Beauveria bassiana, Bb11, to control the Diamondback moth, Plutella xylostella (L.) (Lepidoptera: Plutellidae) on cabbage in Ghana

Demonstration Trials with producers

Technical Report

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AICCRA
Accelerating Impacts of CGIAR Climate Research for Africa

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About AICCRA Reports

Titles in this series aim to disseminate interim research on the scaling of climate services and climate-smart agriculture in Africa, in order to stimulate feedback from the scientific community.

Photos

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About AICCRA

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Background

The diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is one of the most important pests on brassicas and a major constraint to cabbage production around the world. Infestation by DBM can result in 100% crop loss if not controlled, resulting in overuse of insecticides by farmers if they must make profit from cabbage production. This has made cabbage production so expensive that most commercial vegetable producers shun away for it. Indeed, most peri-urban vegetable producers in Ghana, including those at the Tuba Irrigation site have ceased to produce cabbage, citing pest constraints and the cost of crop protection as reasons for not venturing into cabbage production.

As part of the project – Accelerating Impact of CGIAR Climate Research for Africa (AICCRA), the Ghana Cluster is introducing biorational one health sensitive pest management strategies alongside Climate Smart Agriculture (CSA) techniques and Climate Information Systems (CIS) to farmers. This project seeks to demonstrate the combined impact of *Beauveria bassiana* and Black Soldier Fly (BSF) fertilizer as one health sensitive innovations to vegetable farmers at Tuba. *B. bassiana* has been demonstrated to effectively control the major pests of cabbage including *Thrips tabaci*, *Pierris rapae, Plutella xylostella* and *Brevicoryne brassicae* (Nouh et al., 2022). The Bb11 strain of *B. bassiana* has been extensively researched and demonstrated to effectively control cabbage pests. In addition, the IITA and its partners have been developing BSF products including fertilizer for soil amendment and as nutrient for crops. Indeed, the BSF frass has been proven to boost plant vigor and tolerance/resistance to pests and diseases (Barragán-Fonseca et al., 2022). This project sought to introduce vegetable farmers at Tuba to these innovations with the aim of revamping cabbage production in the area.

Main Objective

The main objective was to carry out, on an operational scale, efficacy tests of the optimal dose of the bioinsecticide Bb11 (Bba5653), including observation data on useful non-targets. Specifically, participatory trials with vegetable growers were carried out, at the Tuba Irrigation Site in the Ga West District of the Greater Accra Region of Ghana, to demonstrate the effectiveness of the biological insecticide Bba5653 under field conditions in Ghana. The demonstration also included the evaluation of BSF frass in cabbage production systems. The impact of BSF frass on plant growth, pest and disease tolerance and yield was demonstrated.

1.0 Materials And Methods

1.1 Materials

1.1.1. Locations

The demonstrations were carried out at the AICCRA intervention site in the Greater Accra Region, specifically, the Tuba Irrigation Vegetable Site in the Ga West District of the Greater Accra Region of Ghana. This site is very famous for vegetable production, and once used to be a major hub for peri-urban cabbage production. Farmers at the site no longer produce cabbage due mainly to pest challenges. According to the farmers, diamondback moth courses severe losses at this site, making cabbage production not profitable.

Several stakeholder engagements were held between partners on the AICCRA Ghana project and the partners at the Tuba irrigation farms. The engagement was led by PPRSD, with support from BNARI. The team had several meetings with the manager of the irrigation facility, the farmer group leaders and the general farmers within the association.

On the 16th day of May 2023 meeting was held between a farmer representative at Tuba Hon. Abdul Karim Ms. Elizabeth Akaba an AEA from department of Agriculture at Ga South Municipal Assembly and Awudu Amadu Gariba of PPRSD with regards to the cabbage demonstration at Tuba irrigation. Based on this meeting, land was allocated for the trial within the Weija Water Users Association. Field preparation was done on the 20th to 22nd of May.

Plant material: Cabbage

Certified seeds of a farmer preferred cabbage variety (Oxylus) were purchased locally from an approved store.

