Potential of Moringa (*Moringa oleifera*: Moringaceae) as plant growth regulator and bio-Pesticide against wheat aphids on wheat crop (*Triticum aestivum*; Poaceae)

Mujahid Manzoor, Habib Ali, Abrar Muhammad, Intikhab Alam, Shahzada Hasnain Khalid, Atif Idrees, Muhammad Arif

ABSTRACT

Moringa oleifera commonly known as Moringa is a multipurpose plant. Field trials were conducted to assess the potency of Moringa leaf (MLE) and root extracts (MRE) as plant growth regulator (PGR) and a Bio-pesticide on wheat crop. At distinct crop growth stages (tillering, booting, and heading) with different concentrations (5, 10, 12.5, and 25% v/v or w/v or w/w) of MLE and MRE were applied. Results showed statistically significant increase in crop growth traits and reduction in aphid infestation (booting, milk, and heading stage). As plant growth regulator maximum leaf area duration (LAD), leaf area index (LAI), and total dry matter accumulation (TDM) were recorded at all growth stages for MLE 25%. Highest crop growth rate (CGR) (24.91 $gm^{-2}day^{-1}$) at tillering was achieved for MLE 5%, 13.04 $gm^{-2}day^{-1}$ for MRE 10% at booting stage and 8.76 $gm^{-2}day^{-1}$ for MLE 10% at heading stage. Maximum thousand grains weight (57.33g), highest number of spikes per plant (9.67$plant^{-1}$) and maximum grain yield (4446Kg hac^{-1}) were determined for MLE 25%. The heading stage of the crop was heavily infested with aphids and MLE 5% significantly reduced pest infestation compared to other concentrations of MLE and MRE and control group. Overall, MLE and MRE proved very effective as plant growth regulator and a Bio-pesticide against wheat aphid on wheat crop.

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Key words: MLE, MRE, Plant Growth Regulator, Bio-Pesticide, Wheat.

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INTRODUCTION

It is crucial to explore the potential of botanical and bio-pesticides in agriculture pest management (Jacobson and Crosby, 1971; Chakraboraty and Basu, 1997; Habib *et al*., 2015). Green pesticides provide materials for natural and beneficial pest control and increased production per unit area (Isman and Machial, 2006). Broad spectrum synthetic insecticides have consequences which badly affect human health, environmental cause pollution, destroy the food chain and kill beneficial insects (Sexena *et al*., 1974; Chauhan *et al*., 1987).

Botanical insecticides like neem (*Azadirachta indica* A. Juss) has been proved to be useful as bio-pesticide, efficiently reported (more than 400 species) against insects (Martinez, 2002) but there is an increasing need to discover some new bio-pesticides and their toxicity against insects, birds, fish and mammals as they are environment-friendly, economical, and pose no hazardous threat to human health and other non-targeted organisms (Tang *et al*., 2002). Different plant species belonging to family Meliaceae such as *Tillia. americana, A. indica, Melia volkensii*, and *Azadirachta exelsa* are effective against noctuid caterpillars, *Trichoplusia ni* and *Pseudaletia unipuncta* (Akhtar *et al*., 2008). Without experimental clarification these bio-pesticides cannot be registered.

Moringa oleifera (Moringaceae) is a multipurpose plant, which not only provides nutrition to animals but also serves an incredible alternative for the treatment of several diseases (Mugal *et al*., 2010). Lab trials of moringa application have been proved very effective about and bring many beneficial impacts on crop such as enhanced growth, resulting in vigorous plant development, resistance against pests and diseases (Foidle *et al*., 2001). Moringa leaf extract (MLE) has the potency to enhance plant metabolism due to zeatin, ascorbic acid, phenolic compounds and vitamin E (Isman, 1997). *Moringa oleifera* extract has proved to be a good water purifying agent and used as a natural coagulant, (Schwarz 2000) medicinal plant, biogas, fresh vegetable, livestock feed, green manure, and bio-pesticide (Makkar and Becker 1996). It is also involved in the process of cell elongation and division (Taiz and Zeiger (2006), used as seed priming agent for maize and sunflower (Basra *et al*., 2009a; Iftikhar, 2009) and plant growth promoting agent (Srivastava, 1998).The main objective of this study was to assess the potential of *Moringa oleifera* as a bio-pesticide against wheat aphids and possible impacts as growth regulator in wheat crop.

