




## MANAGEMENT OF WHITE MANGO SCALE (*Aulacaspis tubercularis*) IN ASSOSA DISTRICT, BENISHANGUL GUMUZ REGION, WESTERN ETHIOPIA

 Merkuz Abera<sup>1\*</sup>,  Bizuayehu Jemaneh<sup>2</sup>,  Adane Tesfaye<sup>1\*</sup>

<sup>1</sup>Bahir Dar University, College of Agriculture and Environmental Science, Bahir Dar, Ethiopia

<sup>2</sup>Benishangul-Gumuz Region Bureau of Agriculture, Plant Health Clinic, Assosa, Ethiopia

\*Corresponding Author:

E-mail: [merkuzabera@yahoo.com](mailto:merkuzabera@yahoo.com)

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**ABSTRACT:** The white mango scale has been identified as a new, fast-spreading, and overwhelming insect pest of mango. It emerged as a shocking insect pest that currently damages mango production, causing 50 to 100% losses and forcing the plant out of production in most mango-growing areas of Ethiopia. The research was initiated to develop a strategy for the sound management of white mango scale (*Aulacaspis tubercularis*). Field experiment was conducted to evaluate the effect of Imidacloprid 20SL, Dimethoate 40% EC, White oil extract, Pruning, Imidacloprid 20 SL + Pruning, Dimethoate 40% EC+Pruning and White oil extract + Pruning against white mango scale insect. The experiments were arranged in Randomized Complete Block Design with three replications. The results indicates that all the treatments significantly ( $p < 0.05$ ) reduced infestation of white mango scale and gave higher yield over the control. Imidacloprid 20 SL+pruning treatment was the most significantly effective which also provide a promising alternative cost to producers against white mango scale insect pest than other treatments. Further study on other management tactics which are compatible with cultural practices and reduced dose of insecticide as a part of integrated pest management strategy is mandatory.

**Keywords:** Dimethoate, imidaclopride, integrated pest management, pruning, white scale

### INTRODUCTION

*Mangifera indica* is the only species grown commercially on a wider scale within the genus *Mangifera* [1]. Mango is among the most cherished and nutritious vitamins A and C, carbohydrates, potassium, and phosphorus [1, 2]. Mangoes are grown in Ethiopia for household food, local markets, and, to a lesser extent, modern farms produced for local and export markets [3]. Benishangul Gumuz is one of the most potential areas in the country. The average yield is less than 5.45 tons/ha as compared to the national average yield of 7 tons/ha; however, the yield is very low compared to the crop potential, about 20 – 30 tons/ha [4, 5, 6]. Reasons for low production and productivity mainly include backward production and pest infestation: mango anthracnose, powdery mildew, white mango scales, fruit flies, mango seed weevil, thrips, mealybugs, and scale insects [3, 4, 7]. From these, WMS (white mango scale) (*Aulacaspis tubercularis* Newstead) is a hard-scale insect pest that is reported to cause serious damage to mango plants in many countries [8, 9, 10, 11]. The white mango scale (*Aulacaspis tubercular* Newstead) belongs to the order Hemiptera and is featured by possessing a piercing and sucking mouth. Because of the absence of a strict internal quarantine system for the geographical exchange of planting materials. The white mango scale emerged as a devastating insect pest that destroys mango production, causing 50 to 100% economic losses and killing the plant in most mango-growing areas worldwide [3, 12].

According to reports, the pest first entered the mango seedlings imported from India by Green Focus Ethiopia Ltd. [13]. Within a year, the pest spread 100 kilometers to the west and up to 1,500 km to the north and central Ethiopia [14, 15]. It is also distributed in all regions of

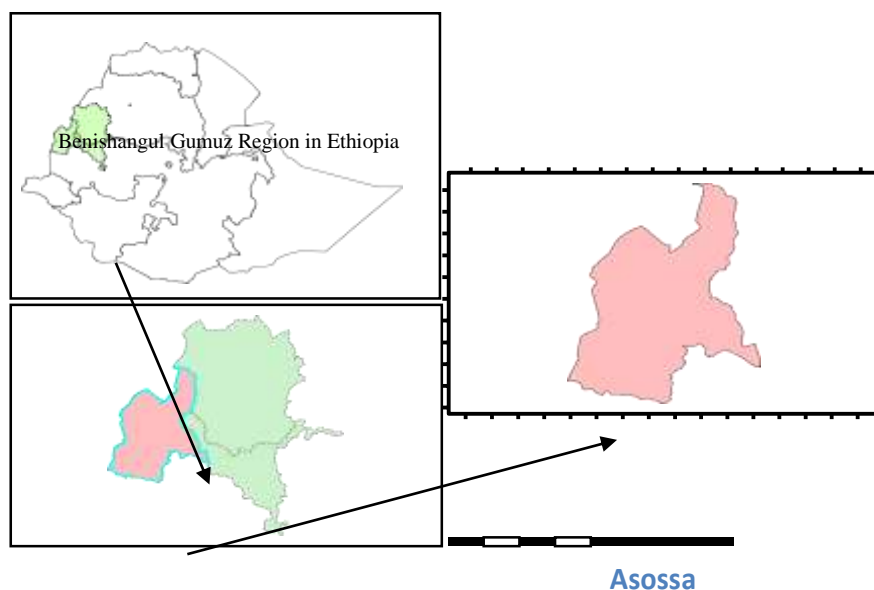
Ethiopia that grow mangoes, including Oromia, Amhara, Benishangule Gumuz, Gambella, Tigray, Southern People's Nation, and Rift Valley areas [3, 16] This pest is causing serious damage to the mango plants in western Ethiopia, causing socio-economic problems and becoming a concern of the government, the civil societies, and the community [17, 18, 19]. The white mango scale damage injures are the mango plant shoots, twigs, leaves, branches, and fruits of mango by sucking plant fluid with the mouthparts, causing deformation, defoliation, drying up of young twigs, dieback, poor blooming, loss of twigs perhaps through toxic substances activity [19, 20]. The damaging impact of the white mango scale on mango is manifested by yellowing the leaves, creating a pink blemishes on mature and ripe fruits, and causing them to die from top to bottom [10, 21]. The emergence of blemishes on the mango fruit results in economic loss by preventing it from being exported [20, 22]. According to farmers in western Welega, the yield of a mango plant to 10 quintals of mango fruit before WMS (white mango scale) infestation has decreased to 2 - 3 quintals of mango fruit, sometimes completely destroying mango fruit production. This loss of Mango fruit production affects Ethiopia's local and export markets [13, 16].

