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RECONNAISSANCE STUDY OF INSECT-PESTS INFESTATION OF GARDEN EGGS IN THE VOLTA REGION OF GHANA

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A B S T R A C T

Garden egg is a widely grown vegetable in Ghana, especially in the Volta Region where it is either cultivated in home gardens or in peri-urban environments. Cultivation of the crop in the Region is however severely constrained by insect pest infestation. This study assessed the severity of insect pest infestation and farmers' coping strategies to infestation by these pests in the Afadzato South and North Dayi districts of the Volta Region of Ghana. Field observations and community level discussions were employed in data collection from a total of 120 farmers and 3 agri. extension agents. Field surveys identified shoot and fruit borer (*Leucinodes orbonalis*) infestation as the main insect pest constraint on garden eggs in the two study areas. Other pests observed on farmers' fields included *Calpodes ethlius* (leaf roller), *Caelifera* spp. (grasshopper), *Caenurgina erechtea* (Larvae), aphids (Aphidoidea), thrips (Thysanoptera) , *Tetranychus urticae* (red spider mites) and white flies (Aleyrodidae). Farmers' main coping strategy to the infestation of their fields by these pests was the repeated application of broad spectrum chemical insecticides such as Lambdacyhalothrin Deltamethrin, Acetamiprid, Chlorpyrifos-Ethyl, Cypermethrin and Dimethoate. Vascular wilt caused by the bacteria *Rastolnia solanacearum*, eggplant mottled dwarf virus and root knot nematode infection were also identified as constraints to garden egg production in the two areas. Varietal development, a formal and well regulated seed system and the development and promotion of integrated pest management (IPM) strategies is required.

Keywords: Garden eggs, *Leucinodes orbonalis*, High incidence, Broad spectrum insecticides

INTRODUCTION

The Vegetables are an integral part of diets worldwide and a reliable source of vitamins, minerals, and plant proteins. Indigenous vegetable crops such as garden eggs (*Solanum aethiopicum*) are focal crops for most nutrition, food security and poverty reduction programmes (Hartmann, 2010). Garden eggs is widely cultivated across the Greater Accra, Ashanti, Brong Ahafo and Volta Regions of Ghana either in home gardens or in peri-urban environments such as lowlands naturally flooded by rainwater or freshwater streams or on small fields around towns and villages. The cultivation of these short duration vegetables throughout the year represents an important uninterrupted source of vegetables to consumers and daily ready cash income for low income farmers and adult female members of farmers' households who are mostly at the forefront of garden eggs harvesting and marketing. Due to the fact that, there is a ready market demand and year-round production of garden eggs in Ghana, it is a commodity that contributes to poverty alleviation and livelihood diversification of poor rural and peri-urban households. Horna (2006) reported that the average yield of the crop in Ghana was 9,9213kg per hectare, yielding a gross margin of GHS1, 267.3 per

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hectare. Output of the crop has however been severely constrained by infestation of *Leucinodes orbonalis* (the eggplant shoot and fruit borer) and other pests and diseases. According to Latif *et al.* (2010), *Leucinodes orbonalis* is the major pest that attacks garden eggs and its damaging effect is realized on almost all garden egg fields (Dutta *et al.,* 2011). Yield reduction attributable to L. orbonalis can be as high as 70 % (Islam & Karim, 1991; Dhandapani *et al*., 2003). Due to the ability of this pest to cause high yield losses to garden eggs, farmers usually spray large volumes of chemical pesticides at frequent intervals in an attempt to control the pest. This practice has adverse effects on crop production costs as well as on human and environmental health. In view of this, the development, promotion and adoption of integrated pest management strategies that will engender a reduction in chemical pesticide abuse has become essential for sustainable garden eggs cultivation in the Volta Region and in Ghana as a whole. Ensuring that IPM strategies to be developed and deployed are targeted at the appropriate constraints and are in sync with the cultivation practices of garden eggs farmers in the Volta Region will greatly enhance the possibility of its adoption by farmers. To this end, a reconnaissance survey was undertaken to identify the major insect pest constraints to garden eggs cultivation and the coping strategies adopted by farmers to mitigate the infestation of these pests on their farms.

MATERIALS AND METHODS

Profile of study locations: Although the Ministry of Food and Agriculture, has reported that the Afadzato South and North Dayi of the Volta Region are major garden eggs producing districts in Ghana, no data exists on the volume of garden eggs produced annually in these areas. These locations were selected based on reports of fruit and stem borer infestations.

