Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(2): 14-19

Received: 07-01-2021
Accepted: 09-02-2021

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Integration of biorationals into management of pepper and tomato pests

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Abstract
Excessive use of harzardous insecticides on vegetables has raise issues about health and environmental implications. Alternative to these insecticides, four biorational insecticides comprising Ozone neem (Neem oil), Bypel (*Bacillus thuringiensis* + *Perisrapae granulosis* virus), Abalon 18EC (Abamectin) and Eradicoat (Maltodextrin) were applied on three varieties each of pepper (PV01, CRI Makontose and CRI ShitoAdope) and tomato (Rosso VFN, Raissa F1 and UC 82 B). Targeted pests were whitefly, thrips, aphids, fruit borers (including the tomato leaf miner *Tutaabsoluta*). Whitefly *Bemisia tabaci* were the predominant pests recorded on both pepper and tomato. All insecticide treated plots recorded significantly lower numbers of whiteflies. While whitefly incidence dropped with time, that of control plots increased over the same period. Abalon 18EC, Bypel, and Eradicoat, however offered better protection compared to Ozone neem. The second most important pest recorded, in terms of incidence on pepper and tomato, was thrips although their numbers were very low. It is concluded here that Ozone neem Abalon 18EC, Bypel, and Eradicoat are effective biorationals for the management of whiteflies in pepper and tomato.

Keywords: pepper, tomato, vegetable, insecticide, whitefly, pests

Introduction

Chili pepper (*Capsicum annum*) and tomato (*Solanum lycopersicum,* L.) are two popular vegetables cultivated and consumed, with the latter being the most important vegetable in Ghana [1]. They are key ingredients in most dishes across the country and there is demand throughout the whole year.

Both vegetables are cultivated in all the agroecological zones and serve as source of income for many rural and peri-urban dwellers. The country is self-sufficient in pepper production with about 123,394 tonnes/annum [2]. With average yield of 8.0 mt/ha [3], pepper is the leading vegetable export from Ghana [4]. Nevertheless, average yield of 7.2mt/ha for tomato [3] giving total production of 381,915 tonnes [2] fall short of demand. Thus, over 6 000 tonnes of tomato is imported annually from Burkina Faso during the lean season (December – May) to supplement local production [1]. Among constraints leading to recorded low yields, especially tomato, are pests, diseases and varietal issues.

Growers rely on excessive application of highly hazardous insecticides to suppress pests, particularly on tomato, which is more prone to pests and diseases [5, 6]. This consequently threatens the environment, human health and beneficial organisms such as pollinators and natural enemies. For these reasons, the use of effective but more environmentally friendly practices, such as biorationals insecticides is highly commendable.

This study therefore assessed efficacy of four biorational insecticides available on the Ghanaian market on common field pests of three varieties each of pepper and tomato. Acceptable performance of these biorationals will pave way for their incorporation into Integrated Pest Management (IPM) packages for sustainable production of these vegetables.

Materials and Methods

Study area

A trial was established at Crops Research Institute’s field at Kwadaso station during the major season, March-July 2019. The area is within the semi-deciduous forest with bimodal rainfall average of 1400mm. Land was slashed, ploughed and ridged with a tractor. Ridges were finished manually.

Experimental design

The experimental design was Randomized Complete Block Design (RCBD) with four replications. Pepper and tomato were planted at two rows per ridge, giving 30 plants plot. Between and within rows were spaced at 60cm and 65cm respectively for tomato and 50cm and 65cm respectively for pepper. Tomato varieties used included Rossol VFN, Raissa F1 and UC82 B. Two hot long cayenne PV 01 and CRI Shito Adope, and one mild long cayenne CRI Makontose pepper varieties were used. Four experimental insecticides, comprising ozone neem (Neem oil), Abalon 18EC (Abamectin), Eradicoat (Maltodextrin), Bypel (Bacillus thuringiensis+ Perisrapae granulosis virus)were applied to both pepper and tomato 2 weeks, 4 weeks and 6 weeks after transplanting. Water was sprayed on control plots. NPK (15-15-15) fertilizer was applied at rate of 10 g/plant (300 kg/ha) two weeks after planting. Urea was applied as side dressing at 2.2 g/plant (66 kg/ha) four weeks after planting [7].