Various Ambo Plant Protection Research Center studies suggested different management options [17]. Though the use of management options (cultural practice, biological control, or insecticidal application methods) separately is suggested by different researchers, integration of different management options is very essential throughout mango production periods [15, 23, 24]. Cultural control, Mineral oils such as Diver®, CAPL2® and super masrona® and insecticide such as Deltametrine and pyrethrin in Kenya; chloropyrifos, methidathion, Dimethoate 40%EC, Movento, Folimat 500SL, D-C-Tron and Closer insecticides showed different effectiveness in reducing the insect number [10, 15, 25, 26, 27]. However, Insecticides currently in use against WMS (White Mango Scale) in the infested mango orchards in Ethiopia are insecticides recommended for the control of armoured scales such as the red scale (*Aonidiella auranti*) on citrus in the early 1980s [28, 29]. Limited report of experiments performed regarding insecticide screening against WMS (white mango scale) insect pest in Ethiopia. Though the result varies from location to location, integrating cultural practice with insecticide application becomes more effective [27]. Therefore, the objective of this research was to evaluate the effective management of various options through integration methods on WMS at Assosa district in Benshungul-Gumuz Region, Western Ethiopia.

## MATERIAL AND METHODS

### *Description of the experimental site*

Field experiments were conducted at Assosa district in Assosa Administrative Zone, village 5, Benishangule Gumuz Region, Ethiopia (Figure. 1). The specific experimental site lies at 1003'22'' - 1003'16''N latitude and 34033'18'' - 34033'20''E longitude and a mean altitude of 1,554-meter above sea level. The site is located in Assosa Poly Technique college mango orchard which was selected purposively by looking accessible uniform size mango trees, naturally infested by WMS and easy access to road for day to day follow up of the site. It is 687 Km far from Addiss Abeba (Capital city). The average annual rainfall is 900-1200 mm and the annual ambient temperature varies from 21-31°C [30].



**Figure 1.** Location map of the experimental site

### **Experimental materials**

The field experiment was conducted to evaluate the effective management options of eight treatments such as Imidacloprid 20SL, Dimethoate 40% EC, White oil extract, Pruning, Imidacloprid 20 SL + Pruning, Dimethoate 40% EC + Pruning, White oil extract + Pruning and untreated check(control). Imidacloprid 20 SL at a rate of 0.8ml per 1 Liter of water dosage was used for this experiment. Since the price, availability, accessibility, and eco-friendly nature of pest management practice matter, as well as the acceptability/affordability and utilization of the application of the selected treatment by farmers, the researchers have selected the treatment considering these factors.

The procedures followed to apply the selected treatment were different. For instance, when Imidacloprid 20 SL were used, first 5 liters of water filled in the sprayer tank and then 4ml of Imidacloprid 20 SL was added and well-shaked and then sprayed for a single mango tree [29]. Dimethoate 40% EC at a rate of 0.75 ml per 1 Liter of water dosage was used for this experiment. First, 5 Liter of water was filled in the sprayer tank and then 3.75 ml Dimethoate 40% EC was added and well-shaked and then sprayed for a single mango tree [31]. White oil extract was prepared by taking an empty plastic bottle, pure edible oil (Trade name: Sekina) was poured in a 250 ml cup and mixed with 62.5ml of hand dish wash liquid detergent (Trade name: BEKAS Sine) and shaken well finally turned to white. The sprayer tank was first filled by 5 Liter of water and then 10ml from prepared white oil per 1 Liter of water calculated a total of 50ml white oil was added and mixed well and used for a single mango tree for this experiment [32]. Average water requirement used for spray was 5 liters per tree. Pruning was done for 12 randomly selected mango trees by removal of undesirable vegetative parts, crowded branches, insect infested and diseased branches, leaves, and flowers and other plant parts. Small branches were cut first followed by large branches and all debris was removed to clean the surroundings [33].

**Table 1.** Dose and formulation of insecticides

Insecticide	Active ingredient	Dose	Mode of application	Source
Gain 20 SL	Imidacloprid 20 SL	0.8ml / 1 Liter of water	Foliar spray	Chemtrade International
Agro-Thoate 40% EC	Dimethoate 40% (W/V)	0.75 ml / 1 Liter of water	Foliar spray	Chemtrade International
White oil extract	--	10ml / 1 Liter of water	Foliar spray	Home made

### **Treatments, experimental design, and procedures**

Mango trees selected for pruning were treated during August 1-15/2022 before the flower induction and right after harvest before spray and spray was taken place during active stage of mango flowering stage [32]. Mango trees were sprayed three times with the interval of two weeks during December 15/2022, December 30/2022, and January 15/2023 after 11:00 hour using motorized knapsack sprayer and an untreated check were maintained for comparison purposes. In this experiment Dimethoate 40% EC and Imidacloprid 20 SL are systemic insecticides and home-made white oil treatments were arranged separately as well as in combination with pruning cultural control method as a management tactics.

The experimental was arranged in Randomised Complete Block Design (RCBD) with three replications. The treatments were eight and three mango trees per treatments were used as three replications in each treatment. A total number of 24 mango trees were used in this experiment. Uniform size, same age (16 years old age) and cultivar mango trees (Kent) were selected for experimental unit. Drift problem was protected by using breaker of a plastic cover of the neighbouring mango trees canopy during spraying. The control was wetted three times with sterile water to avoid moisture difference between treatments. All agronomic practices were kept the same among the treatments during experimental period.

**Table 2.** Treatment types for the experiment

Treatment Code	Treatment Application Rate
(T1)	Imidacloprid 20SL@4ml/5 Liter water
(T2)	Dimethoate 40% EC@3.75ml/5 Liter water
(T3)	White oil extract @50ml 1/5Liter water
(T4)	Pruning
(T5)	Imidacloprid 20SL@4ml/5Liter water + Pruning
(T6)	Dimethoate 40% EC @3.75ml/5 Liter water + Pruning
(T7)	White oil extract @50ml 1/5 Liter water + Pruning
(T8)	Untreated Control @ 5 Liter water

### **Data collection for the experiment**

Experimental data from the treated and untreated control were collected randomly three from lower, four from middle and three from top of canopy a total of ten sample leaves and 30 sample leaves from each treatment. The mean number of WMS population (sum of live nymph and adult) per 10 leaves before and after the treatments application were taken as the data [15, 27]. Mean number of WMS population per 10 leaves prior to treatment application and Mean number of insects from post treatment was used to assess efficacy of the suggested management option.

The average mango fruit number and yield in Kilo gram per tree per treatment was determined during March and April at harvest. During each sampling time the marketable quality of the fruits was subjectively assessed and judged using a 1-9 rating scale with 1=unusable, 3=unsalable (poor), 5=fair, 7=good, 9=excellent to evaluate the fruit quality. The size, color, firmness surface defects, sign of pest and shrinkage were used as visual

parameters for the rating. Fruits that received a rating of five and above were considered marketable while those rated less than five were considered unmarketable [34].