The North Dayi district lies within latitudes 60 20'N and 70 05'N, and Longitude 00 17'E. It shares boundaries with Kpando Municipal to the north, and the South Dayi District to the south. It is bordered on the East by the Afadzato South District. The Volta Lake, which stretches over 80km of the costal line, demarcates the western boundary of the district. The district covers a total land area of 462.8 square kilometres with almost 30 percent of the land being submerged by the Volta Lake. The climate of the district is tropical equatorial and is greatly influenced by the southwest monsoon wind from the south Atlantic and dry harmattan winds from the Sahara. There are two rainy seasons, the major one from mid-April to early July and the minor one from September to November. The average annual rainfall ranges from 900mm to 1300mm. The average annual temperature of the District is about 27°C whereas the daily mean temperature ranges from 22° C to 33° C with an average relative humidity of 80 percent. This climatic condition is favourable for agricultural activities in the district. The vegetation of the District is a mix of Guinea Savannah Woodland and Semi-Deciduous Forest. The population of North Dayi District is 39,913 representing 1.9 percent of Volta Region's total population. Females constitute 53.3 percent and males represent 46.7 percent. Sixty seven percent of households in the district are engaged in agriculture. Most households in the district (91.3%) are engaged in crop farming while 47.1 percent are engaged in livestock rearing. Poultry (chicken) production is the most dominant livestock farming activity accounting for 58.8 percent of the total livestock in the district. The district is well noted as a major garden egg producing area in Ghana with major growing areas such as Jordan-Nu, Aneta, Vakpo and Dunyo among others (GSS, 2010). The Afadzato South District shares boundaries with the Republic of Togo to the East, Ho West District on southeast. The southwestern part of the District shares a common boundary with the South Dayi District; while on the northern section shares a boundary with Hohoe Municipal. The northwestern part of the district is bordered by Kpando Municipal and the North Dayi District. The total land area of the District is 553.0 square kilometers. The District lies in the wet semi-equatorial climatic zone. Annual rainfall is between 1,016mm- 1,210mm with an average of four to five (4-5) months dry season experienced between November and April. The usual rainfall pattern of double maxima regime has gradually changed, giving a long stretch of rainy season starting from late April and ending in October. Temperatures are high throughout the year and range from 26ºC during the coolest months to about 32ºC in the hottest month, usually just before the rainy season. Mean monthly temperature is about 29˚C. The district is located in the forest-savannah transitional ecological zone of Ghana. The pre-dominant vegetation found in the District is Semi-Deciduous Forest and Guinea Savannah Woodlands. The population of Afadzato South District, according to the 2010 Population and Housing Census, is 95,030. Males constitute 48.7 percent and females represent 51.3

percent. The Urban–Rural divide is 18.7 and 81.3 respectively and has a sex ratio of 94.9. The age group 0-14 forms 38.5 percent of the Districts population; this implies that the District's population is youthful. More than half (72.8%) percent of households in the District are engaged in agriculture. In rural localities, more than eight out of ten households (85.3%) are agricultural households while in the urban localities, 14.7 percent of households are into agriculture. Most households in the District (94.8%) are involved in crop farming. Poultry (chicken) is the dominant animal reared in the District. The district is a major garden eggs producing area, with communities such as Tafi Abuife 1 and 2, Have, Have Ando 1 and 2 and Sadzikofe being major garden eggs cultivating areas (GSS, 2010). Sampling: The study employed qualitative methods such as field observations and community level discussions in collecting the relevant data. Two community level discussions (Abuife and Have-Ando) were held with garden eggs farmers in the Afadzato South and North Dayi districts. Two (2) communities were selected in each District on the basis of estimates of garden eggs production volumes. Thus there were four communities in all. These communities were Have and Kpeve for North Dayi and, Tafi Abuife 1 and Have Ando 2 for Afadzato South. Thirty farmers were randomly selected from a purposive pool of garden eggs farmers in each of the selected communities. A list of all garden eggs farmers was obtained from the agricultural extension agents in the various communities. The total sample size was therefore 120 farmers restricted by time and available resources. Information was solicited using a checklist developed in collaboration with the agricultural extension agents in the communities and the regional agricultural directorate in the Volta Region. The development of the checklist was guided by information received via the Research Extension Linkage Committee (RELC) report submitted to the West Africa Agricultural Productivity Programme (WAAPP) on the state of garden eggs production in the study areas listed above. Results presented in this paper reflects consensus that farmers built during the community level discussions. Farmers' response to checklist questions were coded and analysed using SPSS version 22 (IBM, corporation, USA). Frequency counts and percentages were used to describe the socio-demographic profile of respondent farmers and also summarize responses to questions regarding agronomic and pest management practices. With regards to field observations and field data collection, five (5) fields were selected in each location to observe the damage caused by the pest and to identify potential factors or farm practices that were facilitating the infestation of farms by pests. Representative samples of infested plants were collected in zip-lock bags and transported to the laboratory where pest species were recovered and identified.

