INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

Volume-1, Issue-3 Sept-Nov-2011 *www.ijpaes.com* *ISSN 2231-4490*

TOMATO AS AN INTERCROPPED PLANT ON THE PESTS AND NATURAL ENEMIES OF THE PESTS OF CABBAGE (*BRASSICA OLERACEA*)

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ABSTRACT : The excessive and continuous use of synthetic chemicals for cabbage production has received several concerns over chemical residues in food and their resultant effects on the health of humans and animals. It is against this background that an effective and environmentally friendly approach considering tomato as an intercrop in the organic Cabbage production was explored in this study. The experiment was conducted from November, 2010 to March 2011 during the minor cropping season on an experimental field near the Department of Theoretical and Applied Biology at the Kwame Nkrumah University of Science and Technology, Kumasi to evaluate the effectiveness of intercropping cabbage with tomato for pest control in organic cabbage production systems. The experimental design used was a randomized complete block design with five treatments and three replications (blocks). The treatments were sole tomato, sole cabbage, two rows of cabbage to one row of tomato, three rows of cabbage to one row of tomato and four rows of cabbage to one row of tomato. Parameters studied included insect pests' numbers and their natural enemies. Major insect pest recorded included *Brevicoryne brassicae, Plutella xylostella, Hellula undalis* and *Pieris rapae* which caused damage to the cabbage plant (*Brassica oleracae* var. oxyllus). The natural enemies of pests of cabbage identified were the ladybird beetle, (*Cheilomenes sp*), huntsman spider, *Heteropoda venotoria* and black carpenter ant *Camponotus pennsylvanicus*. Data were taken on plant height, canopy spread, per cent head damage and weight of cabbage head at harvest. Results on the insect pest population showed significant differences. However, there was no significant difference ($P = 0.3179$) observed between the control cabbage and the cabbage-tomato intercrops. The results on the cabbage plants showed significant differences ($p<0.05$) in plant height, canopy spread, per cent head damage and weight of cabbage head at harvest. The study concluded that for better insect pest management and high productivity in organic cabbage production, two rows of cabbage to one row tomato among the treatments was the most appropriate.

Key words: cabbage, tomato, intercrop, organic production, cabbage pests, natural enemies

INTRODUCTION

Cabbage (*Brassica oleracea*) is an important exotic vegetable grown in Ghana on both small and large scales. It provides a source of livelihood to all individuals who are engaged in cabbage production from its cultivation till it gets to the final consumer [1]. The cultivation of cabbage provides an excellent source of employment for both rural and urban dwellers through farming and gardening respectively. Cabbage has high nutritive value and it is used in the preparation of various kinds of dishes such as stews and salads [2]. Cabbage is a good source of protein, carbohydrates, calcium, iron, carotene, thiamine, riboflavin, niacin, as well as vitamin C [3]. In spite of the enormous benefits of cabbage to the growth and development of humans, production of the crop is beset with insect pests attack.

These pests include aphids (*Brevicoryne brassicae*), Bagrada bug (*Bagrada hilaris*), flea beetles (*Phyllotreta* sp.), Diamond-back moth (*Plutella xylostella*), cutworm (*Agrotis* sp.) and snails (mollusc) [3, 4]. Pest infestation normally leads to reduction in market value and in some cases total crop failure. Synthetic insecticides have been widely used to control insect pests with a collage of risks. These insecticides may contaminate water bodies, air and the soil [5]. There is therefore a growing concern in connection with environmental pollution and its resultant effects on the health of humans and animals arising from the continuous use of synthetic chemicals (pesticides) in Cabbage production. Hence, the need to find alternative means of controlling the pests rather than using synthetic chemicals. In a recent study, Mochiah et al. [6] evaluated botanicals that significantly reduced pest populations and conveniently maintained the ecological balance with their natural enemies on okra and eggplants.

The need to explore more options under Non-Pesticide Management (NPM) of crops is becoming popular among vegetable growers since they endeavour to keep the management of insect pests and crop cultivation costs to a minimum. Different types of intercropping are used by farmers to produce different crops for commercial and personal consumptions. Crops of the same species may not be the best intercrop. This is because the incidence of pest attack on one crop may invite same attack on the other, leading to total crop loss. Tomatoes therefore, may be useful as an intercrop in a cabbage field in view of its strong, pungent, odour which could repel pests and are valuable sources of food minerals and vitamins, particularly vitamins A and C. As an added advantage, studies have shown that people who eat large amounts of tomatoes or tomato products may be at a lower risk of some kinds of cancer, especially cancer of the prostate gland, lung and stomach [7, 8]. Intercropping cabbage with other crops such as tomatoes, onions and pepper, have been found to disrupt the life cycles of the pests and hence increased plant growth [9]. The use of tomato as pest control intercrop in organic cabbage production systems is discussed

