WEST AFRICA
regional consortium for IPM excellence
regional program: senegal | ghana

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West Africa

program summary

The West Africa Regional Consortium for IPM Excellence project developed packages for: 1) tomato in Ghana and Senegal, 2) potato in Ghana and Senegal and, 3) cabbage in Ghana and Senegal. During this year, several visits by US-based scientists to the participating host countries were made to develop research protocols, perform and coordinate research activities. Research and development of the tomato, cabbage and potato IPM packages has continued progress including experiments with new disease resistant varieties, grafting and host-free period production practices.

SENEGAL

Tomato

Tomato survey

A tomato survey was carried out in Senegal in 15 localities in the zone of the Niayes, a coastal strip 30 km wide stretching from Dakar to St. Louis through the regions of Thiès and Louga. The investigation included Dagana, the largest area of industrial tomato production.

Dakar region - Malika and Keur Massar: This region contains smallholder farmers (holding from 300 m² to 1 ha). The surveyed growers had 15 and 30 years tomato production experience. Common varieties are: Xina, Mongal, Xerewi, and Mboro. All these varieties are sold by input suppliers in Dakar suburbs (Thiaroye and Rufisque) or the informal market. The dominant pest in these tomato growing areas is the tomato fruitworm, *Helicoverpa armigera*. The main disease is *Tomato yellow leaf curl virus* (TYLCV).

Rufisque region - Kayar and Mbidiamlebou producers possess farms of the same small size as Dakar, but also big producers with farms that can vary from 3 to 10 ha. Growers use hybrid varieties (Mongal, Yaki, Asila) and one local variety (Mboro).

Thiès region – Survey activity focused in Niayes area in Fass Boye, Mboro, Notto, Barcendiouloff, where tomato is one of the main crops. The important pests are tomato fruitworm, mites, whitefly and tomato viral disease.

Louga region – Famers in Lompoul on Sea, Potou in Louga and Kébémer areas of the maritime fringe are both fishermen and farmers. Commonly encountered diseases and pests include: *Helicoverpa*, leafminer flies (*Liriomyza trifolii*), mites, and nematodes.

St Louis region - Dagana is the largest area of industrial tomato production. The pests commonly encountered are: *Helicoverpa,* whitefly, leafminer, the mite (*Aculops lycopersici*). The reported diseases are TYLCV and bacterial wilt caused by *Ralstonia solanacearum*. The presence of the newly introduced South American tomato pinworm, *Tuta absoluta*, was not reported in this area, but its presence in the region of Dakar and Thies (Fass Boy and Daroukhoudoss) is a serious concern.

Tomato and eggplant

Bacterial wilt

A study was carried out to evaluate selected tomato and eggplant rootstocks for grafting and resistance to the bacterial wilt. The experiment was conducted in Dagana. A randomized complete block design with four replications and 10 plants per treatment was laid out. Tomato (Roma reference 1, and L06176) and for eggplant (V6, Black beauty, Local reference 2, VI046103, VI047276, and VI 034845) were used. All the tomato plants in the field trial died. Observations on eggplant varieties are continuing.

Adaptability of grafting technique in local condition.

After short training in grafting at the North Carolina State University given to two members of ISRA, field experiments were conducted at Dagana with grafted tomato plants. It was found that a humidifying chamber is important for better establishment of grating.

Various vegetable crops

Whitefly surveys

Carlyle Brewster, Kémo Badji

Surveys were conducted to identify natural enemies of the whitefly in the three vegetable cropping systems (Gorom, Mboro and Kolda). It was found that *Erytmocerus* sp. population attacking whitefly larval population was more important than the *Encarsia* sp. *Erytmocerus* sp. was observed in an overall composition was 10, 14 and 16.5% while *Encarsia* sp. population was observed to be 5, 7 and 8% respectively in Gorom, Mboro and Kolda.

Survey of whitefly parasitoids.