RESULTS AND DISCUSSION

Socio-demographic characteristics: A total of 120 garden eggs farmers were sampled across the two study areas; Sex distribution of respondent farmers showed that 76.7% were males and 23.3% were females. In as much as MOFA-WIAD, (2002) estimates that women contribute 52% of the agricultural labor force, in Ghana, farmers perceived the male to female ratio for every 100 farmers in garden eggs production was 70 and 30 respectively. This supports the long held view that, farming in Ghana is the preserve of men. Garden eggs just like other vegetable crops, were cultivated mostly during the rainy season from April to June. This coincides with the period described by Nsowah (1969) as the major season (March to July). Farm sizes ranged from 1.5 acres to 10 acres across locations with a mean of 2.5 acres.

Field Observations

Cultivation Steps: The garden eggs farmers outlined eight major steps in their garden eggs production cycle; from conception of the idea through cultivation to packaging. After land acquisition, the land was slashed and burnt. After removing stumps that are not fully burnt, a tractor drawn plough tills the field. Nurseries were raised on beds and seedlings were transplanted 4 to 6 weeks after germination. After transplanting, weeds were controlled manually by hoeing. Fertilizer was applied as and when the farmer deemed fit. Spraying of pesticides was also undertaken following signs of pest infestation on garden eggs plants. Harvesting was done 2 to 4 months after transplanting and packed in sacks. With the exception of irrigation, the seasonal garden eggs activities outlined above are similar to that reported by Chen & Li (2008). Garden eggs cultivation in the study area was rain-fed, exposing the potential harvest of farmers to the vagaries of prevailing weather conditions.

Agronomy: The plant spacing (4ft by 4ft) adopted by the farmers was more than the recommended spacing of 2.95ft? by 2.95ft?) (MoFA PG, 2011). Plant population per hectare was therefore less than optimum. The resultant effect was high prevalence of weeds and low yields. Kogbe (1983) reported that, the number of fruits per plant and fruit weight increased at the widest spacing but the number of fruits per hectare and fruit weight per hectare increased at closest spacing. Wide spacing can however contribute to low infestation of pests and diseases because the wide spacing does not create favourable conditions for pyralid moths to build up (Owusu-Ansah *et al.,* 2001, Naik *et al*., 2008). In the study areas however, although wide spacing was adopted by farmers, pest infestation was observed to be high. . Farmers applied inorganic fertilizers to improve soil fertility. However, they were not properly administered. The recommended fertilizer application rate was 2-3 split applications of 250kg to 400kg/ha of 15-15-15 N.P.K compound fertilizer and side dressing at 4,8,12 and 16 weeks after transplanting and after each harvest, 5g/plant of Potassium Nitrate (400g/ha) (MoFA PG, 2011). It was observed that farmers rather applied 200kg of N. P. K and 100kg of Urea per acre. Thus, 500kg of N. P. K and 250kg of Urea was applied in 2 splits per hectare. Aminifard *et al.* (2010) observed that increasing the N levels of fertilizer to 50 kg N per hectare significantly increased the yield of garden eggs while yield decreased at the highest rate of nitrogen. In addition to inorganic fertilizers, farmers used foliar fertilizers. In a few instances, some farmers mixed these foliar fertilizers with insecticides before applying them. The rationale for doing this was to save time. Farmers that applied foliar fertilizer and insecticide mixtures were of the view that it increased the efficacy of both agrochemicals. Petroff (2003) suggested that, combining pesticides with other toxicants, fertilizers, and additives can cause synergic, additive, and antagonist interactions. Farmers reported that they had no means of determining whether the chemicals they were combining in the mixtures were compatible or not. Inadequate water supply to plants was evident in farmers' fields as most of the plants showed signs of wilting. Farmers attributed this situation to the erratic rainfall distribution in the area and the declining volumes of rainfall, reduction in fruit yield, fruit quality, irregular plant vegetative development and decrease in photosynthetic activity in garden eggs has been attributed to water stress (Paksoy & Akilli; 1994; Esiyor & Eser, 1998; Czarnowski 1995). Respondent farmers attributed the high incidence of pests to low soil fertility and low rainfall. Farmers were of the opinion that frequent rainfall prevents pests from multiplying. About 15%of the farms inspected were rated as very weedy. In most cases, farm sanitation was poor possibly affording pests alternate breeding sites and shelter.