MATERIALS AND METHODS

Study Location

This study was conducted from November, 2010 to March 2011 during the minor cropping season on an experimental field near the Department of Theoretical and Applied Biology at the Kwame Nkrumah University of Science and Technology, Kumasi. The site has a comparable soil type of intermediate between sand and clay. Generally, the top soil is about 0.3m deep and contains less gravel. The average annual relative humidity for the period from November, 2010 to March 2011 ranged between 76.6% and 69.3%. Average annual precipitation (mm) at the study area ranged from 72.78 to 166.58 with average annual maximum and minimum air temperatures ranging from 31.45 to 34.18 and 19.78 to 23.24 respectively [10].

Land preparation and transplanting: The land was cleaned and root stumps removed after weeding prior to sowing of seeds. Ploughing and raking activities were performed on the land before beds were made. Both cabbage variety (Oxyllus) and tomato variety (Petomech) were sown with seeds treated with carbendazim or Thiram (from Holland, distributed in Burkina Faso by “KING AGRO”)

Healthy cabbage and tomato seedlings from the nursery were transplanted to the main experimental fields/plots on 12^{th} November, 2010 in the minor and major season. Cabbage seedlings were transplanted at the of spacing 0.6m by 0.6m whilst the tomato seedlings were transplanted using 0.3m by 0.6m spacing. Watering was done twice a day (morning and evening) especially for the first three weeks after which they were watered once daily in the evenings. Weeds were manually controlled with a hoe at two weekly intervals.

Experiment design: The design was a Randomized Complete Block (RCBD) consisting of five treatments replicated three times. The treatments were Intercropping relationship of 2 rows cabbage to 1 row tomato (2 RC1RT), 3 rows cabbage to 1 row tomato (3 RC1RT), 4 rows cabbage to 1 row tomato (4 RC1RT), sole tomato (control, mono cropping) and sole cabbage (control, mono cropping).

Data Collection

Data on insect pest population, plant damage and yield were recorded from the two middle rows which had an average of twenty (20) cabbage plants per plot/bed. Data collected included pest population per cabbage plant, natural enemies which mainly consisted of black ants, lady beetles and spiders. Plant parameters such as plant height and canopy spread were also assessed. The extent of damage caused to the cabbage head by insect pest was estimated and scored using a scale of 0-5 standard procedure according to Aboagye [11] (where 0 = No head damage, 1= 1 – 15% head damage, 2 = 15 – 30% head damage, 3= 30 – 45% head damage, 4= 45 – 60% head damage and 5 = 60% or more head damage). Fresh weights of the plants were taken at harvest. This was done by manually harvesting the above ground parts of the crops and cleaning them from traces of soil and then weighing the individual heads on a pan balance in the laboratory. The weights were recorded respectively for each plant taken randomly on each plot.

Statistical analysis

Data were analysed by analysis of variance (ANOVA), using the general linear model (GLM) procedure of SAS Version 9 [12]. Number of insects were log (x+1) transformed. Treatment means separation was by the Student Newman Keul's (SNK) test and the probability of treatment means being significantly different was set at $P < 0.05$.

RESULTS

Assessment of major insect pests on cabbage

There were significant differences among the sole cabbage and the different tomato intercropping systems for cabbage for the mean aphid (*Brevicoryne brassicae* (L.)) numbers (P = 0.0001), Grasshopper (*Zonocerus variegatus* L.) (P = 0.0014), cabbage webworm (*Helulla undalis* (F.)) (P = 0.0007) as well as diamond-back moth (*Plutella xylostella* (L.)) (P = 0.0001) populations. The highest aphid population was recorded on the sole cabbage (20.14) whilst the least population was found on three rows of cabbage to one row of tomato (10.78). The highest Grasshopper population (5.33) was observed on the sole cabbage whilst the least Grasshopper population (2.67) was on the three rows of cabbage to one row of tomato. For both the Cutworm and the DBM the highest populations were recorded on sole cabbage whilst the least were found on the two rows of cabbage to one row of tomato (Table 1). However, there was no significant difference (P = 0.3179) observed between the control cabbage and the cabbage-tomato intercrops even though the largest Whitefly (*Bemisia tabaci* (Genn.)), population was observed on the sole cabbage plots (5.96) whilst the least was recorded on three rows of cabbage to one row of tomato (4.96) (Table 1). Although a particular snail (mollusc) was observed causing damage to the leaves from the sole cabbage as well as the cabbage from the tomato- intercrop plots, the differences were not significant and again the numbers recorded from the various plots were too low to be considered as a measurable parameter.