### **Data analysis**

Mean number of live nymph and adult of WMS per ten leaves per tree per treatment were taken and subjected to analysis. The treatment effect on WMS population and mortality were analysed using a general linear model (PROC GLM). Count data of WMS was subjected to square root transformation ( $\sqrt{X}$ ) and mortality percentages data was subjected to arcsine/angular transformation before analysis to stabilize the variance. Homogeneity variance of the sample was tested using Levene’s test before and after data transformation ( $p > .05$ ) [35, 36]. The data were reported in the text using the back transformed values. The percent reduction in the WMS population over the control was calculated after each treatment using Abbott’s [35] formula of mortality correction as Eqn 1.

$$\text{Mortality correction} = \left( 1 - \frac{n \text{ in T after treatment}}{n \text{ in Co after treatment}} \right) * 100$$

**Eqn. 1**

Where n in T = Population in the treated plot after treatment; n in Co = Population in control after treatment

The treatment effect on average fruit number and yield in Kilo gram per tree per treatment were taken and subjected to analysis by using the methods described by Gomez and Gomez [35] using a general linear model (PROC GLM). Whenever the F-test was significant, significant means were separated by Fisher’s Least Significant Difference (LSD) at 5% or 1% error level. For two group means t-test was used for comparison using PROC TTEST at 5% or 1% error level [35, 36]. Microsoft Excel was used for data summary.

### **Cost-benefit analysis**

Cost-benefit analysis using partial budget analysis was subjected to agricultural business CIMMYT [37]. Marginal analysis as used within this context is a procedure for calculating marginal rates of return between treatments, proceeding in a stepwise manner from a lower-cost treatment to the next higher-cost treatments, and comparing marginal rates of return to acceptable minimum rates of return. The minimum acceptable rate of return without asking producers what they considered to be a reasonable rate of return, researchers noted that experience and empirical evidence suggest that a rate between 50% and 100% seems adequate. If the technology is new and requires learning new skills, then the upper-bound should be used. In cases where switching technologies simply represents an adjustment, then the lower-bound may be acceptable. An alternative approach to estimating the minimum rate of return is to double the rate of interest charged by the lending institution. In this context as the experiment was new for the recommendation domain, the upper bound 100% was used as minimum rate of return for selecting profitable treatments.

The marginal rate of return was computed as the marginal net benefit (i.e. the change in net benefits) divided by the marginal cost (i.e. the change in costs), expressed as a percentage as Eqn. 2.

$$\text{MRR} = \frac{\text{DNI}}{\text{DIC}}$$

**Eqn. 2**

The “net benefits” of different treatments were determined by first calculating the “gross field benefit” and the “total costs that vary” in switching treatments. The gross field benefit for each treatment was obtained by multiplying the “adjusted yield” by the farm gate price. The adjusted yield was represented by a fraction of 0.9 of the average marketable yield which obtained under an experimental condition. The farm gate price used in the analysis was the price that the producer receives less any harvesting and marketing costs. The price of mango fruits was based on the average farm gate price of fruit between March and April, obtained from personal communication with mango fruit producers around Assosa main market and ‘*Gulit*’ (small market) which were the nearest market to the experiment site. The total costs that vary for each treatment was computed as the sum of only those costs that were expected to change by using another treatment. The net benefit for a given treatment was then obtained by subtracting the total cost from the gross field benefit. The dominance analysis was done by sorting the treatment sum on the basis of costs from the lowest to the highest, together with their respective net benefit. The conclusion of a marginal analysis was also checked by using the concept of “residual” which was calculated by subtracting the return that farmers require (the minimum rate of return multiplied by the total costs that vary) from the net benefits.

## RESULTS

### *Effects of treatments on the White Mango Scales(WMS) population*

The pre treatment observation on WMS population 333.33(18.23) to 370 (19.22) per ten leaves per tree, which was statistically insignificant which indicated uniform distribution of the pest among different treatments. The observations were recorded on WMS population with 14th day’s interval of post first, post second and post third spray application (Table 3).

The data revealed that after first spray mean WMS population ranged from 141.33(11.88) to 407 (20.16) per ten leaves per tree in different treatments were highly significantly different ( $F=244$ ,  $p < .01$ ). The lowest WMS population were observed in Imidacloprid 20SL+pruning treatment 141.33 (11.88) compared to other treatments (Figure 2). The comparative WMS population among treatments against WMS at fourteenth day after first spraying found in descending order were untreated Control 407 (20.16), Pruning 285.33 (16.86), White oil extract 267.67 (16.35), Dimethoate 40% EC 261.33(16.14), Imidacloprid 20 SL 252.67 (15.84), White oil extract+ Pruning 251 (15.8), Dimethoate 40% EC + Pruning 222.67 (14.89) and Imidacloprid 20 SL+Pruning 141.33 (11.88) respectively. All the treatments were significantly different from untreated control. White oil extract + Pruning 251 (15.8) and Imidacloprid 20 SL 252.67 (15.84) which were found to be at par with each other. White oil extract 267.67 (16.35) and Dimethoate 40% EC 261.33(16.14) which were found to be at par with each other (Table 3).

The result findings revealed that after second spray the mean WMS population ranged from 89.33 (9.44) to 447.67(21.14) per ten leaves per tree in different treatment were highly significantly different ( $F= 68.62$ ,  $p < 0.01$ ). The lowest WMS population was observed in Imidacloprid 20 SL + Pruning treatment 89.33 (9.44) compared to other treatments. The comparative WMS population among treatments at fourteenth day after second spraying found in descending order were Control 447.67 (21.14), Pruning 234 (15.24), White oil extract 224 (14.93), Dimethoate 40% EC 184.33 (13.52), Imidacloprid 20 SL 163 (12.63), White oil extract + Pruning 161.33 (12.58), Dimethoate 40% EC + Pruning 138.67 (11.68) and Imidacloprid 20SL+ Pruning 89.33 (9.44) respectively. All the treatments were significantly different from untreated control. Pruning 234 (15.24) and White oil extract 224 (14.93) which were found to be at par with each other. Imidacloprid 20 SL 163 (12.63) and

White oil extract + Pruning 161.33 (12.58) which were found to be at par with each other (Table 3).



**Figure 2.** Effect of application of treatments on white mango scale A) Untreated Control B) Imidacloprid 20 SL+ Pruning

The result findings revealed that after third spray mean WMS population ranged from 24 (4.87) to 492.67 (22.18) per ten leaves per tree in different treatment were highly significantly different ( $F = 90.81, p < .01$ ). The lowest WMS population were observed in Imidacloprid 20SL + Pruning treatment 24 (4.87) compared to other treatments. The comparative WMS population among treatments at fourteenth day after third spraying found in descending order were Control 492.67 (22.18), Pruning 187.33 (13.52), White oil extract 165.67 (12.77), Dimethoate 40% EC 92(9.44), Imidacloprid 20SL 74 (8.46), White oil extract + Pruning 78.67 (8.74), Dimethoate 40% EC + Pruning 66.33 (8.013) and Imidacloprid 20 SL + Pruning 24 (4.87) respectively. All the treatments were significantly different from untreated control. Pruning 187.33 (13.52) and White oil 165.67 (12.77) which were found to be at par with each other. Dimethoate 40% EC 92 (9.44), Imidacloprid 20 SL 74 (8.46) and White oil extract + Pruning 78.67 (8.74) which were found to be at par with each other (Table 3).