Data collection and analyses

Five plants of each variety of pepper and tomato were randomly selected from each plot. The number of larvae of whiteflies, aphids, fruit borers and leaf miners on leaves, stems and fruits were examined, with the aid of hand lens. Counts of each of the target pests were recorded for each variety per plot. Adults of whitefly and thrips on the selected plants were also counted and recorded. Sampling was done early morning, prior to full sunrise, at which time adult whitefly and thrips are most dormant. Data were taken 24 hrs before treatment and 48 hrs after treatment. Thus, there were three data taking sessions under each treatment regime.

Harvesting of fruits commenced at fruit maturity (fully ripe). Pepper was harvested at weekly intervals for 4 consecutive weeks while tomato was harvest at 5 days intervals, also for 4 consecutive times.

Insect counts were $(x + 0.5)^{1/2}$ transformed to normalized them before carrying out analyses of variance and means separated with Tukey's at 0.05 level, using General Linear Model Minitab v15. Statistical analysis of thrips, leaf miners and fruit borers were not evaluated statistically due to limited incidence of these pests during the experiment.

Results

Pests recorded on pepper included whitefly *Bemisia tabaci* and onion thrips *Thrips tabaci*. On tomato, however, *B. tabaci*, *T. tabaci* and tomato leaf miner *Tuta absoluta*, cotton bollworm *Helicoverpa armigera* were observed. *B. tabaci* was the predominant pests recorded on all the three pepper and tomato varieties assessed (Tables 1).

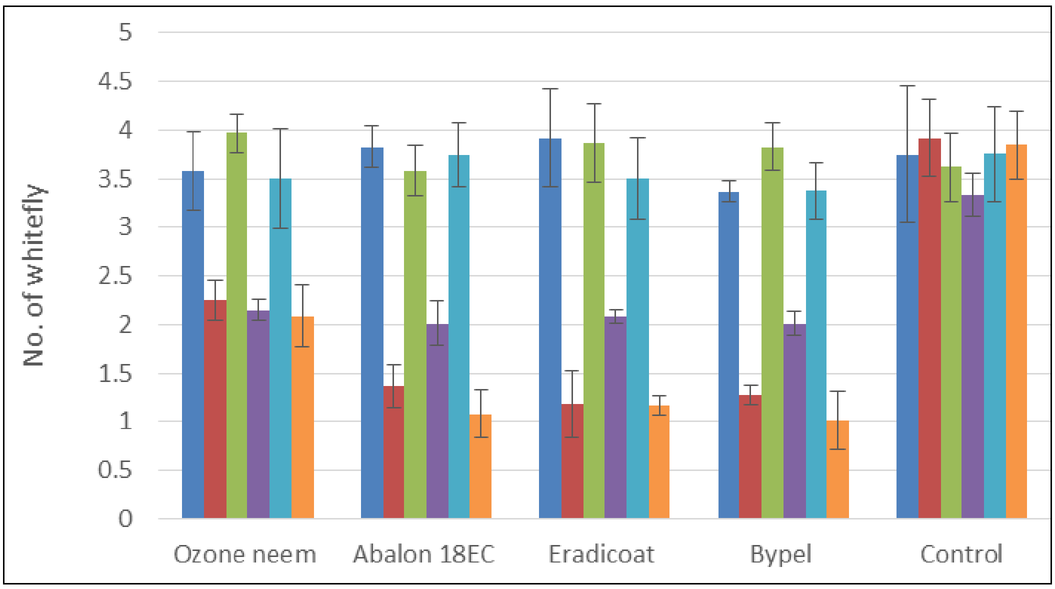
All insecticide treated plots recorded significantly lower numbers of *B. tabaci* compared to the control. Significantly, lower number of this pest was observed on PV 01 and CRI Shito Adope varieties treated with Abalon 18EC, Eradicoat and Bypel compared to those treated with Ozone neem. Similarly, Abalon 18EC, Eradicoat and Bypel recorded significantly lower numbers of *B. tabaci* on tomato than Ozone neem after treatment.

It was also observed that the number of *B. tabaci* population significantly reduced after application of each of the insecticides on both pepper and tomato (Fig. 1a and 1b). There was, however, subsequent population build up to almost the same level as before the first treatment.