Three geographically distinct cropping regions (Gorom, Mboro and Kolda) in Senegal set up for sampling whitefly larval population since previous years were used for this study. A study area of approximately 100 km² (10 km ×10 km) which have thirty sampling locations in each study area for sampling immature whitefly on crops (and weeds) over time were performed.

Each site was visited every second month starting from 9 February 2012. Sampling for whitefly instars population consisted of collecting a single leaf from an infested plant giving 5-leaf samples per host plant; this was replicated 10 times per site). Host plants of tomato, cotton, eggplant, bitter eggplant (*Solanum aethiopicum*), and a weed *Ambrosa maritima* were selected for this study according to observed whitefly preference. Samples were placed individually in 25-ml glass vials and held for 3- 7 days under laboratory natural conditions until parasitoids emerged. Emerging parasitoids were collected and identified to genus with the taxonomic keys for *Eretmocerus, Encarsia*, and others.

Gorom

The composition of the natural enemies attacking *B. tabaci* white fly in Gorom cropping system in Senegal showed that *Eretmocerus* population is much more important than *Encarsia sp*. In this cropping system, farmers apply pesticides weekly and it may be contributing to the low level of the natural enemy population. About 83% of *Bemisia tabaci* larvae were not parasitized.

Mboro

In the Mboro cropping system composition of natural enemies was same as Gorom. *Eretmocerus* population was 14%, and *Encarsia* 7%. This situation left 77% of *B. tabaci* white fly population uncontrolled.

Kolda

This cropping system includes cotton near the vegetable cultivation area. *Bemisia tabaci* population builds up on cotton when vegetable crops are not in season. The population migrates from cotton to the vegetable crops and vice versa. The percentage of parasitism was slightly higher than the two northern cropping systems, 16.5% *Erytmocerus* and 8% *Encarsia.*

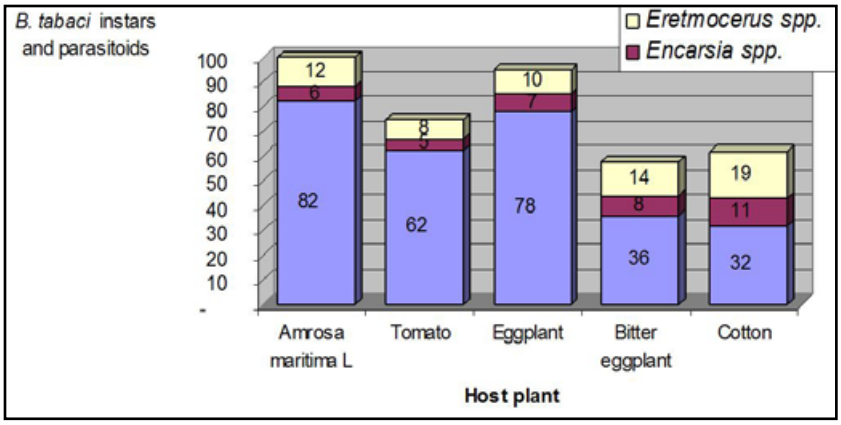

Figure 1. Levels of parasitization of *Bemisia* on various host plants.

Relationship between crop, whitefly and parasitoids

In this study host plants used were: Eggplant, bitter eggplant, pepper and tomato. Parasitoid activity on *B. tabaci* over time suggested that cotton had more activity followed by bitter eggplant, the weed *Amrosa maritime,* eggplant and tomato (fig. 1).

Potato

Potato tuber moth monitoring in Theis, Naiyes and Notto

Sally Miller, Bob Gilbertson, George Mbata, Emile Coly, Kemo Badji

Cultivation and storage of potatoes in Senegal has been severely hampered by the tubermoth. This situation was exacerbated after 2007 efforts by ISRA to produce, multiply and acclimatize third generation potato seeds were hindered by the potato tubermoth. The present study focused on understanding the on-farm dynamics of the tubermoth population, postharvest incidence of tubermoth in stores, and residual on-farm populations of the tubermoth in farms following harvesting of potato tubers.