Variability in garden eggs in the study area: Variability in the garden eggs regarding two leaf and seven fruit characters, flower per inflorescence and plant height were studied from farms in the study communities using eggplant descriptors (IBPGR, 1990). Variability within farms were observed for all the eleven traits.

The leaf characters studied were leaf blade lobbing and tip angle. Within farm variability was high for leaf blade lobbing. Very weak, and strong leaf blade lobbing were observed as shown in Figure 1. Ninety percent farms exhibited a leaf blade tip angle of 45°. The fruit traits studied include fruit curvature, cross section, colour distribution, number of locules and widest part of fruit (Figure 2 to 6) in addition to length and breadth. Fruit length was between 5 and 8 cm across farms. Within farm variability was very high for fruit length and all the other traits studied. Most of the fruits could be classified as intermediate based on their length at the time of the studies.

Fruit breadth was between 3 and 6 cm and showed high within farm variability as well. The fruits could be classified as intermediate to large based on these observations. Three categories were observed in relation to length / breadth ratio. Ten percent were as long as broad, 85% were slightly longer and 5% were twice as long. Fruit curvature, except for one farm where slightly curved fruits were found on few trees, all fruits observed were straight. In terms of fruit cross section, 3 classes namely circular, few grooves and many grooves were observed. Regarding colour distribution, 92% of mature fruits were uniform cream to white, however few were observed to have green stripes. Fifteen percent fruits picked were observed to have a locule in the middle of the fruit in addition to those to the periphery.

All plants had one flower per inflorescence which resulted to one fruit per inflorescence in all farms observed. The position of widest part of fruit varied greatly within farm. The widest part could be near the tip, base or the middle of the fruit. However, some fruits were almost uniformly wide from base to tip. Average plant height was about 100 cm. Some plants were a little taller than others but may be due to field variability and different planting dates. Plant in all farms therefore fell in the 100cm plant height category.