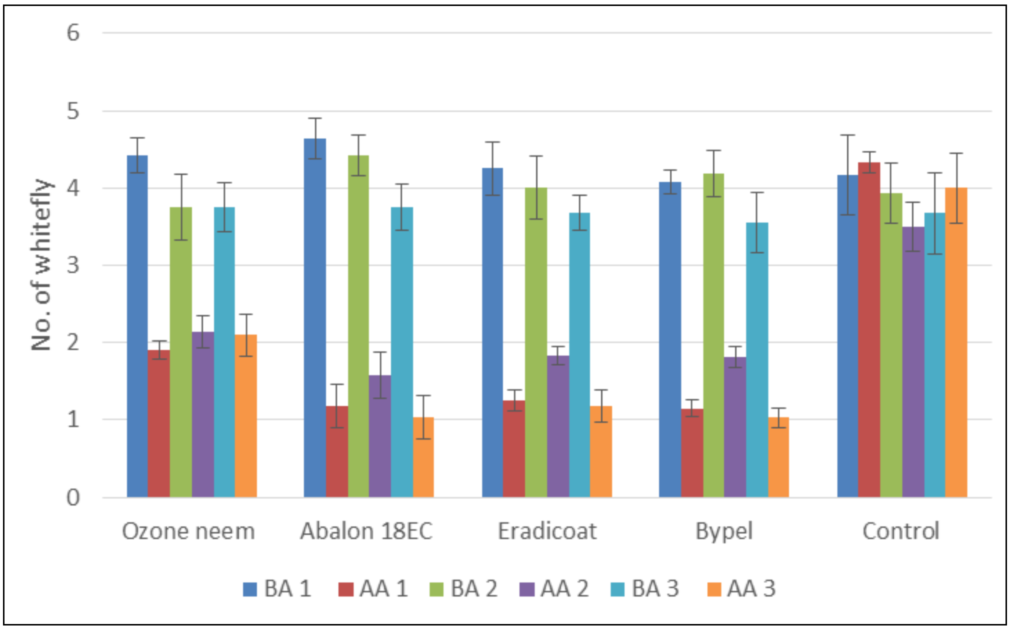
Table 1: Mean number of whitefly *Bemisia tabaci* on different pepper and tomato varieties treated with biorational insecticides

Mean no. whitefly/plant						
	Pepper			Tomato		
Insecticide treatment	PV 01	CRI Makontose	CRI Shito Adope	Rossol VFN	Raissa F1	VC 82 B
Ozone neem (Neem oil)	2.25b	2.15b	2.09b	1.90b	2.14b	2.10b
Abalon 18EC (Abamectin)	1.37c	2.01b	1.08c	1.18c	1.57d	1.03d
Eradicoat (Maltodextrin)	1.18c	2.08a	1.17c	1.25c	1.83c	1.18c
Bypel (Bacillus thuringiensis+ Perisrapae granulosis virus)	1.28c	2.01b	1.01c	1.15c	1.81c	1.03c
Control	3.92a	3.33a	3.85a	4.33a	3.50a	4.00a

Means followed by the different letter in a column indicate significant differences ($p<0.05$).



A



B

Fig 1: Mean whitefly numbers on (a) pepper and (b) tomato before and after treatment with four insecticides over three successive treatments (BA= before application of insecticide, AA = After application of insecticide; 1, 2 and 3 represents 1st, 2nd and 3rd insecticide applications respectively).

The second most common pest recorded on both vegetables was *T. tabaci* although their numbers were very low, as many plots did not record the presence of the pest. Mean *T. tabaci* counts of 0.08 – 0.25 were recorded on PV01 and CRI Makontose pepper varieties, with CRI Shito Adope recording none. For tomato, mean counts of 0.08 – 0.17 were recorded on only Rossol VRN.

Fruits with bores were occasionally observed but no fruit borer was recorded. Pepper fruits with bores (but no fruit borer was detected) were recorded from CRI Makontose (on one control plot) and PV01 (one plot each treated with Ozone neem, Abalon 18EC and Eradicoat).

Table 2 indicate significantly higher yield of pepper fruits were obtained from insecticide treated plots, compared with the control. There were also significant yield variations among different insecticide treatments but this did not follow a particular pattern for the three pepper varieties. Whilst Eradcoat treated plots gave the best yield for PV 01 variety, Bypel and Ozone neem recorded the best yields for CRI Makontose and CRI Shito Adope respectively. CRI Shito Adope gave the best fruit yield among the three varieties, recording excess of twice the yield of the other two varieties.

Yield of tomato among treatment and control plots were not significantly different forUC82 B (Table 2). The differences between the insecticide treated and control plots planted with Rossol VFN and Raissa F1 were significantly different. While the highest yield of 7,336.69 kg/ha was obtained for Rosso VFN treated with Eradicoat, 6,046.21 kg/ha was the highest for Raissa F1 treated with Bypel.