Traps baited with synthetic (PTM) lures were used in monitoring moth populations in 2011 and 2012. The commercial formulation is dispensed on a rubber septum in 1*mg* doses of the active product. The PTM lures used in this study were obtained from ISCA Technologies, Riverside, CA 92517. The PTM lures from ISCA Technologies had high isomeric purity pheromone and were loaded in controlled release rubber septa dispenser.

Surveys were carried out to determine the incidence and abundance of potato tubermoth in select potato plots in Theis and Naiyes areas. The approximate location of the experimental area was N: 14°52' 10.4" and W: 17°08'09".7 and the distance from Dakar is 87.8 km. The experimental plots measured 3.86 hectares. The surveys involved trapping male tubermoths with plastic delta traps baited with PTW lures formulated by ISCA Technologies. Each trap had an internal disposable permanent glue liner that provided large active surface for the trap. Dimensions of the traps were 28 x 20 x 15 cm. Though the traps came in different colors, those used in the current study were white in color.

Trapping potato tubermoth in experimental plots

Seeds potatoes were planted in experimental plots in mid-November 2011, and harvesting of the potatoes took place in May 2012. The potato seeds used were imported from Holland. Traps were deployed by the third week of January when the vines of the potatoes were about 12 cm above ground surface. The traps were suspended about 1 m above the ground surface using wooden stakes. Sixteen traps were deployed per hectare, and this trap density was lower than those found to be successful in massive trapping of males of potato tubermoth. The traps were inspected every week and number of moths caught were recorded. The sticky liners of the traps were replaced every two weeks, while the septa impregnated with the pheromone were discarded every eight weeks. Trapping of male moths lasted 26 weeks. The duration of trapping in the plots included a post harvest period of 12 weeks. The post harvest period was included in order to determine if the density of moth will thin down following harvest of potatoes.

Evaluation of potato tubers in experimental plots left after harvest

Following the termination of the trapping experiment, potato tubers abandoned on the farm plots were picked up and placed in insect rearing cages in DPV entomology laboratory. Potatoes weighing about 1 kg were placed in one cage and 5 cages were set. The laboratory temperature ranged from 25.0 and 28.7°C, while the relative humidity ranged between 63 and 73%. The cages were monitored for emergence of the moths every two weeks for two months. The moths were counted and recorded.

Trapping of potato tubermoth in potato stores

Potato storage facilities in Senegal are small brick warehouses of dimensions 30ft W x 90ft L x 15ftH. The warehouses had a steel door and 6 windows of dimensions 1.5H x3ftL, which were covered screen mesh for aeration. These warehouses are owned by cooperatives and famers within the group stored their potatoes for a short period of time to allow prices to appreciate. Tubermoths were monitored for the period warehouses had potatoes, which was between the last week of May and the first week of July, 2012. ISCA Technologies delta traps with the PTM lures were used to monitor incidence of moths in these facilities.

Both trapping data and emergence numbers were analyzed using analysis of variance to determine variations in the incidence of moths caught over time and numbers of moths emerging from potato tubers abandoned in the experimental plots. Prior to analysis, all data in percentages were arcsine of square root transformed.

Tubermoths trapped in cultivated potato plots were very low during 2011 farming season and had means below 5 males per trap. However, during 2012 farming season, the tubermoths were more abundant and the highest number of moths were trapped in February and the lowest incidence in July. The population of the moth peaked four times: February, April, May and June. The last peak of the population occurred in June, two months after potatoes had been harvested. Statistical analysis using ANOVA showed a significant difference among the mean numbers of trapped moths. Moths continued to be trapped in the potato plots after potatoes were harvested but the population tapered after harvest.

Trapping of moths in potato stores

The number of moths trapped in stores containing newly harvested potatoes was highest during the first week

following which the number dropped in subsequent weeks. The mean weekly numbers of moths trapped in the stores varied between 1.0 and 7.8 per trap but these numbers were not significantly different.