Figure 1. Leaf Lobbing

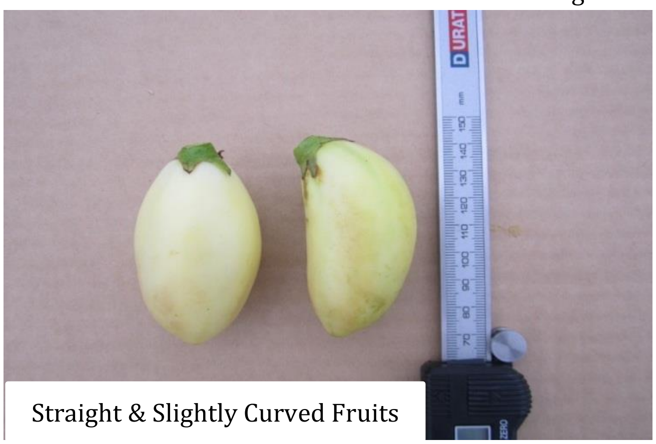

Figure 2. Curved Fruits

Figure 3. Cross Section of Fruits

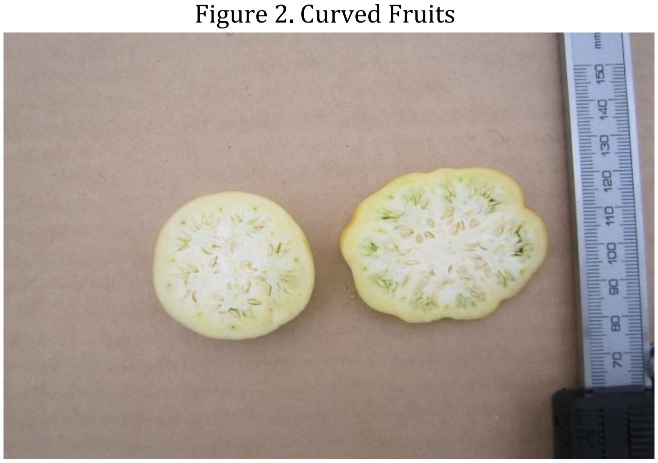

Figure 4. Fruit Color Distribution

Figure 5 & 6 Widest Part of the Fruit

Assessment of Insect pest infestation: The infestation of stem and shoot borer (Figure 7), was very high in almost all the farms visited. Seventy percent (70%) of the farms visited had various level of the pest infestation. The other major pest observed was Calpodes ethlius (leaf roller). In an attempt to control the heavy infestations of pests on their farms, respondent farmers applied broad spectrum insecticides such as Lambda cyhalothrin, Deltamethrin, Acetamiprid, Chlorpyrifos-Ethyl, Cypermethrin and Dimethoate. The frequency of use of these chemicals were reported to be high, with some farmers spraying their farms fortnightly. This trend seems to confirm the assertion by Gerken *et al.* (2001) that, pesticide use in the production of high-value cash crops and vegetables in Ghana, has increased over time. Aside adverse effects on the cost of production and human health, indiscriminate use of broad spectrum pesticides can disrupt the activities of beneficial insects. For instance, farms which showed signs of proliferation of beneficial insects such as the Coccinellidae (lady bird beetles) had low insect pest infestation. It is worth noting that these latter fields had no pesticide application hence the presence of beneficial insects on the field. The broad spectrum chemicals used therefore kills both beneficial insects and pest leaving the fields prone to subsequent pest infestations. There is therefore the need to educate garden eggs farmers on the hazards of indiscriminate use of these broad spectrum chemicals. Farmers were of the opinion that, the presence of pests reduced yield and discouraged production because the pest found its way into the fruit, rendering the fruit unmarketable and causing a yield loss of up to 90 percent (Baral *et al.,* 2006). According to Sharma (2002) the pest reduces the quality of eggplant and also the vitamin C levels in the fruits up to about 80 percent. This coupled with other factors make eggplant production less lucrative hence farmers leave to grow other commodities (Gapud & Canapi, 1994).

Garden egg plant infested with the Egg plant fruit and shoot borer (*Leucinodes orbonalis*)

Leucinodes in the Garden Egg shoot and fruit

Figure 7. Garden egg infested with fruit and shoot borer.

Farmers' knowledge of garden eggs pest and diseases and their control: The pest identified by farmers as being present on their farms and causing damage to their crops and produce were grasshoppers (Caelifera spp.), moths (Caenurgina erechtea), caterpillar (Larva), aphids (Aphidoidea), thrips (Thysanoptera), red spider mites (Tetranychus urticae) and white flies (Aleyrodidae). It is worth noting that similar results were recorded by Avicor *et al.* (2011). These insects either feed on the leaves, stalk/stem, fruits or the roots. The end results of their activities reduced yields and disfigured fruits. The farmers perceived that some of the plants die off at the fruiting stage due to soil borne diseases and no amount of spraying is able to redeem plants in this very case. Famers confirmed that plant diseases, and insect pests are the major problems to realizing the desired output from production. These insect pests and diseases were controlled by spraying chemical pesticides, insecticides and fungicides using knapsack sprayers. Cooper & Dobson (2007), stated that, pesticide use increases crop yield and improves quality of produce by reducing or elimination the effect of pests. Mostly in accordance with the findings of Avicor et al. (2001), farmers affirmed the use of pesticides such as pawa (Lambda-cyhalothrin), combat (Fipronil), attack (Emamectin Benzoate), top cop (Sulphur), K- optimal (Lambda + Acetamiprid) , anti ataa (Imidacloprid), sunpyrifos (Chlorpyrifos-methyl) and cydim (Dimethoate + Cypermethrin) in controlling the insect pests. Dinham (2003) estimated that 87% of farmers in Ghana use chemical pesticides to control pests and diseases on vegetables. These chemicals were purchased from agro dealers in the various market centres within the district and beyond. They used different pesticides and sprayed as many times as possible (up to as frequent as once every week) during a planting season as was observed by Owusu-Ansah *et al*. (2001) leading to insect pests developing resistance. Farmers either sprayed when they see insects appearing on their farms (reactive) or in every week after transplanting (preventive) with the latter being dominant. About 90% of the farmers did not calibrate their machines before using them to apply pesticides increasing the possibility for over- or under-dosing. Farmers also used the same knap sack sprayer in applying weedicides, insecticides, and fungicides on their farms. In the case where they are not well washed after an application there could be mixtures of two or three of the chemicals. This can lead to destruction of crops or food poisoning. Farmers did not also change their preferred pesticides except in cases where the preferred pesticide was not available on the market. Owing to the possible danger pesticides and other chemical could have on humans and the environment, it is vital to ensure that it is used safely else it could lead to direct or indirect poisoning. Ntow *et al*. (2006) alluded to the fact that, about 80% of vegetable farmers surveyed in six (6) regions of Ghana had farm chemical related illnesses ranging from weakness, headache, and/or dizziness. The respondents were duly aware of the negative implication of excess use of pesticides and other chemicals. They perceived that this had negative effects on their eye sight; caused skin irritations and high blood pressure in extreme cases as confirmed by doctors who treated some of their colleagues. Respondents perceived that some chemical residues were present in harvested fruits and that it had negative health implications.