MATERIALS AND METHODS

Field experiment details

The current study was conducted at Faisalabad (Latitude of 24° to 37° N, and Longitude of 61° to 76° E) during the wheat growing season 2013-2014. Wheat variety, Sahar-2006, obtained from Ayyub Agriculture Research Institute, Faisalabad, Pakistan, was sown in 5 x 5m size plots with three replicates in a Complete Randomized Block (CRB) design. The crop was sown in the last week of December, 2013 in clay loamy soil with the seed rate of 110kg h^{-1}, using broadcast method. The crop was harvested in the second week of April, 2014. To assess the potential of *M. oleifera* as plant growth regulator and a bio-pesticide we applied different concentrations (5, 10, 12.5, and 25%) of Moringa leaf (MLE) and root (MRE) extracts at different growth stages (tillering, booting, and heading) with a hand sprayer on wheat crop. Data regarding yield, growth and pest population were measured before and after each growth stage (tillering, booting, and heading) of the crop.

Preparation of moringa leaf and root extracts

Roots and young leaves with shoots were picked from the moringa plants grown in the main campus of the University of Agriculture, Faisalabad, Pakistan. The roots and young leaves were crushed in the lab using a locally made grinder. Moringa leaf and root extracts were prepared according to method modified by Price (2007). MLE and MRE were sieved through a cheese cloth, centrifuged at 8000 × *g* for 15 min and the required concentrations (5, 10, 12.5, and 25%) were obtained by diluting with sterilized distilled water. After one month (30 days) of sowing moringa leaf and root extracts were applied using a hand sprayer.

Yield and growth parameters

To calculate the leaf area we randomly selected a unit area of one square meter from each plot. Crop Growth Rate (CGR) and Leaf Area Duration (LAD) were measured by the method modified by Hunt, (1978). The crop was harvested at its physiological maturity and data regarding yield, growth and pest population were determined. CGR and LAD were calculated using the given equations:

$(CGR) = (W2 - W1)/ (T2 - T1)\ g\ m^{-2}\ d^{-1}$

$(LAD) = (LAI1 + LAI2) \times (T2 - T1)/2$

where, LAD denotes the leaf area duration between two harvests, TDM shows the total dry matter (DM) accumulated during two harvests, W1 and W2 indicate the oven-dry weight of the first and the second harvest respectively, while T2 - T1 is the time interval between two harvests.

Leaf area per plant (cm^2)

After 75 days of the sowing date, leaf area was measured using CI-203 Handheld Laser Leaf Area Meter- CID Inc., USA, for each randomly selected plant.

Leaf area duration (LAD) days

Leaf area duration (LAD) days was calculated by the equation:

$$LAD = (LAI1 + LAI2) \times (T2 - T1) / 2$$

where,
LAI1 = Leaf Area Index measured first time in the beginning of crop rising season.
LAI2 = Leaf Area Index recorded at the time of crop ripeness.
T2 – T1= Time period difference between these two readings (Reddy, 2004).

Leaf area index (LAI)

Data on Leaf Area Index (LAI) was started on a weekly basis on 55 Days after Sowing (DAS) and continued up to 90 days after sowing.

Crop growth rate (CGR) (g m^{-2} day^{-1})

A unit area of $1m^2$ was harvested to determine the Crop Growth Rate (CGR) (g m^{-2} day^{-1}). This was also started on a weekly basis on 55 Days after Sowing (DAS) and continued up to 90 days after sowing (DAS). The leaves were dried in the oven to get the constant dry weight and the values of crop growth rate were measured according to Reddy, (2004).

$$CGR = (W2 – W1) / (T2 – T1)$$

where,
W1 is the dried weight during the first sampling,
W2 is the dried weight for the second sampling,
while T1 and T2 denote the time at the first and the second sampling data measurement.