Fungal material: Bb11

Bb 11 fungal powder produced by the IITA-Benin production unit was used for the experiments.

Organic fertilizer: BSF frass fertilizer

BSF frass fertilizer from the BSF rearing facility at BNARI-GAEC was obtained for the trials. In addition, standard farmer practice of spreading chicken manure on the land before land preparation was used as farmer practice and a no fertilizer control.

Methods

Experimental Design

Field layout : The experimental layout was a split plot design with two factors, fertilizer and insecticide rates each having three levels of treatments including control (Fig 1). The fertilizer rate factor is represented by the acronym FR and for insecticide rate/type, IR. The acronyms FR1, FR2 and FR3 means fertilizer rate/type for control plots at rate/type say zero, treated plots at rates/type, say 2 and 3 to cabbage respectively. Also, the acronyms IR1, IR2, and IR3 means insecticide rate/type for control plots at rate/type say zero, treated plots at rate/type, say 2 and 3 to cabbage respectively.

The main-plot factor in this design is fertilizer rate. Every replication or block in this design has three main plots because the fertilizer rates/types have three treatment levels. So, each main plot takes one of the three levels of the fertilizer rates/types, indicated on top with the acronyms FR1, FR2, and FR3. The sub-plot factor in this design is insecticide rate/type. The sub plots were created by dividing the main plots within each replication into three because the sub-plot factor has three treatment levels. So, each sub-plot within the main plots takes one of the three levels of the insecticide rates/types, indicated inside with the acronyms IR1, IR2 and IR3. The main plots found in each replication measures 2m x 24m in breadth and length whiles each sub plot measures 2m x 6m, also in breadth and length. The total distance on top of the entire design is 66m. The total distance on the vertical side is 24m. By this, the area of entire field is 66m x 24m in breadth and length. The breadth has increased in distance because of the path distances between main plots and replications. The path distance between main plots is 3m and between replications or blocks it is 1.5m, beginning from the end of the three main plots. Finally, the path distance between the sub plots is 3m on the longest side of the main plot. So, in totality there was 45 experimental units, after setting out this experimental layout on well prepared field. Thus, 3 levels of fertilizer rates/types x 3 levels of insecticide rates/types x 5 replications equal 45 experimental units, with randomised experimental treatments.

Experimental unit: An experimental unit or plot within the main plots measured 2m x 6m in breadth and length. Considering a cabbage planting distance of 60cm x 40cm between and within row spacing, a unit sub plot had three rows with 60cm distance apart. A surplus distance of 20cm was left as boundaries of the main row distances and 10cm on the right and left. Addition of all these distance on top of the unit plot gives 2m, thus the unit plot breadth. The within row spacing was 15 in number and each measured 40cm. Addition of all these distances on the side of the unit plot gave 6m, the unit plot length.

Plant population: The population of cabbage per line in a unit plot was 16 and this multiplied by 4 lines will gave 64 cabbage plants. So, the cabbage population per unit plot was 64 cabbages per 2m x 6m area. Cabbage population determination for the factor treatment levels IR1, IR2 and IR3 were the same per replication.

In each replication, each factor treatment level was repeated three times and the cabbage population per sub plot was 64. So, 64 multiplied by 3 gave the total cabbage population for each factor treatment level, which was 192 cabbages per 2m x 18m area.

To know the grand total population of cabbage for each insecticide treatment level in all five replications, multiply 192 x 5 and it gives 960 cabbages per 10m x 18m area. So, the cabbage population for IR1, IR2 and IR3 was 960 cabbages per $180m^2$ for each, which was the same. The same cabbage population density was used for FR1, FR2, and FR3 factor treatment levels, which also was 960 cabbages per $180m^2$ for each.

So, in a nutshell the cabbage population was the same throughout for all the experimental factor levels, and this was not a factor. Meaning only one cabbage variety was use in this experiment.