Moths that emerged from tubers abandoned in farms

Tubers that were abandoned in farms after harvest were collected and placed in cages in the laboratory where emergence of the moths was observed. The mean weekly moths emerging from each of 4 cages ranged between 17.1 and 80.5.

Cabbage

Develop and implement an IPM package for cabbage in Senegal

Doug Pfeiffer, Dieynaba Sall

Cabbage survey in Niayes area

The survey was done in North Niayes, in the Louga region (Potou) and Saint Louis region (Rao), Niayes Centre (Thies : Mboro. Fassboye, Diambalo, Jender, Notto Gouye Diama and Lompoul) and in South Niayes Dakar: Gorom, djenderkayarmalika, Keurmassar). The participatory approach was used on Niayes growers union association (AUMN) members and completed by observations at farms. The sites devoted to cabbage are of the traditional family type. Cabbage sowing period is between September and February. The transplantation is done 25 to 35 days later, when the healthy and strong young plants have 5 - 6 leaves.

In terms of varietal preferences, about 78% of the respondents use 'Tropica Cross' and about 16% like 'Santa' in the rainy season because those varieties are adapted to wet and warm conditions and are more tolerant to cabbage pests and diseases, contrary to the other varieties.

Many constraints are indicated by farmers in cabbage production: pest and diseases, marketing, access to the financing, availability of effective pesticides, human resources, training and the access to land especially for women. In the hope of solving these problems, the producers are ready to adopt proposed IPM packages which complement FAO IPM projects (GIPD).

GHANA

Tomato

Dynamics of whitefly populations and of the biotypes

Carlyle Brewster, Michael Osei

Sampling of whitefly populations in tomato cropping systems was based on the three regions identified for implementation of tomato IPM program. Samples of adult whiteflies were collected from infested tomato plants from tomato growing areas of Brong Ahafo (Tuobodom and Tanoso), Ashanti (Agogo and Akumadan) and Upper East (Tono, Vea and Pwalugu) regions. Adult whiteflies were placed into plastic tubes containing 95% ethanol and stored at - 20oC for molecular studies.

Tomato IPM package

Bob Gilbertson, Michael Osei

The study is to introduce alternative pest management technologies other than use of conventional pesticides to farmers through farmer-researcher participatory approach. By this approach it is expected that the IPM technologies generated together with the farmers would reduce the use of noxious conventional pesticides in the management of vegetable (tomato) pests, thus making vegetables safer to produce and eat. In this activity, data from last year's tomato IPM trials across the seven locations in the three regions were analyzed and discussed. Data were collected on percent plant establishment, days to flowering, mean plant height at flowering, fruit set and fruit abortion/drop, level of insect injury, especially fruit borers per plot and yield assessment were subjected to analyses of variance (SAS Institute, 2005-2008).

The package was also extended to many other farmers as a way of technology transfer to tomato farmers at Tanoso in the Brong Ahafo region of Ghana. The trials were conducted in two locations at Tanoso. The nursery for the trials was established on 20 July 2012 and seedlings were transplanted three weeks thereafter. The nursery bed was heat-sterilized by burning dried wood shavings on it as against farmers' practice (no sterilization). Seeding was done the following day. Four tomato varieties; Shasta, Heinz, OP-B155, OP-B149 were obtained from the US and a local control variety, Power Rano resulted in a total of five treatments; these were transplanted on ridges and replicated three times resulting in fifteen plots of 10m x 3 m each at two locations. Seedlings were transplanted at a spacing of 100 and 50 cm between and within rows at both locations.