The mean of the third spray data revealed that the mean WMS population ranged from 85 (9.21) to 449.33(21.18) per ten leaves per tree in different treatment were highly significantly different ( $F = 98.63, p < .01$ ). The lowest WMS population were observed in Imidacloprid 20 SL + Pruning treatment 85 (9.21) compared to other treatments. The comparative WMS population among treatments against WMS found in descending order were Control 449.33 (21.8), Pruning 235.67 (15.28), White oil extract 219.33 (14.78), Dimethoate 40% EC 179.33 (13.34), Imidacloprid 20SL 163.33(12.69), White oil extract + Pruning 163.67 (12.72), Dimethoate 40% EC + Pruning 142.67 (11.89) and Imidacloprid 20 SL+ Pruning 85 (9.21) respectively. All the treatments were significantly different from untreated control. Pruning

235.67 (15.28) and White oil extract 219.33 (14.78) which were found to be at par with each other. Imidacloprid 20 SL 163.33 (12.69) and White oil extract + Pruning 163.67 (12.72) which were found to be at par with each other (Table 3).

**Table 3.** Mean number of white mango scales in the experimental mango orchards

Treatment	Mean				
	PrT	PFS	PSS	PTS	MS
Control	370(19.22)	407(20.16)a	447.67(21.14)a	492.67(22.18)a	449.33(21.18)a
Pruning	348.33(18.64)	285.33(16.86) <sup>b</sup>	234(15.24) <sup>b</sup>	187.33(13.52) <sup>b</sup>	235.67(15.28) <sup>b</sup>
White oil extract	355(18.84)	267.67(16.35) <sup>bc</sup>	224(14.93) <sup>b</sup>	165.67(12.77) <sup>b</sup>	219.33(14.78) <sup>b</sup>
Dimethoate	333.33(18.23)	261.33(16.14) <sup>bc</sup>	184.33(13.52) <sup>c</sup>	92(9.44) <sup>c</sup>	179.33(13.34) <sup>c</sup>
Imidacloprid	340(18.41)	252.67(15.84) <sup>c</sup>	163(12.63) <sup>cd</sup>	74(8.46) <sup>c</sup>	163.33(12.69) <sup>cd</sup>
White oil + Pruning	358.33(18.9)	251(15.8) <sup>c</sup>	161.33(12.58) <sup>cd</sup>	78.67(8.74) <sup>c</sup>	163.67(12.72) <sup>cd</sup>
Dimethoate+ Pruning	351.67(18.72)	222.67(14.89) <sup>d</sup>	138.67(11.68) <sup>d</sup>	66.33(8.013) <sup>cd</sup>	142.67(11.89) <sup>d</sup>
Imidacloprid + Pruning	353.33(18.78)	141.33(11.88) <sup>e</sup>	89.33(9.44) <sup>e</sup>	24(4.87) <sup>d</sup>	85(9.21) <sup>e</sup>
Mean	351.3(18.7)	261.1(15.99)	205.3(13.9)	147.6(10.99)	204.8(13.89)
SE <sub>m</sub>	4.4(0.11)	5.8(0.17)	6.8(0.25)	9.2(0.34)	6.4(0.21)
LSD	21.8(059)	28.7(0.85)	33.46(1.27)	45.44(1.68)	31.77(1.064)
CV%	3.53(1.79)	6.28(3.044)	9.31(5.199)	17.58(8.72)	8.86(4.37)
Sign. Difference	Ns	**	**	**	**

Values given in parenthesis are square root transformed values; Values in each column of the same letter are not significantly different; SE<sub>m</sub>=Standard error of mean; LSD=Least Significant Difference; CV=Coefficient of Variation;\* significant at P < .05; \*\* significant at .01; ns=Non \_significant; PrT=Pre\_Treatment WMS count/10 leaves, PFS=Post First Spray WMS count/10 leaves, PSS=Post Second Spray WMS count/10 leaves, PTS=Post Third Spray WMS count/10 leaves, MS=mean WMS count/10 leaves after all spray

### Effects of treatments on white mango scales mortality

The WMS mortality percentage over untreated check was worked out after each treatment using Abbott's [32] formula of mortality correction (Table 4). The mortality percentage of WMS fourteen days after the first application was highly significantly different among treatments (F = 136, p <0.01). The highest mortality percentage was observed in Imidacloprid 20SL+ Pruning treatment 65 (53.73) compared to other treatments. The comparative mortality percentage among treatments in descending order were Imidacloprid 20 SL + Pruning 65 (53.73), Dimethoate 40% EC + Pruning 45.33 (42.27), White oil extract + Pruning 38.67 (38.42), Imidacloprid 20 SL 38.33 (38.18), Dimethoate 40% EC 36 (36.9), White oil extract 34 (35.5), Pruning 30.33 (33.3) and Control 0 (0.33) respectively. All the treatments were significantly different from untreated control. Dimethoate 40% EC + Pruning 45.33 (42.27) and White oil extract + Pruning 38.67 (38.42) which was found to be at par with each other. Dimethoate 40 EC 36 (36.9) and White oil extract 34 (35.5) which were found to be at par with each other.

The mortality percentage of WMS fourteen \_days after the second application were highly significantly different among treatments (F= 167, p < .01). The highest mortality percentage was observed in Imidacloprid 20 SL + Pruning treatment 80 (63.44) compared to other treatments. The comparative mortality percentage among treatments in descending order were Imidacloprid 20 SL + Pruning 80 (63.44), Dimethoate 40% EC+ Pruning 69 (56.3), Imidacloprid 20 SL 64 (53.1), White oil extract + Pruning 64 (53.3), Dimethoate 40% EC 59 (50.2), White oil extract 50 (45.0), Pruning 47.67 (43.7) and Control 0 (0.33) respectively. All the treatments were significantly different from untreated control. Imidacloprid 20 SL 64 (53.1) and White oil extract + Pruning 64 (53.3) which were found to be at par with each other. White oil extract 50 (45.0) and Pruning 47.67 (43.7) which were found to be at par with each other.