Bed preparation: In making the beds, the gross dimension of the main plot was used as a measure. So, a long bed was made with a length of 24m and breadth of 2m using a ridger after the field was ploughed and harrowed. In all fifteen (15) of these beds were made because, the main plots were three in each replication and multiplying the number of replications, which is five (5) gave fifteen beds. Following the dimensions on the design, path and replication distances on the breadth of the entire field dimension, was considered when making the beds. Path and replication distances of 1.5m and 3.0m were left between main plots and replications/blocks along the breadth of the field design, which measured 66m.

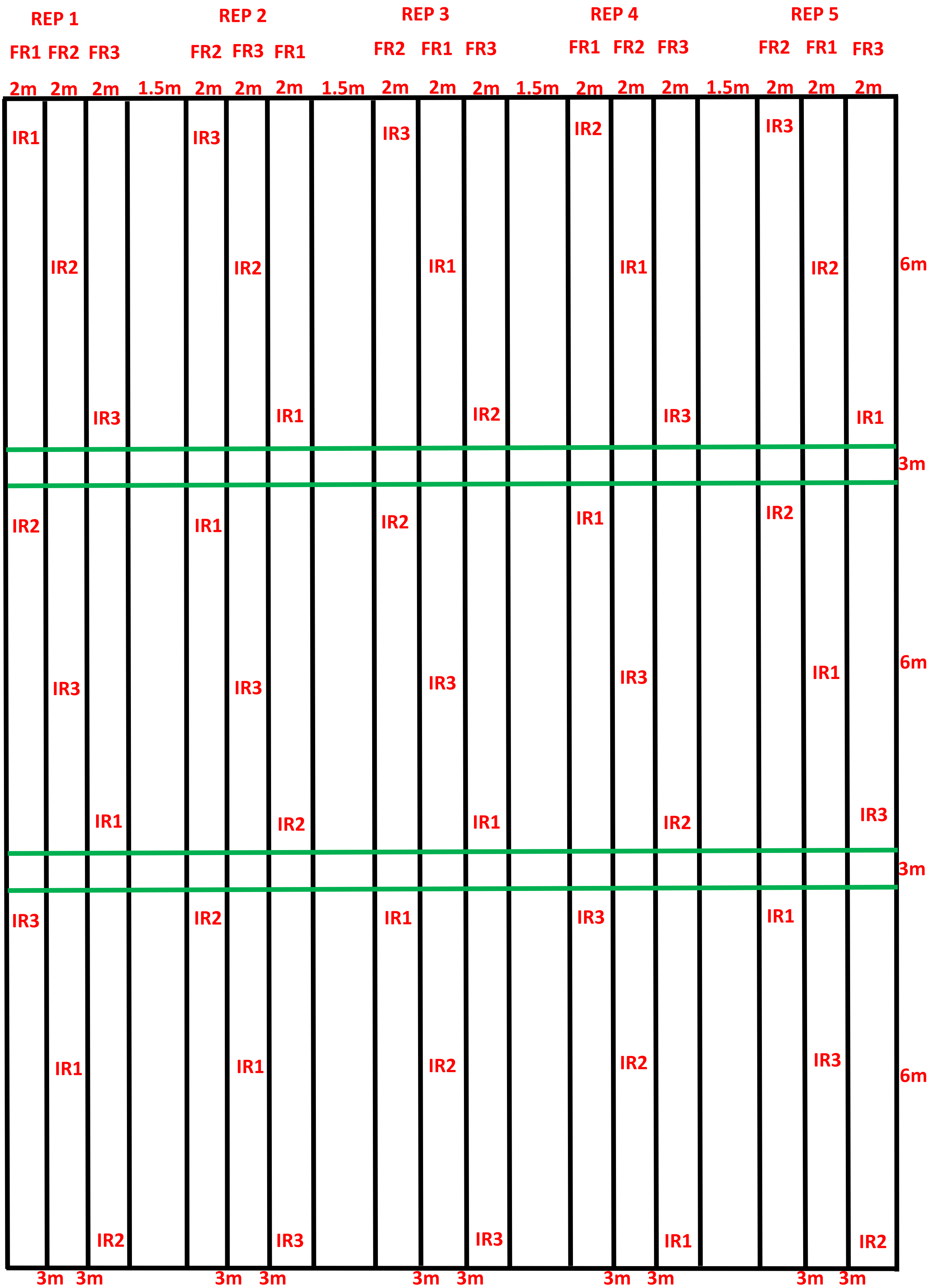

Figure 1 : Layout of experimental design. *Figure 1: Layout of experiment design.*