Table 2: Yield of pepper after treatment with different insecticides

Insecticide treatment	Yield (kg/ha)					
	Pepper			Tomato		
	PV 01	CRI Makontose	CRI Shito Adope	Rossol VFN	Raissa F1	UC 82 B
Ozone neem (Neem oil)	178.48b	197.14c	676.87c	5204.33b	4574.22b	4303.95a
Abalon 18EC (Abamectin)	191.78c	143.47b	534.22b	4623.49a	3906.16b	3132.23a
Eradicoat (Maltodextrin)	212.61d	160.48b	571.29b	7336.69c	4185.01b	4112.90a
Bypel (Bacillus thuringiensis+ Perisrapae granulosis virus)	166.19b	229.89c	641.15c	4499.44a	6046.21c	4682.38a
Control	110.32a	110.81a	360.02a	3749.03a	2536.48a	3321.98a

Means followed by the different letter in a column indicate significant differences ($p<0.05$).

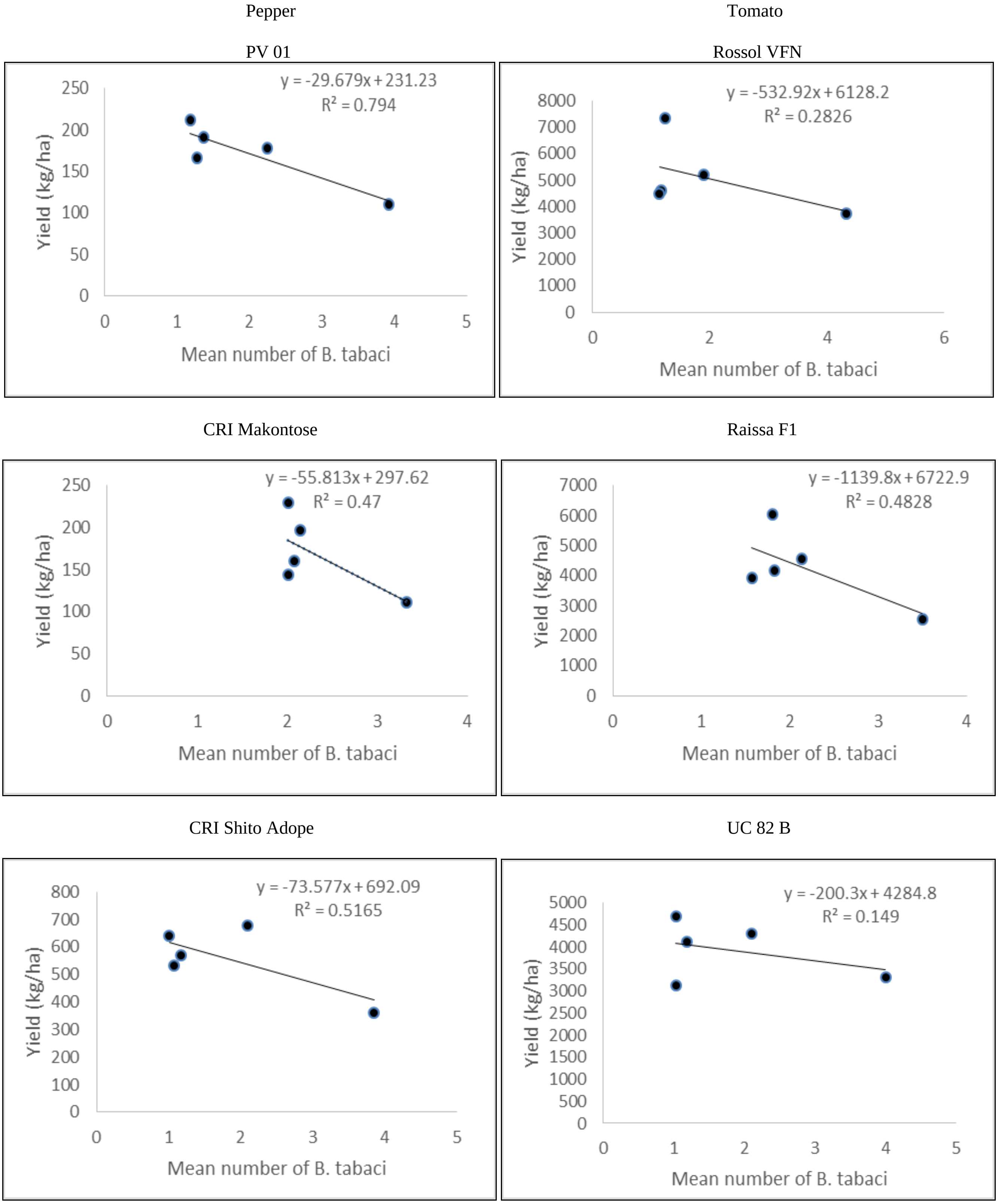


Fig 2: Relationship between *B. tabaci* and fruit yield of three pepper and tomato varieties.