Results from **Agogo** revealed that the number of days to first flowering, number of days to 50% flowering, number of days to 100% flowering, number of fruit borers per plot, number of lodged plants per plot as well as the fruit weight did not show significant differences among the four varieties. However, significant differences were observed for plant height, number of s per plant, number of plants infested with aphids, dropped fruits and the number of fruits with borer holes across the varities. The greatest plant height was recorded from 'Peto fake' and 'Power rano' whilst 'Shasta' recorded the least. Many fruits were also recorded on 'Peto fake' with least being on 'Shasta'. 'OPV2', however recorded the highest aphid population with the lowest on 'Peto fake'. Generally, all the parameters studied recorded a decrease over farmers practice with the exception of fruit weight which showed a reverse trend. More fruits were recorded from the farmers' fields compared with those from the researchers'. Thus the lesser number of fruits from the researchers' fields were compensated by weight of individual fruit.

At **Akumadan** the number of days to first flowering, number of days to 50% flowering, number of days to 100%, flowering for number of fruit borers per plot and number of lodged plants per plot did not show significant differences among the four varieties. However, significant differences were observed for plant height, fruit weight, number of fruit per plant, number of plants infested with aphids, dropped fruits, the number of fruits with borer holes and fruit weight across the varieties. For plant height, the highest was recorded from 'Peto fake' and 'Power rano' while 'Shasta' and 'OPV2' recorded the least. Fruits with the heaviest weight were taken from 'OPV1' followed by 'Peto fake' and 'Power rano' with the least from 'Shasta'. Least fruits per plant basis were also recorded on 'Shasta'. 'Power rano', however recorded the lowest aphid population followed by 'OPV1' while the rest of the varieties having significantly high population.

At **Tanoso** no significant differences were observed among the four varieties for parameters such as the number of days to first flowering, number of days to 50% flowering, number of days to 100% flowering, fruit weight and number of lodged plants per plot. However, significant differences were observed across the varieties for plant height, number of fruit per plant, number of fruit borers per plot, number of plants infested with aphids, dropped fruits and the number of fruits with borer holes. For plant height, the highest was recorded from 'Peto fake' and 'Power rano' whilst the three other varieties, 'Shasta', 'OPV1' and 'OPV2' recorded the least. Least number of fruits was also recorded on 'OPV2'. 'OPV2', however recorded the highest aphids population followed by 'Power rano' whilst the least was on Shasta'.

At **Tuobodom** all the parameters measured showed significant differences among the four varieties with the exception of plant height, number of fruit borers per plot, number of lodged plants per plot and number of fruits dropped. For parameters such as the number of days to first flowering and number of days to 50% flowering 'Shasta' recorded the highest whilst 'OPV2' was the least. It took 'Shasta' about 57 days to attain 100% flowering while 'OPV2' took 49 days to attain 100% flowering. 'OPV2' produced the number of fruits with the least being produced from 'Shasta'. However, number of plants infested with aphids was highest with 'Peto fake'. The highest fruit weight was recorded from 'Power rano' whilst the least was from 'Shasta' and 'OPV2'.

At **Vea** there were significant differences among the four varieties for the parameters measured such as number of days to first flowering, number of days to 50% flowering, number of days to 100% flowering, plant height as well as the fruit weight. 'Shasta' and the Local variety were the first to flower while 'OP B155' was the last. Plant height was highest in 'Shasta' with 'OP B149', 'OP B155' and the Local variety being relatively shorter. 'OP B155' had the heaviest fruit while the lightest were on the Local variety. The following parameters: number of fruits per plot, number of fruit borers per plot, number of lodged plants per plot and number of fruits dropped however, did not show any significant differences among the five varieties.

Similarly at **Tono** there were significant differences among the four varieties for the parameters measured such as number of days to 50% flowering, number of days to 100% flowering, plant height as well as the fruit weight. 'Shasta' took relatively fewer days to attain 50% flowering whilst 'OP B155' was highest with 47 days. Plant height was highest in 'Shasta', 'OP B155' and the Local variety being relatively shorter. Again 'OP B155' recorded the heaviest in terms of fruit weight whilst the least was the Local variety. The following parameters i.e. number of days to first flowering, number of fruits per plot, number of fruit borers per plot, number of lodged plants per plot and number of fruits dropped, however, did not show any significant differences among the five varieties.