The mortality percentage of WMS fourteen \_days after the third application were highly significantly different among treatments (F= 168.1, p < .01). The highest mortality percentage was observed in Imidacloprid 20 SL + Pruning treatment 95 (77.12) compared to

other treatments. The comparative mortality percentage among treatments in descending order were Imidacloprid 20SL + Pruning 95 (77.12), Dimethoate 40% EC + pruning 87 (69.1), Imidacloprid 20 SL 85.33(67.7), White oil + Pruning 84.67 (67.1), Dimethoate 40% EC 81.67 (64.9), White oil extract 66 (54.5), Pruning 62.33 (52.4) and Control 0 (0.33) respectively. All the treatments were significantly different from untreated control. Dimethoate 40% EC + Pruning 87 (69.1), Imidacloprid 20 SL 85.33 (67.7), White oil extract + Pruning 84.67 (67.1) and Dimethoate 40% EC 81.67 (64.9) which were found to be at par with each other. White oil extract 66 (54.5) and Pruning 62.33 (52.4) which were found to be at par with each other.

Mortality percentages of WMS showed a progressive increase from first spray to third spray application for all treatments compared to untreated control. The progressive increase of mortality percentage of each treatments Imidacloprid 20 SL + Pruning, Dimethoate 40% EC + Pruning, Imidacloprid 20 SL, White oil extract + Pruning, Dimethoate 40% EC, White oil extract and Pruning were 65 to 95, 45.33 to 87, 38.33 to 85.33, 38.67 to 84.67, 36 to 81.67, 34 to 66 and 30.33 to 62.33 respectively.

**Table 4.** Mortality percentage of white mango scales in response of treatments in the experimental mango orchards

Treatment	Mean		
	First spray mortality %	Second spray mortality %	Third spray mortality %
Imidacloprid + Pruning	65(53.73) <sup>a</sup>	80(63.44) <sup>a</sup>	95(77.12) <sup>a</sup>
Dimethoate + Pruning	45.33(42.27) <sup>b</sup>	69(56.3) <sup>b</sup>	87(69.1) <sup>b</sup>
Imidacloprid	38.33(38.18) <sup>c</sup>	64(53.1) <sup>bc</sup>	85.33(67.7) <sup>b</sup>
White oil +Pruning	38.67(38.42) <sup>b</sup>	64(53.3) <sup>bc</sup>	84.67(67.1) <sup>b</sup>
Dimethoate	36 (36.9) <sup>cd</sup>	59(50.2) <sup>c</sup>	81.67(64.9) <sup>b</sup>
White oil	34(35.5) <sup>cd</sup>	50(45.0) <sup>d</sup>	66(54.5) <sup>c</sup>
Pruning	30.33(33.3) <sup>d</sup>	47.67(43.7) <sup>d</sup>	62.33(52.4) <sup>c</sup>
Control	0(0.33) <sup>e</sup>	0(0.33) <sup>e</sup>	0(0.33) <sup>d</sup>
Mean	35.97(34.8)	54.22(45.7)	70.3(56.6)
SE <sub>m</sub>	1.3(0.8)	1.5(0.9)	1.9(1.14)
LSD	6.49(3.97)	7.34(4.5)	9.24(5.6)
CV%	10.31(6.5)	7.73(5.7)	7.51(5.7)
Sign.difference	**	**	**

Values given in parenthesis are angular transformed value; Values in each column of the same letter are not significantly different; SE<sub>m</sub>=Standard error of mean; LSD=Least Significant Difference; CV=Coefficient of Variation;\* significant at P < .05; \*\* significant at .01; ns=Non\_significant

**Effects of treatments on mango fruit number and yield (kg/tree)**

The mean marketable fruit number ranged from 43.33 to 262 per tree in different treatments were highly significantly different (F = 23.68, p < .01). The lowest marketable fruit number was untreated check (43.33) compared to other treatments. The comparative marketable fruit number among treatments found in descending order were Imidacloprid 20 SL + Pruning (262), Dimethoate 40% EC + Pruning (170.67), Imidacloprid 20 SL (145.33), White oil extract + Pruning (142.33), Dimethoate 40% EC (137.33), White oil extract (115.67), Pruning (112), Untreated control (43.33), respectively. Imidacloprid 20 SL (145.33), White oil extract + Pruning (142.33) and Dimethoate 40% EC (137.33) which were found to be at par with each other. White oil extract (115.67) and Pruning (112) which were found to be at par with each other. The mean unmarketable fruit number ranged from 83.33 to

176.67 per tree in different treatments were highly significantly different ( $F= 6.46, p < .01$ ). The lowest unmarketable fruit number was Imidacloprid 20 SL + Pruning treated 83.33 compared to other treatments. The comparative marketable fruit number among treatments found in descending order were untreated control (176.67), Pruning (154.67), White oil extract (147), White oil extract + Pruning (144.67), Dimethoate 40% EC (132.67), Dimethoate 40% EC+Pruning (130), Imidacloprid 20 SL (122.33), and Imidacloprid 20 SL+Pruning (83.33) respectively. Pruning (154.67), White oil extract (147) and White oil extract + Pruning (144.67) which were found to be at par with each other. Dimethoate 40% EC (132.67), Dimethoate 40% EC + Pruning (130) and Imidacloprid 20 SL (122.33) which were found to be at par with each other. The mean total fruit number ranged from 345.33 to 220 per tree in different treatments were significantly different ( $F= 3.66, p < 0.05$ ). The lowest total fruit number was untreated control 220 compared to other treatments. The comparative total fruit number among treatments found in descending order were Imidacloprid 20SL + Pruning (345.33), Dimethoate 40% EC + Pruning (300.67), White oil extract + Pruning (287), Dimethoate 40% EC (270), Imidacloprid 20 SL (267.67), Pruning (266.67), White oil extract (262.67) and Untreated control (220) respectively. Dimethoate 40% EC (270), Imidacloprid 20 SL (267.67), Pruning (266.67) and White oil extract (262.67) which were found to be at par with each other (Table 5).