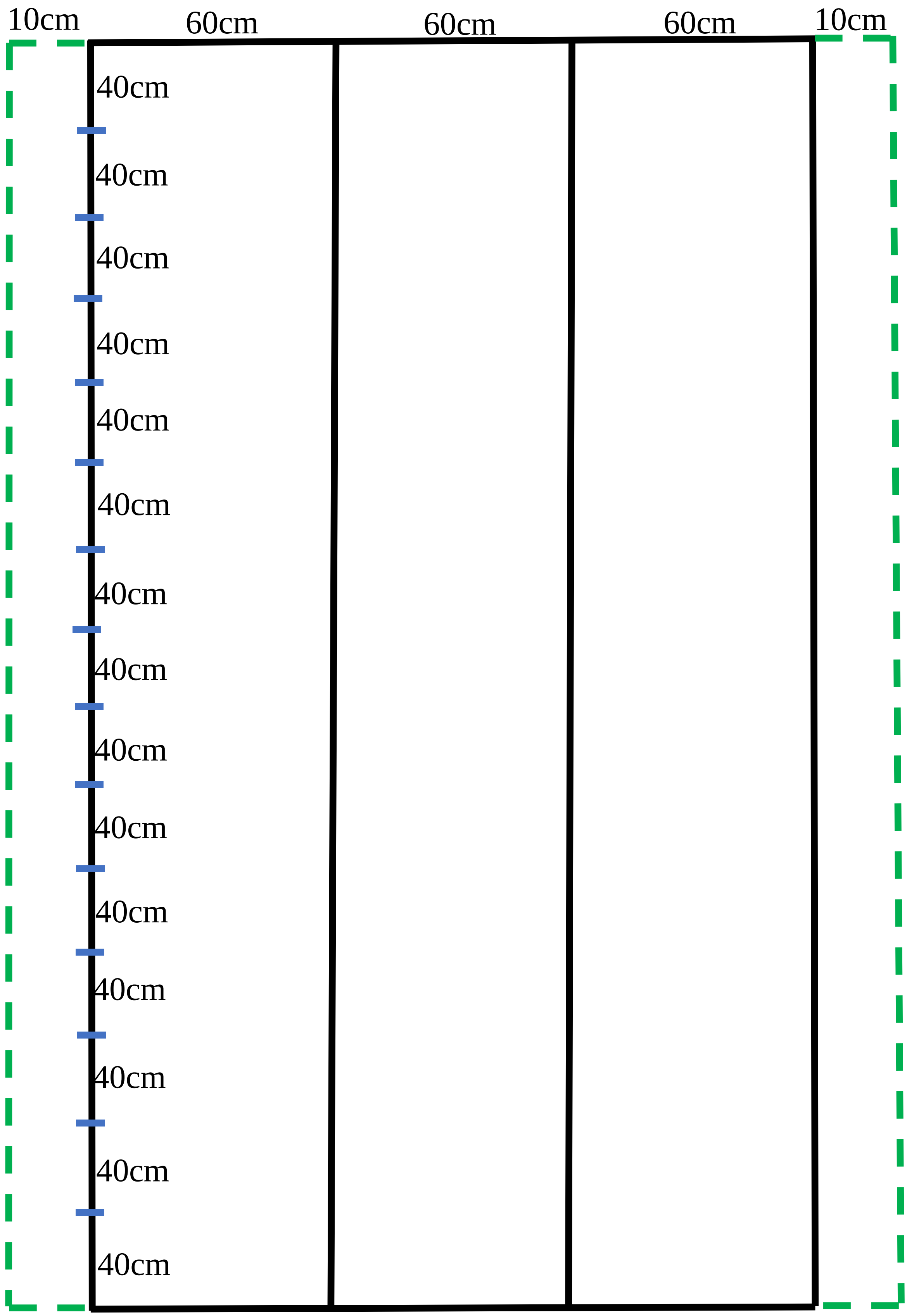

Figure 2 : Layout of experimental units

Nursery Establishment and Maintenance

Cabbage seeds were nursed on the five beds by the farmer groups on the 30th of May 2023. Emastar and biopesticide (Bb11) were applied to control pest on two beds each at the nursery depending on which insecticide treatment they were designated. For one nursery bed designated to be planted on control plots, there was no insecticide control. All the above pesticides were applied both at the nursery stage and on the main field. During the nursery stage soil magic was applied to boost the nutrient in the soil for plant growth.

Transplanting and Field Establishment

On 30th of June 2023, the main field was ploughed and field preparation and labelling of plots were done in blocks on the 3rd of July 2023. Transplanting of cabbage seedling was done by the various farmer groups on the 8th of July, 2023. Fields were allocated to farmer groups in different blocks.

Regular monitoring and data collection were done regularly by the team involved and various observation were made such as appearance of some pest such as Diamond back moth, Aphids etc.

BSF Frass Fertilizer Application Rate

BSF Frass was applied at a rate of 2.5t/ha (3kg per 12m^2 plot). The frass was placed in holes at the base of the plant, 5 cm from the stem. Standard compost and synthetic fertilizer were applied according to farmer practice.

Formulation of Bb11 Biopesticide

An aqueous formulation (water + 0.05% tween 80 water) was used.

The table below shows the process.

Surface area	Bb 11 powder	Quantity of water	Quantity of tween 80 (0,05%)	observation
1 ha	50 g	315 L	157,5 ml	This is the basis for calculation
(5 planks of 12 m^2 each (= 60 m^2) 60 m^2	0.3 g (300 mg)	1.89 L	0.945 ml ˜ 1 ml	

Treatments

The treatments consisted of one dose of Bb11 as treatment 1 (T1), Emastar (Emamectin Benzoate 48g/L + Acetamiprid 64g/L) at manufacturers recommended rate as treatment 2 (T2). A no insecticide control served as T0. Application of treatments was done at the first sign of diamondback moth infestation according to the experimental design outlined in 3.2.1 above. Personal protection equipment (PPE) were also provided for farmers including other farming equipment's in order to protect themselves from hazardous chemicals and also to enhance effective work on the field.