Tomato varietal screening for resistance to nematodes.

The trials were conducted at four locations at Tanoso in the Brong Ahafo region during 2012 minor season. Tomato is intensively cultivated in this area. The nursery for the trials was established on 20 July 2012 and tomato seedlings were transplanted three weeks thereafter. The nursery bed was heat sterilized by burning dried wood shavings on it. Four tomato cultivars; Shasta, Heinz, OP-B155, OP-B149 obtained from the US and a local check, Power Rano making a total of five treatments were transplanted on ridges and replicated three times resulting in fifteen plots of 10 x 3 m each. Seedlings were transplanted at a spacing of 100 and 50 cm between and within rows at Loc 1 and Loc 2 and 100 and 25 cm at Loc. 3 and Loc. 4 respectively. Basal fertilizer (NPK-15:15:15) and the insecticide acetamiprid (Golan) were applied at the rates of 5 bags/ha and 30ml/16 l of water respectively at 2 weeks after transplanting.

Soil samples, 200cm^3/plot were randomly taken from each plot before transplanting of tomato seedlings. Three plants per plot were chosen randomly for sampling. The three soil samples collected from each plot were mixed homogenously to constitute a composite sample. Each soil sample was poured into a black polythene bag, sealed and labeled. Samples were kept in iced chest to prevent excessive heat during transit. In the laboratory, nematodes were extracted from the soil samples using the modified Baermann funnel technique. Five tomato plants per plot were sampled at harvest and the root system rated for gall index according to the Zeck's 0-10 scale.

Motile stages of the nematodes were also extracted from 5 cm^3 of tomato root samples (five samples/treatment) using the same method from the same root system used for gall indexing. The root samples came from the very tomato plants whose rhizosphere-soil was sampled. After 24 h of extraction, nematodes were relaxed in warm water (60ºC) for 3 min and fixed with 40: 1: 89 (formalin: glacial acetic acid: distilled water) solution. Second, third and fourth stage nematodes were mounted on aluminium double-cover-glass slides and specimens were identified using morphological characteristics such as the spear, head skeleton, lumen of the oesophagus, excretory pore and spicules. Nematode count and index based data were normalized using logarithmic ($Log_{10}(x+1)$ and square root $\sqrt{(x + 0.5)}$ transformation respectively prior to analysis of variance using GenStat 8.1. (Lawes Agricultural Trust, VSN International). Means were compared using Fisher's protected Least Significant Difference (LSD) test at ($p < 0.05$).

Four plant parasitic nematodes have been identified from initial soil samples. They were: *Meloidogyne* spp., *Pratylenchus brachyurus, Helicotylenchus multicintus* and *Tylenchorhynchus* spp.

Serological detection of *Tobacco mosaic virus* (TMV) and *Cucumber mosaic virus* (CMV) on tomato

Four tomato growing locations in Ashanti (forest ecological zone) and Brong-Ahafo (forest-transition) regions were surveyed for the presence of TMV and CMV. The locations were Agogo and Akumadan (Ashanti region) and Tuobodom and Tanoso (Brong-Ahafo region). Also in the Upper East region, three locations were assessed for the presence of the tobamovirus and cucumomovirus. These were Vea, Tono and Pwalugu.

In Ashanti and Brong-Ahafo regions, four farms in Tuobodom, and three farms each in Tanoso, Agogo and Akumadan were assessed for the presence of the viruses. In the Upper East region, three farms were assessed at Vea, six farms at Tono and one at Pwalugu. In the Upper East region some farms in certain locations especially Pwalugu were heavily flooded making disease assessment virtually impossible.

Infected leaf samples were collected from plants showing obvious symptoms and placed in ice chest containing ice cubes. Three to five samples were collected for each location. These were sent to the laboratory for serological diagnosis using Agdia immunostrip (a lateral flow immunoassay technique).