The mean marketable fruit yield ranged from 10.83 to 65.5 per tree in different treatments were significantly different ( $F = 23.68, p < .01$ ). The lowest marketable fruit yield was untreated control (10.83) compared to other treatments. The comparative marketable fruit yield among treatments found in descending order were Imidacloprid 20 SL + Pruning (65.5), Dimethoate 40% EC + Pruning (42.67), Imidacloprid 20 SL (36.33), White oil extract + Pruning (35.58), Dimethoate 40% EC (34.33), White oil extract (28.92), Pruning (28), Untreated control (10.83) respectively. Imidacloprid 20 SL (36.33), White oil extract + Pruning (35.58) and Dimethoate 40% EC (34.33) which were found to be at par with each other. White oil extract (28.92) and Pruning (28) which were found to be at par with each other. The mean unmarketable fruit yield ranged from 20.83 to 44.17 per tree in different treatments were significantly different ( $F = 6.46, p < 0.01$ ). The lowest unmarketable fruit yield was Imidacloprid 20 SL + Pruning treated (20.83) compared to other treatments. The comparative unmarketable fruit yield among treatments found in descending order were untreated control (44.17), Pruning (38.67), White oil extract (36.75), White oil extract + Pruning (36.17), Dimethoate 40% EC (33.17), Dimethoate 40% EC + Pruning (32.5), Imidacloprid 20 SL (30.58), and Imidacloprid 20 SL + Pruning (20.83) respectively. Pruning (38.67), White oil extract (36.75) and White oil extract + Pruning (36.17) which were found to be at par with each other. Dimethoate 40% EC (33.17), Dimethoate 40% EC + Pruning (32.5) and Imidacloprid 20 SL (30.58) which were found to be at par with each other. The average total fruit yield ranged from 55 to 86.33 per tree in different treatments were significantly different ( $F = 3.66, p < 0.05$ ). The lowest total fruit yield was untreated control 55 compared to other treatments. The comparative total fruit yield among treatments found in descending order were Imidacloprid 20 SL + Pruning (86.33), Dimethoate 40% EC + Pruning (75.17), White oil extract + Pruning (71.75), Dimethoate 40% EC (67.5), Imidacloprid 20 SL (66.92), Pruning (66.67), White oil extract (65.67) and Untreated control (55) respectively. Dimethoate 40% EC (67.5), Imidacloprid 20 SL (66.92), Pruning (66.67) and White oil extract (65.67) which were found to be at par with each other (Table 5).

**Table 5.** Mean number of mango fruit and yield per tree in response of treatments in experimental mango orchards

Treatment	Fruit mean (Number/per tree)			Fruit Yield mean (kg/tree)		
	Marketable	Unmarketable	Total	Marketable	Unmarketable	Total
Imidacloprid + Pruning	262 <sup>a</sup>	83.33 <sup>c</sup>	345.33 <sup>a</sup>	65.5 <sup>a</sup>	20.83 <sup>c</sup>	86.33 <sup>a</sup>
Dimethoate+ Pruning	170.67 <sup>b</sup>	130 <sup>b</sup>	300.67 <sup>ab</sup>	42.67 <sup>b</sup>	32.5 <sup>b</sup>	75.17 <sup>ab</sup>
Imidacloprid	145.33 <sup>bc</sup>	122.33 <sup>b</sup>	267.67 <sup>bc</sup>	36.33 <sup>bc</sup>	30.58 <sup>b</sup>	66.92 <sup>bc</sup>
White oil + Pruning	142.33 <sup>bc</sup>	144.67 <sup>ab</sup>	287 <sup>b</sup>	35.58 <sup>bc</sup>	36.17 <sup>ab</sup>	71.75 <sup>b</sup>
Dimethoate	137.33 <sup>bc</sup>	132.67 <sup>b</sup>	270 <sup>bc</sup>	34.33 <sup>bc</sup>	33.17 <sup>b</sup>	67.5 <sup>bc</sup>
White oil	115.67 <sup>c</sup>	147 <sup>ab</sup>	262.67 <sup>bc</sup>	28.92 <sup>c</sup>	36.75 <sup>ab</sup>	65.67 <sup>bc</sup>
Pruning	112 <sup>c</sup>	154.67 <sup>ab</sup>	266.67 <sup>bc</sup>	28 <sup>c</sup>	38.67 <sup>ab</sup>	66.67 <sup>bc</sup>
Control	43.33 <sup>d</sup>	176.67 <sup>a</sup>	220 <sup>c</sup>	10.83 <sup>d</sup>	44.17 <sup>a</sup>	55 <sup>c</sup>
Mean	141.1	136.4	277.5	35.3	34.1	69.4
SEm	7.8	6.6	11.5	1.9	1.9	2.7
LSD	38.41	32.54	56.91	9.6	8.13	14.23
CV%	15.54	13.62	11.71	15.54	13.62	11.71
Sign. Difference	**	**	*	**	**	*

Values in each column of the same letter are not significantly different; SE<sub>m</sub>=Standard error of the mean; LSD=Least Significant Difference; CV=Coefficient of Variation; \* significant at P < .05; \*\* significant at .01; ns=Non\_significant

### Cost benefit analysis

Partial budget analysis for white mango scale management experiment: Table 6 illustrates the partial budget analysis of treatments. ETB18/Kg was used as farm gate price (1 USD=50 ETB). Adjusted yield, total costs that vary and net benefit was done for each treatment.

**Table 6.** Partial budget analysis for white mango scale management experiment

Item	Treatments							
	Control	Pruning	White oil extract	Dimethoate 40% EC	White oil + Pruning	Imidacloprid 20 SL	Dimethoate 40%EC + Pruning	Imidacloprid 20SL + Pruning
Average yield (kg/tree)	10.83	28	28.92	34.33	35.58	36.33	42.67	65.5
Adjusted yield (kg/tree)	9.747	25.2	26.028	30.897	32.022	32.697	38.403	58.95
Gross field benefits (ETB/tree)	175.446	453.6	468.50	556.146	576.396	588.546	691.254	1061.1
cost of insecticide (ETB/tree)	0	0	0	3.94	0	9.36	3.94	9.36
cost of white oil (ETB/tree)	0	0	10.3	--	10.3	0	0	0
Cost of labor to apply insecticide (ETB/tree)	0	0	0	90	0	90	90	90
Cost of sprayer rental (ETB/tree)	0	0	40	60	40	60	60	60
Cost of labor to apply white oil (ETB/tree)	0	0	30	0	30	0	0	0
Cost of labor for pruning (ETB/tree)	0	75	0	0	75	0	75	75
Total costs that vary (ETB/tree)	0	75	80.3	153.94	155.3	159.36	228.94	234.36
Net benefits (ETB/tree)	175.446	378.6	388.20	402.206	421.096	429.186	462.314	826.74

The dominance analysis for white mango scale management experiment as illustrated in Table 7:- In moving from the lowest to the highest, there were no ‘dominated’ treatments obtained which costs more than the previous. Therefore all treatments were taken in to MRR analysis.

Marginal analysis for WMS management experiment between treatments as illustrated in Table 7. The MRR by switching from untreated control to pruning treatment was 270.87%, well above the minimum. Hence, a 270.87% MRR in switching from untreated control to pruning treatment implied that for each ETB invested in the new treatment, the producer can expect to recover the 1ETB invested plus an additional return of 2.7087 ETB. Therefore pruning was certainly a worthwhile alternative to the untreated control.

The MRR by switching from pruning to white oil extract treatment the marginal rate of return was 181.21%, also well above the minimum. Hence, a 181.21% MRR in switching from pruning to white oil treatment implied that for each ETB invested in the new treatment, the producer can expect to recover the 1ETB invested plus an additional return of 1.8121ETB, and therefore white oil was certainly a worthwhile alternative to pruning management option.