There was moderately negative correlation between the population of *B. tabaci* and the yield of PV 01 and CRI Shito Adope pepper varieties. The correlation was however strongly negative for CRI Makontose (Fig. 2). With respect to tomato, while the correlation between *B. tabaci* population and yield for Rossol VFN and UC 82 B were weakly negative, that for Raissa F1 was moderately negative.

Discussion

Although four pests *B, tabaci*, *T. tabaci*, *T. absoluta* and *H. armigera* were registered in this study only *B. tabaci* population were enough for inference to be drawn from, with respect to the efficacy of the tested insecticides and impact on the productivity of the two vegetables.

B. tabaci consist of a complex of whiteflies that are polyphagous, and attack wide range of vegetables including the Solanaceous crops and weeds [8]. This pest is prevalent on tomato and peppers and is vector to pepper leaf curl virus (PepLCV) in pepper and tomato yellow leaf curl virus (TYLCV) in tomato, which is a major constraint in production of pepper and tomato worldwide [9, 10]. In tomato, TYLCV can cause 100% yield loss, depending on the variety and stage of the crop at which they are infected [11, 12]. In Ghana, the net importation of tomato over the years has been linked to TYLCV [13, 14], which is transmitted by the dominant pest recorded in this study, *B. tabaci*. In pepper, *B. tabaci* mediated PepLCV transmission can result in 90 -100% yield losses [15]. In addition to the viral diseases, the pest suck nutrients from the crop which can cause withering, reduced pollen production, premature flower and fruit drop, sooty mould and reduction in plant vigour [10, 12, 16]. Thus, suppression of *B. tabaci* and consequential reduction of TYLCV incidence is key to increasing tomato production in Ghana.

The significantly lowering of the dominant pest recorded in this study, *B. tabaci* after spraying with the assessed biorational insecticides suggest all are potential candidates for development of IPM for both pepper and tomato in Ghana. Neem extract, abamectin and *Bacillus thuringiensis* formulations gave good *B. tabaci* suppression when tested on a number of crops [17-19]. Eradicoat also upon application on other species of whiteflies resulted in mortality comparable to Spiromesifen, which is known to be very effective against whiteflies [20, 21]. Although Ozone neem offered good protection against *B. tabaci*, in this study, Abalon 18EC, Eradicoat and Bypel gave better protection and therefore more preferred.

The high population influx of *B. tabaci* to insecticide treated plots within 2 weeks of insecticide re-application could be attributed to the probable abundance of alternate hosts on adjourning vegetation. Additionally, proximal distribution of control plots among treated plots were major sources of re-infestation. Considering these facts, the frequency of insecticide re-application adopted in this study appears reasonable. However, it will be appropriate to assess the abundance of alternate hosts within the vicinity prior to establishment of tomato and pepper. This will give idea of the pest load to expect in other to help put the appropriate management strategies right from the time of establishment of the farm.

None of the pepper and tomato varieties distinctly exhibited preference for by *B. tabaci.* This is because although PV 01 and CRI Shito Adope varieties showed lower *B. tabaci* populations on treated plots compared to CRI Makontose, both showed higher population (though not significant) on control plots. This also affirms the re-distribution of the pest from the persistently high pest populations on the control plots throughout the experiment.

With the problem of excessive use of synthetic insecticides and low observance of pre-harvest intervals resulting in high residues in the harvested produce [22], the acceptable performance of the tested insecticides is good for the industry. There is the need to undertake demonstrations on the efficacy of these biorational insecticides in major tomato production enclaves in Ghana.

Conclusion

Biorational insecticides are becoming important component of IPM due to their relatively less deleterious effect on health, environment and untargeted organisms. Results from the current study showed all biorational insecticides evaluated significantly suppress the predominant pest, *B. tabaci*, recorded on both pepper and tomato. Bypel, Abalon 18EC and Eradicoat however, performed better against *B. tabaci* than Ozone neem. Nevertheless, any of the assessed biorational insecticides will be appropriate component of IPM strategy for pepper and tomato production in Ghana.

Acknowledgement

This study was funded by the World Vegetable Center (AVRDC) as part of the strengthening quality vegetable seed supplies in Africa (SC-336-08).

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