Sample extraction bags containing SEB1 buffer were cut open with scissors along the top of the labels. These were bags for both TMV and CMV detection. A section of the diseased leaf sample was inserted between the mesh linings near the bottom of the sample extraction bag. Sap from the sample was extracted by rubbing gently between the mesh linings with a blunt object. The sap extracted had a light brown to green color. The Immunostrip from Agdia Inc. was then inserted into the channel portion of the buffer filled bag and allowed to remain in the sample extract for about 30 minutes. Samples which tested positive had purple lines similar to that of the control lines and those that tested negative did not have the test lines appearing.

Field incidence and severity of CMV and TMV were difficult to quantify using visual symptoms as symptoms caused by Tomato yellow leaf curl virus, TMV and CMV did overlap in most cases. However, in locations where the two viruses were identified, incidence was estimated to range from 0.0 - 53% and this is shown in Table 8. Severity scores were based on a 5-point scale of 1-5 where 1 represented apparently no symptoms, 2 - slight infection, 3 – moderate infection and 4 – severe infection and 5- very severe infection.

CMV was detected at all the locations (except Pwalugu) surveyed in the three regions of Ghana which lie in the forest, forest-transition and Guinea savannah zone while TMV was detected at Tuobodom (forest-transition), Vea and Tono (Guinea savannah). Mixed infections were detected at Tuobodom, Vea and Tono. Incidence and severity of CMV were high for two farms assessed at both Agogo and Tuobodom and one farm each at Vea and Tono while incidence of TMV was high at one farm each at Tuobodom and Tono. The immunoserological detection of CMV and TMV in all the locations surveyed at the Ashanti and Brong-Ahafo region regions give an indication of a potential widespread occurrence of the two viruses in important tomato growing areas in the two regions.

Cabbage

Survey with cabbage farmers and their results across the selected areas

Doug Pfeiffer, Michael Osei

The study aimed at determining farmers' production practices and problems to cabbage production to assist in introducing integrated pest management (IPM) strategies/packages to some selected communities with the hope of minimizing the unsafe use of agro-chemicals in the production of cabbage in Ghana.

A questionnaire was designed to elicit information from cabbage farmers in Ashanti and Brong Ahafo regions of Ghana. This was pretested at Kwadaso, a suburb of Kumasi. Visits were made to the capitals of two administrative regions of the country. Three communities from each region: Ashanti; Asiwa in the Bosome Freho district, Gyinyase near KNUST and Tanoso both in the Kumasi Metropolis, Brong Ahafo region; Berekum, Dorma Ahenkro and Sunyani municipalities were randomly sampled and questionnaire was administered to twenty cabbage farmers from each location. Basically, the questionnaire dealt with the biodata of respondents, cabbage production system in those areas, varieties grown, sources of seeds used to establish fields, disease and arthropod pest problems, pesticides and other practices used to control disease or arthropod pests and the yields that are typical of the area. This information would be used to assess the best time to implement IPM packages.

A total of 10 communities were covered from three districts in the Ashanti region, while 23 communities were covered from three districts in the Brong Ahafo region. It was observed that more communities in the Brong Ahafo region were involved in cabbage production compared with their Ashanti region counterparts. It was observed that two varieties of cabbage, 'KK Cross' and 'Oxylus' were cultivated by farmers with 99% of them obtaining their supplies from credible sources - Agro input dealers.

Most of the respondents (98%) raised seedlings for transplanting in the field. Major nursery operations included method of soil sterilization, method of sowing seed on the nursery bed, post emergence practices and length of time seedlings spend on nursery beds. The most popular sterilization method was burning slashed weeds before bed preparation (26%) while the least popular was digging up soil and exposing to the sun (0.9%). Drilling was the most popular method of seed sowing at the nursery (approximately75%) while the least employed method was dibbling (approximately (4%). Significant post emergence operations were; raising of sheds over seedlings to protect seedlings from direct sun energy (42%), hand weeding (40%), covering of seedlings with net to prevent insect injury (approximately 4%), thinning out of seedling to prevent etiolation (0.9%) and applying pesticides to protect seedlings from pest injury (12%). Farmers transplanted seedlings at different stages of growth. Approximately 48% transplant at 3 weeks of age, 44% at 4 weeks with the longest time of 6 weeks being practiced by approximately 4% of farmers.