Yield

The number of grains per spike was calculated from separately threshed spikes from each plot and averaged to obtain the number of grains per spike. 1, 000 grains were randomly isolated from the threshed grains and weighed.

Aphid's population count

The aphid population was recorded from randomly selected plants (number of aphids/5 tillers) for different dates during the crop growing season. Before and after the foliar application of moringa leaf and root extracts (5, 10, 12.5, and 25%) as bio-pesticide against wheat aphids, the number of aphids/ 5tillers was counted and the average number of aphids in the population was obtained. The data was recorded before and after the treatment at booting, milk, and heading stage.

Statistical analysis

Data regarding growth traits and pest population were subjected to statistical analysis using Fisher's Analysis of Variance (ANOVA) and Least Significant Difference (LSD) test at 5% significance level, and treatment means were compared according to Steel and Torrie (1997).

RESULTS AND DISCUSSIONS

Leaf area duration (LAD)

Different concentrations of MLE and MRE had significant effect on Leaf Area Duration calculated at different growth stages (Tillering, Booting, and heading) of the crop. MLE 25% yielded maximum leaf area duration in all stages followed by MLE at 12.5, 10, and 5% and MRE at 25, 12.5,10, and 5% compared to control group (Fig. 1).

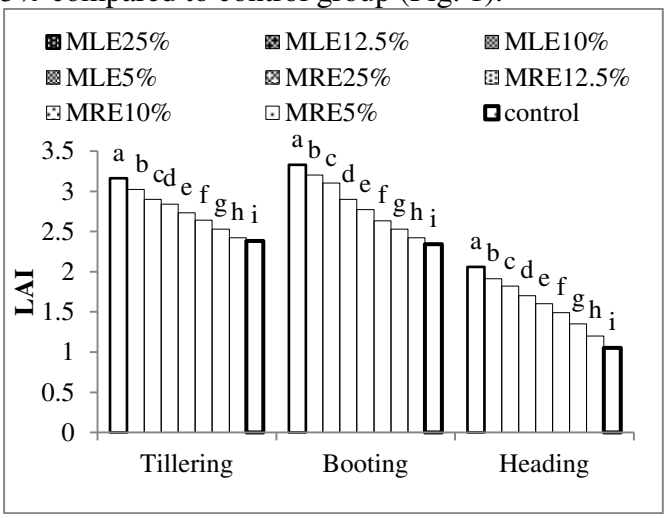

Fig. 1. Effect of different concentrations (5, 10, 12.5, and 25%) of MLE and MRE with control group applied at different growth stages on LAD (leaf area duration) of wheat.

Leaf area index (LAI)

Leaf area index was also found to be was high all growth stages when MLE 25% was applied followed by the other concentration of MLE and MRE. Maximum LAI at tillering at booting and at heading stage was recorded for MLE 25%, while, minimum LAI at tillering, booting and heading stage was recorded for the 5% concentration of MRE25%, though it was higher than the control group whose LAI were 2.38, 2.34, and 1.05 at the tillering, booting, and heading stages respectively (Fig. 2).

Dry matter accumulation

Dry matter accumulation was significantly higher at heading stage, at booting stage and at tillering stage with the foliar application of

MLE 25%, followed by other concentration (MLE 12.5, 10, and 5%, MRE 25, 12.5 and 10%). However, TDM was higher in control group at heading stage than MRE 5%. Overall, MLE 25% contributed more to total dry matter (TDM) accumulation in all growth stages (Fig. 3).