The MRR by switching from white oil to Dimethoate 40% EC treatment the was 19.014%, and below the minimum. Hence, a 19.014% MRR in switching from pruning to white oil treatment implied that for each ETB invested in the new treatment, the producer can expect to recover the 1ETB invested plus an additional return of 0.19014 ETB which was less than white oil treatment. Therefore Dimethoate 40% EC treatment had had been eliminated from consideration.

The MRR by switching from Dimethoate 40% EC to white oil + Pruning treatment was 1388.97% and above the minimum rate of return which seems profitable. However the MRR by switching from white oil to white oil + Pruning was 43.86%, below the minimum. Hence, a 43.86% MRR in switching from white oil to white oil + Pruning implied that for each ETB invested in the new treatment, the producer can expect to recover the 1ETB invested plus an additional return of 0.4386 ETB which was less than White oil treatment. Therefore White oil + Pruning had had been eliminated from consideration.

The MRR by switching from White oil + Pruning to Imidacloprid 20 SL treatment there was 199.26%, well above the minimum, which seems profitable however the MRR by switching from white oil to Imidacloprid 20 SL treatment was 51.85%, below the minimum. Hence, a 51.85% MRR in switching from white oil to Imidacloprid 20 SL treatment implied that for each ETB invested in the new treatment, the producer can expect to recover the 1 ETB invested plus an additional return of 0.5185 ETB which was less than white oil treatment. Therefore Imidacloprid 20 SL treatment had had been eliminated from consideration.

The MRR by switching from Imidacloprid 20 SL treatment to Dimethoate 40% EC + pruning was 47.61%, below the minimum and also by switching from white oil to Dimethoate 40% EC + pruning the MRR was 49.85, below the minimum. Hence, a 49.85% MRR in switching from white oil to Dimethoate 40% EC + Pruning treatment implied that for each ETB invested in the new treatment, the producer can expect to recover the 1ETB invested plus an additional return of 0.4985 ETB which was less than white oil treatment. Therefore Dimethoate 40% EC + pruning treatment had had been eliminated from consideration.

The MRR by switching from Dimethoat 40% EC e + pruning to Imidacloprid 20 SL+ pruning treatment was 6723.72%, well above the minimum which seems unrealistic since which was seen from not profitable treatment. But by switching from white oil to Imidacloprid 20 SL + pruning treatment the MRR was 284.65%, also well above the minimum. Hence, a 284.65%, MRR in switching from white oil to Imidacloprid

20SL+pruning treatment implies that for each ETB invested in the new treatment, the producer can expect to recover the 1ETB invested plus an additional return of 2.8465ETB which was greater than white oil treatment. Therefore Imidacloprid 20 SL + pruning treatment was certainly a worthwhile alternative to all management option. Therefore white oil and pruning should be considered as second and third alternative to producers.

Researchers should continue to experiment white oil, pruning and Imidacloprid 20SL + pruning treatment which seems to be a promising alternative to producers white mango scale management. Dimethoate 40% EC, White oil + Pruning, Imidacloprid 20 SL and Dimethoate 40% EC + pruning treatments gave higher marketable yield and statistically significant different from pruning and white oil treatment but their costs were such that they did not provide an acceptable rate of return. However Imidacloprid 20 SL + pruning treatment costs higher compared with all other treatment but gave higher yield and acceptable rate of return.

Residual analysis of treatments for white mango scale management experiment as illustrated in Table 7 illustrates: - The treatments were arranged in order from lowest to highest total costs that vary. Since producers will be interested in the treatment with the highest residual. The treatment with highest residual was Imidacloprid 20 SL + pruning treatment and the second and third highest residual were white oil and pruning respectively which was the same conclusion reached in the previous MRR analysis.

**Table 7: Dominance analysis, Marginal analysis, Residual analysis for white mango scale management experiment**

Treatment	Dominance analysis for white mango scale management experiment		Marginal analysis for white mango scale management experiment	Residual analysis for white mango scale management experiment	
	1	2	Marginal of return (MRR)%	3	4
	Total costs that vary (ETB/tree)	Net benefits (ETB/tree)		Return required [100%*(1)] ETB/tree	Residual [(2)-(3)] ETB/tree
Untreated Check	0	175.446	270.87	0	175.446
Pruning	75	378.6	181.21	75	303.6 <sup>c</sup>
White oil extract	80.3	388.2	19.01	80.3	307.904 <sup>b</sup>
Dimethoate 40% EC	153.94	402.206	1388.90	153.94	248.266
White oil extract + pruning	155.3	421.096	199.26	155.3	265.796
Imidacloprid 20SL	159.36	429.186	51.9	159.36	269.826
Dimethoate 40% EC + pruning	228.94	462.314	6723.70	228.94	233.374
Imidacloprid 20SL+ pruning	234.36	826.74	284.6	234.36	592.38 <sup>a</sup>

a /The first Maximum residual    b /The second Maximum residual    c /The third Maximum residual

## DISCUSSION

White mango scale is a sucking and hard scale which secrete tough waxy protective covering coat attached to the plant surface while the insect is free within the cover [38, 39, 40]. This insect pest reproduces during both dry and wet seasons and produce five to six generations per year, at a maximum day time temperature of 26°C and night time minimum temperature of 13°C and also overlapping generations throughout the year and reached peak population during the flowering time of spring and harvesting period in western Wellega area [17, 41, 42].

Different literatures and research experience indicated that management of white mango scale using applaud, white oil extract, mineral oils such as Diver®, CAPL2® and super masrona®, insecticide such as Deltametrine and pyrethrin in Kenya, chloropyrifos, methidathion, Dimethoate 40% EC, Movento, Folimat 500SL, D-C-Tron and Closer insecticides showed different effectiveness in reducing the insect number [10, 15, 17, 25, 26, 27]. However, since its introduction in Ethiopia in the last two decades, the literature and recommendations were limited literature and recommendation for the white mango scale management. Therefore, this experiment was used different management options such as systemic insecticide, white oil extract and pruning each separately and systemic insecticide and white oil extract each in combination with pruning as management tactics. All the management tactics were highly significant effectiveness as compared with untreated check.

However, the treatments were showed different effectiveness in decreasing population number of white mango scale causing mortality percentage and increasing mango fruits yields. The treatments against white mango scale population found in descending order were (Pruning at par with White oil extract) > (Dimethoate 40% EC) > (Imidacloprid 20 SL at par with White oil extract + Pruning) > (Dimethoate 40% EC + Pruning) > (Imidacloprid 20 SL + Pruning) respectively. The treatments against mortality percentage found in descending order were (Imidacloprid 20 SL + Pruning) > (Dimethoate 40% EC + Pruning), (Imidacloprid 20 SL), (White oil + Pruning and Dimethoate 40% EC at par with each other) > (White oil extract at par with Pruning) respectively. Fruit number and yield among treatments found in descending order were (Imidacloprid 20 SL + Pruning) > (Dimethoate 40% EC + Pruning) > (White oil extract + Pruning) > (Dimethoate 40% EC, Imidacloprid 20 SL, Pruning, White oil extract at par with each) other respectively.