Natural enemy population of cabbage pests

The natural enemies of pests of cabbage identified were the ladybird beetle, (*Cheilomenes* sp). (Coleoptera: Coccinellidae), huntsman spider, *Heteropoda venotoria* (Araneae: Lnyphiinae) and black carpenter ant *Camponotus pennsylvanicus* (Hymenoptera: Formicidae). The mean numbers of the various natural enemies are presented in Table 2. Results from the study indicated that ladybird beetle, *H. venotoria* and the *C. pennsylvanicus* populations were least on the 2 rows of cabbage and 1row tomato plots and largest on the control plots, even though the differences were not significant (Table 2).

Table 1: Mean populations of insect pests of cabbage (*Brassica oleracea* var. oxyllus) grown under different tomato intercrop systems

Treatment	Mean ± (SE) number of insect pests /plot				
	Aphids	Whiteflies	Grasshoppers	cutworms	Diamond back moth
Sole C	20.14 ± 0.3b	5.96 ± 0.2a	5.33 ± 0.3c	3.57± 0.4b	9.37 ± 1.3c
2 RC1RT	10.97 ± 0.2a	5.13 ± 0.2a	3.25 ± 0.2b	1.27± 0.1a	2.83 ± 0.9a
3 RC1RT	13.78 ± 0.2a	4.96 ± 0.3a	2.67 ± 0.3a	1.37± 0.2a	3.82 ± 0.9a
4 RC1RT	12.93 ± 0.3a	5.23 ± 0.1a	3.49 ± 0.2b	1.87± 0.3a	4.92 ± 1.1b
P	0.0038	0.3179	0.0014	0.0007	0.0001

Means with the same letters in the same column are not significantly different at P=0.05.

Table 2: Mean numbers of natural enemies of pests of cabbage (*Brassica oleracea* var. oxyllus) grown under different tomato intercrop systems

Treatment	Mean ± (SE) number of natural enemies/plot		
	ladybird beetles	spiders	black ants
Sole C	5.80 ± 0.1a	3.33 ± 0.4a	4.33± 0.3a
2 RC1RT	3.58 ± 0.3a	2.17 ± 0.1a	2.48± 0.3a
3 RC1RT	4.57 ± 0.3a	2.25 ± 0.2a	3.57± 0.1a
4 RC1RT	4.55 ± 0.2a	2.32 ± 1.3a	3.68± 0.1a
P	0.4938	0.3179	0.4347

Means with the same letters in the same column are not significantly different at P=0.05.

Plant growth parameters and yield

There were significant differences among the sole cabbage and the different tomato/cabbage intercropping systems for the canopy spread (P = 0.0003), per cent head damage (P = 0.0042) and yield of the cabbage (P = 0.0001). The highest canopy spread was recorded on two rows of cabbage to one row of tomato (34.69 cm) whilst the least was recorded on the sole cabbage (30.25). The highest per cent head damage (18.33) was observed on the sole cabbage whilst the least (9.50cm) was on the two rows of cabbage to one row of tomato. In the case of plant height, there was no significant difference (P = 0.4938) observed between the control cabbage and the cabbage-tomato intercrops even though the highest plant height was observed on four rows of cabbage to one row of tomato plots (17.35 cm) whilst the least was recorded on the sole cabbage plots (13.24 cm) (Table 3). Similarly, the highest yield was recorded on two rows of cabbage to one row of tomato (1336 g) whilst the least was found on the sole cabbage (961g) (Table 3).

Table 3: Mean plant growth parameters, head damage and yield of cabbage (*Brassica oleracea* var. oxyllus) grown under different tomato intercrop systems

	Mean ± (SE) number of insect pests /plot			
Treatment	Plant height (cm)	Canopy spread (cm)	% head damage	Yield (g)
Sole C	13.24± 0.8a	30.25 ± 1.3a	18.33 ± 2.2c	960.67 ± 20.4a
2 RC1RT	16.17± 0.3a	34.69 ± 1.4b	9.50 ± 1.0a	1335.68 ± 26.5c
3 RC1RT	15.22± 0.5a	32.69 ± 1.5b	11.88 ± 2.0b	1241.29 ± 30.2b
4 RC1RT	17.35± 0.4a	33.38 ± 1.4b	12.54 ± 2.0b	1138.01 ± 28.4b
P	0.4938	0.0003	0.0042	0.0001

Means with the same letters in the same column are not significantly different at P=0.05.

DISCUSSION

Results from this study revealed lower pests pressure on cabbage/tomato systems, lower percent cabbage leaf damage and the extent of leaf damage reduction by *P. xylostella,* diamond-back moth (DBM), which were observed to be associated with cabbage/tomato cropping systems. In similar studies significantly lower populations of DBM were recorded in cabbage plants intercropped with other non-host plants due to the confusing olfactory and visual cues received [9, 13, 14, 1]. Björkman [15] in examining how intercropping of cabbage (*Brassica oleracea*) and red clover (*Trifolium pratense*) affects the different life cycle stages of *Delia floralis*, it was indicated that intercropping reduced turnip root fly, *D. floralis* oviposition compared with monoculture.