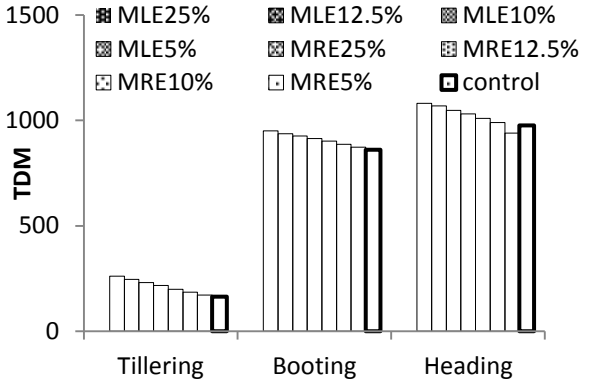

Fig. 2. Effect of different concentrations (5, 10, 12.5, and 25%) of MLE and MRE with control group applied at different growth stages on LAI (leaf area index) of wheat.

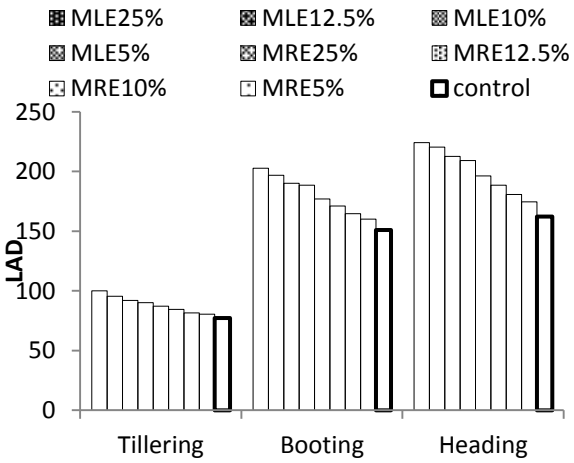

Fig. 3. Effect of different concentrations (5, 10, 12.5, and 25%) of MLE and MRE with control group applied at different growth stages on TDM of wheat.

Crop growth rate (CGR) (g m^{-2} day^{-1})

Maximum crop growth rate (CGR) at tillering stage was recorded for MLE 5% than MLE 10%, MRE 10%, MRE 5%, MRE 12.5%, control group, MRE25% and MLE 25% and minimum was observed for MLE 12.5% during the same growth stage. At the booting stage higher crop growth rate (CGR) was recorded for MRE 10% followed by other concentrations MRE 25%, MLE12.5%, MRE 12.5%, MLE 5%, MLE 10%, MLE 25%, and MRE 5% with the crop growth rate of 12.65, 12.62, 12.60, 12.53, 12.11, 11.67, and 10.49 respectively. In control group the crop growth rate was higher than MLE 10% and MRE 25%. In heading stage higher crop growth rate was calculated for MLE 10% and MLE 12.5 % while the lowest was recorded for MRE 5% (Fig. 4).

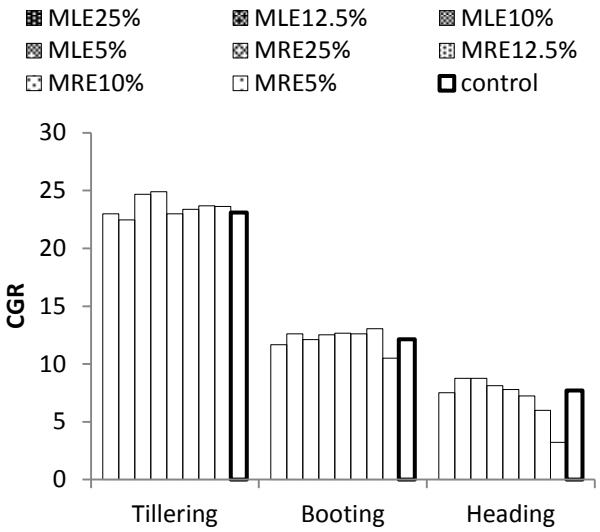

Fig. 4. Effect of different concentrations (5, 10, 12.5, and 25%) of MLE and MRE with control group applied at different growth stages on CGR of wheat.