Management of white mango scale using pruning was one of the method of pest management on mango trees by removal of undesirable vegetative parts, crowded branches, insect-infested and diseased branches, leaves, flowers and other plant parts [32]. Therefore the mango trees were pruned during the vegetative stage soon after mango fruits harvest. The white mango scale was relatively decreased its population and increased its mortality than untreated control during 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> count, respectively. Therefore the management using pruning helps free sunlight penetration in the mango canopy which forces white mango scale population to the lower canopy and under shade area and some might be killed by the direct sunlight which helps to decrease the infestation status. Integrated management tactics using white oil extract, Imidacloprid 20 SL and dimethoate 40% EC each with pruning operation were increased the effectiveness of white mango scale control since pruning increased the penetration for the spray. Post-harvest pruning was an effective control measure and also helps the penetration of chemical sprays through the tree canopy [43]. In addition pruning was significantly reduced the number of females per leaf [44]; and also reported that pruning used as cultural management for obtaining quality yield by reducing incidence of pests and disease occurs due to high relative humidity [45].

Pruning decreased mango fruits number during the first year soon after pruning which kept increasing in the successive years [46]. However, in this experiment as the pre-treatment data showed that white mango scale natural infestation was not significantly different infestation status which implied comparatively similar dead leaf, twigs and branches which was unproductive and used for harbouring the pest which in turn contribute infestation of the newly emerged leaf. Therefore avoiding of such dead tree parts which was not initially used for fruit baring did not affect the yield obtained per tree rather than these tree parts used for harbouring the pest as shelter for further infestation while the newly emerged leaf. So in this case the yield was compensated comparatively with other unpruned treatments.

Management of white mango scale using white oil extract was significantly effective compared with untreated control. White oil extract was prepared by taking an empty plastic bottle, pure edible oil (Trade name: Sekina) was poured in a 250ml cup and mixed with 62.5ml of hand dish wash liquid detergent (Trade name: BEKAS Sine) and shaken well finally turned to white. White oil extract of 50 ml per 5-liter water mixed well and used for a single mango tree for this experiment [32]. Since the white oil extract was used for suffocating and dried out the white mango scale results a decreased population. Different literature indicated that white oil extract used for white mango scale management. Assosa Agricultural research institute recommended white oil extract for control of white mango scale [17]. In addition Author [47]. supports to use such type of botanical control due to biodegradable nature, systemicity after application, capacity to alter the behaviour of target pests and favourable safety profile [46]. Management of white mango scale using pruning and white oil extract at par with each other and effective compared with untreated control but less effective compared with white oil extract with pruning management tactics.

In this experiment, Imidacloprid 20 SL was used for the management of white mango scale. Experiments conducted on mango varieties, Alphanso and Bangampalli showed that imidacloprid recommendation dosage between 0.2 to 0.8 ml/liter was found effective [48]. Therefore for this experiment 0.8ml of Imidacloprid 20 SL per 1-liter of water dose at rate of 4ml per 5 liters of water was sprayed for a single mango tree. Mango white scale insect decrease highly significant in population and increase in mortality percentage while using Imidacloprid 20 SL as compared with pruning and white oil extract. The effect of Imidacloprid 20 SL with pruning operation was highly significant effectiveness compared with all other treatments. Various authors reported that Imidacloprid is a new class of insecticide and its potency against sucking insect in different countries of the world [49, 50]. Other studies also stated that imidacloprid is comparatively safer than other conventional insecticides and once it is applied, the action continued for a longer period [51, 52]. On the other hand, the action of imidacloprid persisted at least up to day 10 which raises the possibility that once it enters into the plant system, the imidacloprid remains comparatively for a longer period of time and also supports as this imidacloprid is comparatively less toxicity to human and environment. In this experiment Dimethoate 40% EC was sprayed for the management of WMS. Dimethoate 40% EC application at the rate of 0.75ml per 1-liter of water with a dilution of 3.75 ml per 5-liter of water per a single mango tree was used for spray [31]. Management of WMS using Dimethoate 40% EC was highly significant effectiveness as compared with white oil extract and pruning in decreasing population number and increasing mortality percentage. In the case of white mango scale population number reduction management using Dimethoate 40% EC with pruning operation was highly significant effectiveness as compared with Dimethoate 40% EC without pruning management tactics. Management using Dimethoate 40% EC with pruning operation in the case of population number reduction was highly significant effectiveness as compared with other treatments excluding Imidacloprid 20 SL+pruning treatment. Management of white mango scale using Dimethoate 40% EC and Dimethoate 40% EC with pruning management tactics were highly significant effectiveness as compared with untreated control. Dimethoate 40 % E.C was reported as an effective insecticide in reducing the effect of sucking insect pest including WMS [15, 20, 53]. In general, management of white mango scale using white oil extract, imidacloprid 20 SL and dimethoate 40% EC integrating with pruning increases the effectiveness which in lined with who reported post-harvest pruning is an effective control measure which helps the penetration of chemical sprays through the tree canopy [43, 54]. In cost wise, effectiveness of white oil, pruning and Imidacloprid 20SL + Pruning treatment seems to be a promising alternative to producers for white mango scale management. Management with Dimethoate 40% EC, White oil + Pruning, Imidacloprid 20 SL and

Dimethoate 40% EC + Pruning treatments gave higher marketable yield and statistically highly significant different from pruning and white oil treatment but their costs were such that they did not provide an acceptable rate of return. However, in this experiment Imidacloprid 20 SL + Pruning treatment costs higher compared with all other treatment gave higher yield and acceptable rate of return.

## CONCLUSION

Results of the present study indicated that integrated application of Imidacloprid 20 SL with pruning of mango tree was the most effective method for management of white mango scale. In addition to that, this study result revealed that application of Imidacloprid 20 SL + Pruning treatment provides a promising cost effective management options for producers against white mango scale insect pest. Since Imidacloprid 20SL is ecologically safe insecticide compared to Dimethoate 40% EC, it is more preferable for white mango scale insect pest management. Since only this integrated option is not sufficient to adapt in various locations and seasons, As recommended further evaluation study on other management tactics such as biological control (Natural enemies and microbials), host resistances and other novel insecticides which are compatible with cultural practices and reduced dose of insecticide as a part of integrated pest management strategy is mandatory to come with sustainable strategy for management of white mango scale and increase productivity of mango.

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