In reducing chemical inputs in vegetable production systems using crop diversification strategies, Broad [16] indicated that the insect pest population of broccoli, *P. xylostella* was reduced by the mixed cropping system. In a another related study which dealt with pest management by agrosystem diversification, Theunissen [17] showed that intercropping field vegetables with other species such as clovers manifested in insect pest suppression and contended that such approaches when adopted properly by farmers may make chemical control unnecessary. This may be due to the fact that tomato crops might be insect pest repellants considering the odour they produce [18]. Besides, intercropping cabbage with tomato could lead to the disruption of life cycles of the pests unlike in the mono-cropping [1]. Therefore, intercropping cabbage with non-host crops like tomato may be better than sole cabbage cropping which may lead to total crop failure if pest infestation and damages go beyond the economic injury level. In this study, intercropping reduced the incidence of pests, therefore, less time and efforts were required in controlling pests which is a major constraint in crop production. By intercropping cabbage with a non-host crop, Guvenc & Yildirim [8] and James et al. [19] indicated that the incidence of pests attack could be reduced on the cabbage considerably hence, saving labour in controlling the pests associated with the crop.

Intercropping is widely applied as a normal cultural practice in the tropics for a variety of reasons. These reasons are often not explicitly clear to the growers but in traditional agriculture, benefits derived from such systems must be made abundantly clear to sustain such practices. Vegetable cropping systems are becoming larger, more specialized and increasingly reliant on agro-chemicals to manage pests in general. These trends in vegetable production have resulted in increased efficiencies and allowed producers to maintain profitability in a marketplace with greater competition and declining gross margins.

Broad [16] indicated the benefits and costs of alternative vegetable production systems with increased plant species diversity and their potential to reduce chemical inputs. The results from this study indicated that both vegetable intercrops irrespective of the systems showed reduced pest incidence by enabling predators such as ladybirds to build up their populations by feeding on aphids supported by the intercrop.

Intercropping effects in terms of suppression of pests and population build-up of natural enemies such as lady bird beetles were found. Natural enemies, in this case mainly ladybird beetle, spider and black ant predators, significantly increased in numbers on the sole crop but this effect did not differ among the different tomato systems. However, this study showed that it was possible to retain the predation pressure in the intercropped systems despite lower predator activity-densities. The ladybird beetles are natural enemies of aphids and as such their high presence on the sole cabbage was indicative of the high population of aphids on the sole cabbage. This paper agrees and supports the natural enemies hypothesis put forward by Bach [20] and attributed lower pest abundance on intercropped plants or more diverse systems to a higher density of predators and parasitoids. Authors of this study want to advise that cabbage/tomato cropping systems should be promoted in addition to other pest management strategies, aiming at enhancing pest control in cabbage production.

The wider canopy spread observed on the cabbage/tomato intercrop to one row tomato compared to the control may be due to the competition for soil and water resources that caused plants to spread up the leaves. These results are similar to those obtained by Dzoku [21]. The low head weight recorded for the sole cabbage plants could be attributed to high population of insect pests, especially *P. xylostella* observed on those plants with their corresponding higher leaf and head damage, which probably affected their photosynthetic activities and growth rates. The findings of this study are in agreement with that of De Lannoy [3] in which the same *P. xylostella* was responsible for low marketable yield of the crop.

Although no pesticides were used in this trial, intercropping with tomato reduced pest populations and the yield on intercropped cabbage could lead to better financial results compared to the mono-cropped cabbage. This study again lends support to similar findings by Munyuli et al. [22] who recorded lower pest pressures on cowpea crop, higher abundance of predators and higher cowpea yields associated with cowpea/greengram cropping systems. Intercropping fits into environmentally acceptable and sustainable vegetable-producing practices. Based on our earlier research findings and our own experiences this study was aimed at exploring and developing intercropping in field vegetable as a chemical free option that would contribute to economically and ecologically acceptable forms of sustainable vegetable production. In this study means by which intercropping may influence the dynamics of some vegetable pest populations was also addressed. The study concluded that for better insect pest management and high productivity in organic cabbage production, two rows of cabbage to one row tomato was the most appropriate to increase the marketable yield and improve the livelihood of growers.

ACKNOWLEDGEMENTS

We thank Messrs Augustine Agyekum and Anthony Gyimah for assistance with data collection and compilation; and Dr. K. O. Fening for his inspiration and technical support to bring the manuscript in this form. This study was supported by a collaborative project between CSIR-Crops Research Institute and Kwame Nkrumah University of Science and Technology.

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