Thousand grain weight (g)

Higher thousand grain weight was achieved by MLE 25% followed by MLE 12.5%, MLE 10%, MLE 5% , MRE 25%, MRE 12.5%, MRE 10% and MRE 5% with thousand grains weight of 49.37, 48.33, 41.94, 40.03, 34.33, 33.67, and 32.33 respectively. The minimum thousand grains weight was recorded in control group (Fig. 5).

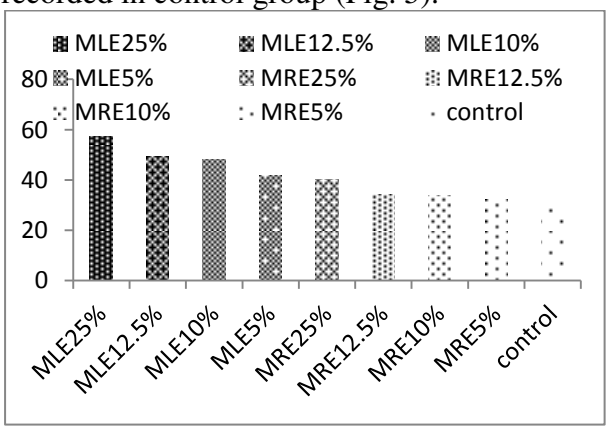

Fig. 5. Effect of different concentrations (5, 10, 12.5, and 25%) of MLE and MRE with control group applied at different growth stages on Thousand Grain Weight of wheat.

Number of spikes plant^{-1}

All concentrations of MLE and MRE had a significant effect on number of spikes plant^{-1}. Foliar application of MLE 25% yielded higher number of spikes plant^{-1} followed by MRE and MLE concentrations, while the minimum number of spikes per plant was recorded in control group (Fig. 6)

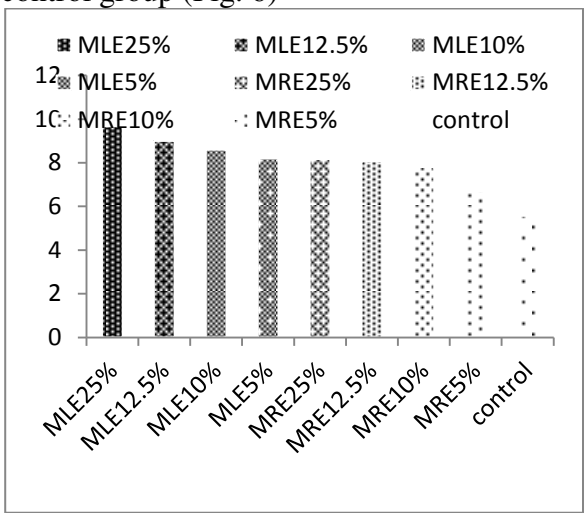

Fig. 6. Effect of different concentrations (5, 10, 12.5, and 25%) of MLE and MRE with control group applied at different growth stages on Number of Spikes per Plant of wheat

Grain yield (kg ha^{-1})

MLE and MRE significantly affected grain yield. Maximum grain yield was recorded at tillering, booting and heading stage of MLE 25% followed by MLE 12.5%, MLE 10%, MLE 5%, and MRE. However, MRE 25% gave higher grain yield than MLE 5% (Fig. 7).

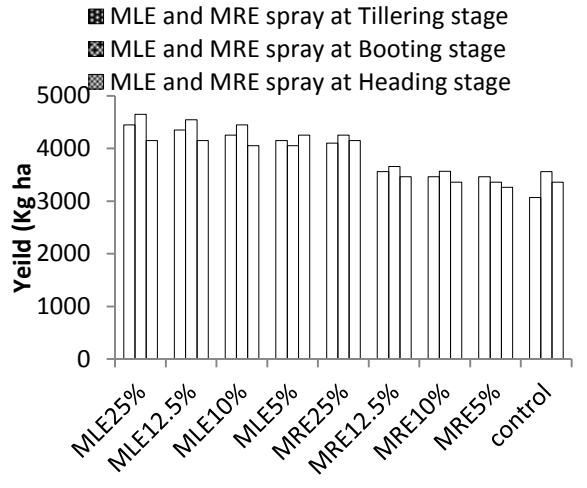

Fig. 7. Effect of different concentrations (5, 10, 12.5, and 25%) of MLE and MRE with control group applied at different growth stages on Grain Yield (kg ha^{-1}) of wheat.