Three land preparation methods and various planting distances were employed by respondents. The three methods were: planting on the flat, on raised beds and ridges. Most farmers, 69 representing (approximately 62%) planted on raised beds whilst 20 farmers (18%) planted on ridges. Of the 15 different planting distances used by farmers, (75 x 45 cm) was the most popular as 30 farmers representing (approximately 30%) practiced that.

The majority of farmers, 104 (approximately 96%) use fertilizer in cabbage production. Inorganic fertilizer, particularly NPK is used by about 53% of the farmers. Most of the farmers, (approximately 53%) apply fertilizer three times before harvesting of crop.

Various weed species were encountered on cabbage farms but the most prominent were: spear grass, *Chromolaena odorata*, elephant grass, *Centrosema pubenscens* and Asase ne aboo (local name). Three methods of weed control were employed; hand picking, use of garden tools such as hoes or hand fork, and application of herbicides. As many as 68% used garden tools whilst as few as 3% used herbicides.

Caterpillars, aphids, whiteflies and grasshoppers are predominant pests. Pesticide application is the most popular insect control method. Depending on the pest pressure majority of the farmers apply pesticides more than four times before harvesting of crop.

Nematode infestation resulted in stunting of growth, yellowing of foliage, galling of the root system, and reduction in yield. Approximately 66% of the farmers knew about nematodes

and 58% control nematodes with chemicals, 18% do not control them and 3% use neem extracts.

Cabbage IPM trial

An IPM trial on cabbage production under rain-fed condition was conducted from June 2012 at Asiwa in Bosome Freho district, Ashanti regions. The design was a Randomized Complete Block consisting of three treatments replicated three times. The treatments were planting on the flat, planting on raised beds and planting on ridges. Healthy cabbage seedlings were transplanted from the nursery to the main experimental fields/plots on 25 July 2012. The cabbage variety used for the trial was 'Oxylus'. Every pest management intervention was preceded by regular monitoring of pest population increase that warranted chemical intervention. This idea of pest monitoring was imparted to the farmers as against the calendar spraying they are used to.

Data collection started two weeks after transplanting and it is on-going. Data being collected include insect pest population, plant damage and yield. Yield assessment will be done based on the heads per bed which would be weighed at harvest.

Evaluation of land preparation methods on nematode density and yield of cabbage

Two field trials were conducted at Asiwa deciduous forest agro-ecological zone and Dormaa Central districts of the Ashanti and Brong Ahafo regions of Ghana respectively. The variety 'Oxylus' which is commonly cultivated at both locations was used in the study.

At Asiwa, the nursery was established on 26 June and seedlings transplanted on 25 July 2012. The nursery bed was heat sterilized by burning dried wood shavings on it and seeding was done the following day. Nursery bed sterilization was done to control nematodes, soil arthropods and weeds. The bed was covered with gauze material after nursing the seed to prevent insect damage.

Three treatments of land preparation methods were used. These were transplanting of cabbage on the flat, ridges and raised beds and were replicated three times resulting in nine (9) plots of 6 x 6 m each. Seedlings were transplanted at 60cm and 60 cm between and within rows. Plant height, six plants per treatment was taken at two (2) weeks after transplanting. Sampling for nematodes was done as explained earlier in the tomato nematode control trial. Plant height at 2 weeks after transplanting (WAT), plant density/treatment, leaf width at 4 WAT and nematode density from initial soil samples have been taken but yet to be analyzed. However, four species; *Meloidogyne* spp., *Pratylenchus brachyurus*, *Helicotylenchus multicintus* and *Rotylenchus reniformis* were encountered