis

Twelve leaves were randomly picked from each of the four cardinal directions (i.e. east, west, south and north) from upper, middle and lower canopy of the trees before each treatment application and every month thereafter for two consecutive months. The collected samples were placed in labeled polyethylene bags pierced for aeration and transported to Ambo Agricultural Research Center laboratory for further examination. Estimation of infestation level, counting and recording of life stages of white mango scale on the upper and lower surface of the leaves was conducted using a stereo microscope.

Test of homogeneity of variance (HoV test) was done with Bartlet method to decide if data could be combined over years. All count data were transformed using square root transformation ($\sqrt{x}$) method. Analysis of variance was done on transformed data but only means of untransformed data are presented. Data analysis was done using SAS software (version 9.1.) and significant means were separated using the Least Significant Different (LSD) test.

Results and Discussion

Estimation of the initial leaf infestation level of mango trees by WMS life stages before treatment applications in each of the sites in the respective years is given in Table 3.

The total number of WMS life stages varied significantly among the different treatments throughout the two years and application seasons at Uke site (Table 1). In the first season, Thiamethoxam 25% WG at 18g/tree + pruning treated trees showed the minimum mean number of WMS life stages per leaf (42.23) followed by Thiamethoxam 25% WG at 12g/tree + pruning treated trees (86.83) which did not significantly differ from each other and the trees receiving pruning alone treatment after the first treatment applications. The highest number of WMS life stages was observed on Thiamethoxam 25% WG at 6g/tree treated trees (276.08) which did not significantly differ from the control (334.33). Similarly, in the second application season, Thiamethoxam 25% WG at 18g/tree + pruning treated trees showed the minimum mean number of WMS life stages (27.83) as in the first season followed by Thiamethoxam 25% WG at 12g/tree + pruning treated trees (61.0) which did not significantly differ from each other and the trees receiving Thiamethoxam 25% WG at 18g/tree, Thiamethoxam 25% WG at 6g/tree + pruning, Thiamethoxam 25% WG at 12g/tree + pruning and pruning alone treatment after the second treatment applications. The highest number of WMS life stages (591.29) was recorded from the control which differed significantly from all the other treatments.

When data of the Uke site were combined for the two years, the lowest mean total population of WMS life stages per leaf (138.46) was observed in the second year which varied significantly from that of the first year (178.71).

Table 1: Mean combined treatment effects on total number of life stages (crawlers, male and female) of the WMS over years (2018 & 2019) at Uke

	Mean number of summed WMS life stages per leaf		
	Treatment application time		
	Before	**After 1st**	**After 2nd**
Year 1(2018)	323.00	178.71a	200.41a
Year2 (2019)	182.75	138.46b	132.25b
LSD (5%)	-	37.36	45.87
Thiamethoxam 25% WG at 6g/tree	233.00	276.08a	236.83b
Thiamethoxam 25% WG at 12g/tree	254.67	156.83b	128.00c
Thiamethoxam 25% WG at 18g/tree	256.83	136.00b	90.17cd
Thiamethoxam 25% WG at 6g/tree + pruning	291.50	124.33b	107.50cd
Thiamethoxam 25% WG at 12g/tree + pruning	242.17	86.83bc	61.00cd
Thiamethoxam 25% WG at 18g/tree + pruning	231.00	42.23c	27.83d
Pruning only	289.17	109.04bc	88.00cd
Control	215.67	334.33a	591.29a
LSD (5%)	-	74.72	91.74
CV (%)	32.53	39.96	46.78

Significant variations among the treatments were observed in the total number of WMS life stages throughout the two years and application seasons at Bako site as well (Table 2). In the first treatment application season, the lowest mean number of WMS life stages (60.17) was observed on Thiamethoxam 25% WG at 18g/tree + pruning treated trees and was significantly different from all the other treatments except Thiamethoxam 25% WG at 12g/tree + pruning treated trees (93.83). The highest number of WMS life stages (295.67) was recorded from the control. Similar trends were observed in the second treatment application season as well with (31.17) and (69.33) number of WMS life stages for Thiamethoxam 25% WG at 18g/tree + pruning treated trees and Thiamethoxam 25% WG at 12g/tree + pruning treated trees respectively. There were no significant variations between the two years and application seasons in the mean number of WMS life stages at Bako site.

Table 2: Mean combined treatment effects on total number of life stages (crawlers, males and females) of the WMS over years (2018 & 2019) at Bako

	Mean number of summed WMS life stages per leaf		
	Treatment application time		
	Before	**After 1st**	**After 2nd**
Year 1(2018)	220.90	168.19	171.90
Year2 (2019)	185.86	155.81	156.71
LSD (%)	--	ns	ns
Thiamethoxam 25% WG at 6g/tree	243.83	245.17b	291.83b
Thiamethoxam 25% WG at 12g/tree	192.67	145.17cd	130.17c
Thiamethoxam 25% WG at 18g/tree	216.50	117.83de	104.33dc
Thiamethoxam 25% WG at 6g/tree + pruning	212.67	176.17c	142.83c
Thiamethoxam 25% WG at 12g/tree + pruning	171.17	93.83ef	69.33de
Thiamethoxam 25% WG at 18g/tree + pruning	160.83	60.17f	31.17f
Control	223.00	295.67a	280.50a
LSD (5%)	83.02	43.78	55.86
CV (%)	34.40	22.77	47.07

Table 3. Estimated mean initial leaf infestation by WMS life stages before treatment applications in each of the sites in the respective years

No	Site	Mean leaf infestation (%)Year 1 (2018)	Mean leaf infestation (%)Year 2 (2019)	Remarks
1	Uke	41	35	Whole tree basis
2	Bako	38	33	Whole tree basis

The study has shown that the integrated use of a systemic soil drenching insecticide (Thiamethoxam 25% WG) and tree management can significantly reduce the number of WMS life stages on infested mango trees indicating that it is a promising approach to the control of the WMS. Although evaluation of foliar insecticides in Ethiopia have shown the efficacy of some of them such as Spirotetramat and Methidathion (Gashawbeza *et al*., 2015), there are no studies of the use of this approach in Ethiopia. However, studies conducted else were have shown the effectiveness of soil drenching of mango trees with Thiamethoxam 25% WG for the control of WMS. One such study is that of Qureshi *et al.* (2011)

which showed the efficacy of Thiamethoxam 25% WG against mango scale insects when applied by irrigation once in a season. The authors found that Thiamethoxam 25% WG applied to 12 years old Kingston Pride variety of mango at 20% flowering with a dose of 6g/tree and 12g/tree significantly reduced scale insect infestation compared to the control in Australia.

The recommended dose of Thiamethoxam 25% WG is 6g/tree in Ethiopia. However, this study has indicated that higher than the recommended dose may be required to achieve the desired effect on the WMS. This may be because of the need for high amount of irrigation water for the uptake of the systemic insecticide to reach the entire canopy especially in areas where irrigation is less commonly and less regularly used for mango production in the study area. Integration of these approach with other management components such as biological control agents should be considered in the next steps. In addition to this, the effect of higher than recommended dose on the content of the edible fruit deserves further study.

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