Diseases Assessment: The three diseases identified in the fields were, eggplant vascular wilt caused by the bacteria Rastolnia solanacearum, eggplant mottled dwarf virus disease and root knot nematode infection. Eggplant vascular wilt disease which was observed in 33% the farms had disease incidence ranging from 3-12%. According to Chen & Li (2008), bacterial wilt disease which is severe in the tropics affects eggplant showing symptoms such as yellowing, curling and wilting of leaf; disintegration of stem and root; and dying of the plant. The symptoms initially appeared as a wilt of the upper leaves and then progressed to the lower leaves causing the death of the plant. The farmers tried to control the disease by rouging the infected plants but the debris were left on the farms which served as a source of infection for other plants in subsequent planting seasons. Eggplant mottled dwarf virus (EMDV) is a member of the genus Nucleorhabdovirus in the family Rhabdoviridae (Tordo *et al.,* 2005). According to Martelli *et al.* (2011), it has a genome made up of a linear, single stranded and negative-sense molecule of RNA, contained in enveloped bacilliform particles and transmitted by the leafhoppers; Anaceratogallia laevis, A. ribauti and Agallia vorobjevi (Della Giustina *et al*., 2000; Babaie & Izadpanah, 2003). Eggplant mottled dwarf virus disease was present in 25% of the farms investigated. Infected plants looked stunted had short internodes with mottled and crinkled leaves which were likely to reduce photosynthesis. The incidence of eggplant mottled dwarf virus disease in the farms was low and ranged from 1 -3%.

Root knot nematode infection caused by Meloidogyne spp. was observed in only one farm with the infestation limited to a very small area. The infected plants appeared stunted with short internodes and galls on the roots which could impede nutrient absorption and reduce yield (Luc *et al.,* 2005). Apparently the farmers were not aware that the root knot nematode infection was soil borne. The farms surveyed were routinely sprayed with fungicides such as Mancozeb and Golan to protect the plants from diseases. However, the indiscriminate use of these fungicides could impede their effectiveness and cause damage to the soil. In applying the chemical, a certain quantity may stray into nearby and underground water bodies which could lead to mutation in or loss of aquatic life. (Wightwick & Allinson, 2007). Among other negative effects of fungicides on the soil, microbial degradation dominates. (Katayama et al., 2010). Both inorganic and organic fungicide compounds can be strongly bonded within soil (Gevao *et al*., 2000; Komarek *et al.,* 2010) depending on the level of accumulation. This could affect soil microbes operations, hence less nutrients for plant growth and a resultant poor yield in crops.

Other Constraints: As is the case with agricultural production in Ghana, garden eggs production in Ghana is faced other constraints, aside pest infestation, that limits production and output. Amongst these were were low farm gate price for produce, especially during glut periods, lack of storage facilities, difficulty in accessing fertilizer, high cost of tractor services, unreliable rainfall pattern, lack of irrigation facilities, unavailable credit facilities and difficulty in securing land for farming. These concur with the findings of Adu-Dapaah & Oppong Konadu (2002) Farmers recommended that if these problems could be addressed appropriately, then garden eggs production would be a lucrative venture.

CONCLUSION AND RECOMMENDATIONS

Fruit and shoot borer (Leucinoded orbonalis) infestation appears to be major constraint to garden eggs cultivation in the Afadjato South and North Dayi Districts. On average, 70% of garden egg sampled farms showed signs of Leucinodes Orbonalis infestation. In order to reduce pest infestation on garden eggs farms, screening or varietal development is essential as well as a formal and well regulated seed system to ensure that disease free seeds are provided to farmers for cultivation. Farmers should be advised on proper ways of disposing infested fruits and crop residue from the previous cropping season. The development, promotion and adoption of Integrated Pest Management (IPM) strategies would also go a long way to reducing pesticide use and abuse, and enhance the activities of beneficial organisms in the farms. Achieving this will however require concerted efforts by all stakeholders involved in the garden eggs value chain.

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