Pre-treatment aphid population

Average number of aphids was recorded before the foliar application of Moringa leaf and root extracts at booting, milk, and heading stage. Maximum number of aphids was calculated at the heading stage of the wheat crop, followed by milk and booting stages. The control group was highly infested in all three stages (Booting, milk, and heading) compared to MLE and MRE previous application as plant growth enhancer (Fig. 8).

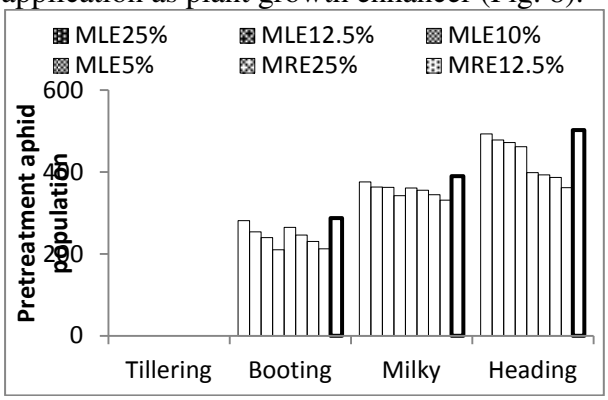

Fig. 8. Pre-treatment aphid population at different stages on wheat crop.

Post-treatment aphid population

After the foliar application of Moringa leaf and root extracts significant reduction was observed in the population of wheat aphid in all stages. In booting stage minimum aphid population was recorded for MRE 5% , followed by MLE 5%, MLE 10%, MRE 10%, MRE 12.5%,MLE 15.5%, MLE 25%, and MRE 25%. In milk stage MLE5 %, and in heading stage MRE 5% significantly reduced the aphid population. High population was associated with the later growth stages of wheat crop (Fig. 9).

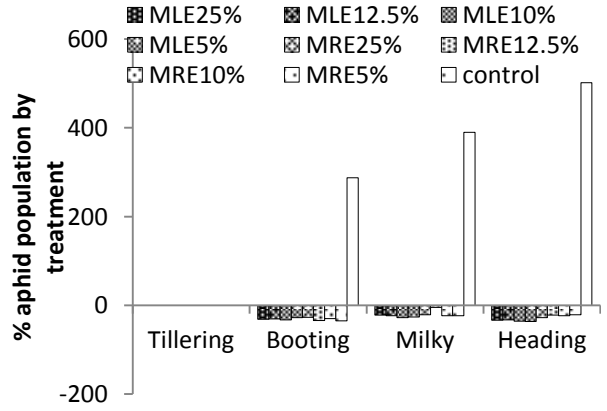

Fig. 9: Post-treatment aphid population at different stages on wheat crop.

Our field experiment results show that all concentrations of MLE and MLE has significantly reduced the aphid infestation in all three stages (booting, milk, and heading). Meanwhile, the growth traits also witnessed significant increase at tillering, booting and heading stage. Moringa leaf extract is rich in many macro (Ca, P, Mg, Na, and K) and micro (Fe, Mn, Zn, and Cu) elements which are important plant growth enhancer, when used as seed priming agent and growth stimulator (Farooq *et al.,* 2010). Pre sowing treatments, seed priming, and plant growth regulators (PGRs) improve the germination rate and hence increase net production and reduce the risk of pest attack in many crops (Taylor and Harman, 1990). Under stress conditions such as salinity PGRs and seed priming increase the overall productivity of many crops. Fuglie (2000) reported that application of leaf extracts of moringa (MLE) promotes the growth rate of plants and reduces the pest population. Different plant extracts have been assessed as seed priming agents and growth enhancers that have increased crop yield and growth rate in many crops. This study demonstrate that the foliar application of MLE and MRE has increased the overall growth and yield by increasing dry matter content (TDM), leaf area duration (LAD), leaf area index (LAI), crop growth rate (CGR) and other growth traits of wheat crop. Meanwhile, aphid infestation reduced significantly in booting, milk, and heading stage after the foliar application of MLE and MLE. Diluted (1:30 with distilled H_2O) MLE elevated metabolism increased emergence and produced vigorous plant growth (Seed primed in MLE) in maize, wheat, range grasses and several other crops (Iftikhar, 2009).