Parameters to Measure

a) Pest density

A non-destructive sampling was carried out on 5 randomly selected plants per plot on a weekly basis before pesticide application each time. Pest data included the number of Plutella xylostella larvae (live/dead) and number of other pests found on plant (dead/alive).

b) Assessments of natural enemies

Number of insect natural enemies found on cabbage plants was counted and recorded. Field staff were trained on the recognition and field identification of the following natural enemies: Cotesia plutellae (adults and cocoons), syrphid larvae, spiders, ladybugs, big eyed bugs, assassin bugs and ants.

c) Assessment of damage and yield

Damage to cabbage (leaves, heads) was assessed according to the following scale: no damage = 0; ≤ 25% =1; ≤ 50% = 2; ≤ 75% = 3; >75%= 4. Yield/plot was estimated in by weighing the cabbage heads harvested from each plot and scaled to tons per hectare.

Preliminary Results

The Bb11 biopesticide was able to control the DBM to the satisfaction of the farmers and partners. However, the presence of high aphid infestation was a challenge as the Bb11 biopesticide was not able to control the Aphids. Emastar outperformed all the Bb11 as an insecticide treatment in terms of pest infestation and yield. This is because Emastar was effective against all the different types of pests present on the field. The effects of BSF frass, mainly on crop yield and other parameters was not obvious because of the high aphid infestation which resulted in widespread viral diseases and stunting on the control and Bb11 treated plots.

During the trial, private sector actors, especially those into Biopesticide production, farmers, exporters of vegetables and academia were invited to witness and participate to share the success story. To draw conclusions, it is important to repeat the trial taking into consideration the aphid situation and put in place measures to integrate other tools that can deal with the aphids and other pests that are not amenable to control by Bb11.

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