In another study Basra *et al*. (2011) primed the maize seeds for 18 hours in 30 times diluted MLE, which significantly increased maize growth. The multifaceted nature of *Moringa oleifera* is due to the presence of many important elements such as Ascorbic acid, Calcium, Phosphorus, Potassium, Zeatin and plant growth regulator (PGR) Hormones (Fuglie, 1999). Benzyl adenine, cytokinin and some other compounds present in m*oringa oleifera* extract enhance growth in wheat crop (Gupta *et al*., 2000). It is crucial to increase the yield of cereals using different strategies, as seed priming of MLE in maize, wheat and other range grasses has increased the growth and metabolism. This approach can be extended to other crops for higher production and pest management (Khan *et al*., 2006). Pill and Savage (2008) reported that seed priming with inorganic salts, sugar beet extracts and other plant growth regulators increase the metabolism and germination rate and physiological adaptation of plants. Synthetic insecticides pose problems in resistance development in insect pests and badly affect the environment. Therefore more research has been focused on to explore the pesticidal potential of plant extracts against important agricultural pests and their impact on non-target organisms (Prabhu *et al*., 2011). *Moringa oleifera* seed extracts used against larvae and pupae of different mosquito species such as *Aedes Albopictus*, *Aedes aegypti* and *Culex quinquefasciatus* produced high mortality (Pace- Asciak *et al*., 1995). Botanical insecticides are acutely toxic and act as growth inhibitors and feeding deterrents in lepidopteron pests (Akhtar *et al*., 2008). Habib *et al*., (2015) used moringa leaf extract (MLE) in combination with neem leaf extract (NLE) and eucalyptus leaf extract (ELE), observed significant reduction in aphid, *Diuraphis noxia* (Mordvilko) (Homoptera: Aphididae) infestation in wheat crop compared their sole application suggesting that moringa leaf and root extracts are compatible with other pest control methods.

Moringa oleifera leaf and root extracts are effective plant growth regulators and bio-pesticides against different chewing and sucking insect pests, especially wheat aphids. Moringa leaves contain several macro and micro elements which are important plant growth enhancers leave no hazardous residual effects. Moreover, moringa is a multipurpose plant and can be used as plant growth enhancer, animal feed and bio pesticide, As Biogas has developed special interest among the researchers to explore new aspects for eco-

friendly sustainable agriculture. There is further need to identify the synergistic effects of moringa with other synthetic insecticides and biological control agents.

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Mujahid Manzoor[1], Habib Ali[2*], Abrar Muhammad[2], Intikhab Alam[3], Shahzada Hasnain Khalid[4], Atif Idrees[1], Muhammad Arif[2]

[1]Department of Entomology, University of Agriculture, Faisalabad, Pakistan

[2*]Fujian Provincial Key Laboratory of Insect Ecology, Department of Plant Protection, Fujian Agriculture and Forestry University, Fuzhou, China

[3]Laboratory of Plant Molecular Genetics and Gene Improvement, Fujian Agriculture and Forestry University, Fuzhou, China

[4]Department of Agricultural Extension, University of Agriculture, Faisalabad – Pakistan

[*]Corresponding Author

E-mail: habib_ali1417@yahoo.com.