Effect of Intercropping Collard with Beans or Onions on Aphid Populations and Yields of Collard Under High Altitude Conditions in Kenya

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Abstract

Collard (Brassica oleracea var.acephala D.C) is an important source of income to many small-scale farmers in Kenya and constitutes part of the diet of many Kenyans especially in urban areas. Successful production of collard is however, constrained by several pests, with aphid s (Brevicoryne brassicae and Myzus persicae) being among the major pests. Control of aphids has mainly been by chemical sprays, which has tended to result in pest resistance and pollution to the environment. This study was therefore, an attempt to look into alternative and environmentally friendly ways of controlling aphids in collard. To achieve this, two studies were conducted in Kenya to determine the effects of intercropping and nitrogen fertilization on aphid population on collard and the yield response of the crop to these practices. The experimental design used was a split plot arranged in a randomized complete block design with three replications. Nitrogen levels (0,145,289, and 361kg N/ha) comprised the main plots while cropping regimes (collard intercropped with onions (Allium cepa L.), collard intercropped with beans (Phaseolus vulgaris L), monocrop collard sprayed with 'Bulldock' and unsprayed monocrop collard formed the subplots. Intercropping collard with either beans or onions significantly lowered aphid population on collard compared to unsprayed monocrop collard. Overall, the lowest aphid population was recorded in insecticide sprayed monocrop collard during the first season of the study. In the second season, aphid populations recorded in sprayed collard plots were not significantly different from those recorded in collard – bean intercrop. Nitrogen fertilization increased aphid population on collard plants but did not have any significant effect on leaf vegetable yields. Intercropping increased food output per unit area of land, measured by Land Equivalent Ratios. In both seasons, nitrogen fertilization did not significantly affect collard, bean or onion yields. Considering the potential risks associated with frequent use of synthetic insecticides and high doses of nitrogen in crop production, these results indicate that intercropping collard and beans or onions and use of low nitrogen rates can be effectively used to suppress aphid populations in collard.

Key words: *Allium cepa., Brassica oleracea, Brevicoryne brassicae,* Intercropping, IPM, LER, *Myzus persicae, Nitrogen fertilizer, Phaseolus vulgaris.*

Introduction

The cultivation and sale of collard (*Brassica oleracea var. acephala D.C*) and other brassicas are an important source of income to many small-scale farmers in Kenya (Oduor *et al.*, 1998). The crop is one of the most popular leafy vegetables (Itulya and Aguyoh, 1998) and constitutes part of the diet of many Kenyans. In spite of its importance, there is paucity of information as regards improving quality and quality of the crop.

Pest management is one of the major practices that affect collard leaf yields and quality. In Kenya, like in most other brassica growing regions of Africa, the aphid complex (*Brevicoryne brassicae, Myzus persicae and*

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Accepted March, 2008

Lipaphis erysimi) has been shown to be among the most serious pests of collard and other brassicas (Oduor *et al.*, 1998; Nyambo and Pekker, 1995). In most collard growing areas, management strategies for controlling aphids are based on regular sprays of synthetic pesticides without due regard to the impact of these chemical sprays to the ecosystem. The extensive and regular use of synthetic pesticides has been shown to interfere with the biological balance of the ecosystem and has tended to result in problems of resistance to most pesticides as new aphid variants emerge (Oduor *et al.,* 1998). Hence, the need to search for more reliable and environmentally friendly alternative methods for use by small scale collard growers in controlling aphids.Even though some research work has been conducted in the recent times on collard culture in Kenya, especially as regard nitrogen nutrition and intercropping (Itulya and Aguyoh, 1998; Itulya, 1995; Madumadu *et al.*, 1991), most of these works have delved on how such practices directly affect yields. Recommendations that have been given are based on yields. Most local researchers have not addressed the question of how these recommended practices affect pest populations and their control. Yet, intercropping and nitrogen fertilization have been shown to influence attack and management of many crop pests. Costello and Altieri (1995) recorded low aphid populations in broccoli undersown with leguminous cover crops (while clover, strawberry clover and red clover) compared with aphid populations on broccoli without cover crop. Aphids and other leaf mining grubs also been shown to breed or develop more rapidly on plants receiving less nitrogen (van Emden, 1992). The objective of this study was therefore to determine the effects of intercropping collards with either beans or onion and nitrogen fertilization on aphid population on collard, and also to establish the impact of these practices on collard, bean and onion yields.

Materials and Methods

Two studies were conducted at Egerton University horticulture demonstration field, Tatton farm, in Kenya, at approximately $0^{0}23'$ south, 35^{0}, east, and an altitude of 2200 m above sea level. The soils are well-drained silty clay loams classified as Haplic Phoeozem (Jaetzold and Schmidt, 1983). Soil to have an organic matter content of 2.17% in upper 0-30cm, $pH(H_2O)$ 6.15, pH(KCl)5.54 and total nitrogen 0.23%.

The first experiment was conducted during the long rains (14 May to 14 September 1999) and the second experiment was conducted during the short rains (from 14 October 1999 to 18 February 2000). The amount of rainfall received was 240.8 mm and 196.1 mm during the first and second experiments respectively. The temperatures ranged from 15^{0}C to 22^{0}C during experiment 1 and from 16^{0}C to 24^{0}C during experiment 2 with monthly mean temperatures as shown in Table 1.

The experimental design was split plot, arranged in a randomized complete block, with three replications. Nitrogen levels comprised the main-pots and cropping regimes were the sub plots. The nitrogen levels were 0, 145, 289 and 361 kg N/ha. 0 kg N/ha was the control, 289 kg N/ha is the rate recommended by the ministry of Agriculture for most collard growing areas in Kenya, 145kg N/ha is half the recommended rate, while 361 kg kg N/ha is one and a quarter of the recommended rate. The cropping regimes were collard –bean intercrop (KB), collard-onion intercrop (KO), monocrop collard sprayed with insecticide 'Bulldock' (KD), monocrop collard unsprayed (K), and monocrop beans (B) and monocrop onions (O). Main-plots measured 9m x 12.8m. Sub-plots measured 4m x 3.6m. A one-meter path separated sub-plots and main- plots in a block were separated by a two meters path.

One collard cultivar 'Georgia', one bean cultivar 'GLP2' and one onion cultivar 'Red Creole' were used in both experiments. In both seasons, beans were sown at a spacing of 45cm x 10cm, onions were transplanted at a spacing of 30cm x 10cm, while collard seedling were transplanted at a spacing of 90cm x 30cm. Bean sowing and transplanting of onions and collard were done by hand. The planting of beans and transplanting of onions and collard were done by hand. The planting of beans and transplanting of onions were done two week prior to transplanting of collard. Similar spacing for the individual crops were used in both moncropped and intercropped plots giving plant populations of 3 plants/m^2, 22 plants/m^2 and 33plants/m^2 in collard, bean and onion monocrop respectively and 25 plant/m^2 and 36 plants/m^2 in collard, bean and onion intercrops respectively. Nitrogen was broadcasted in half-rate splits, with the first split applied two weeks after collard transplanting and the second split three weeks later. Calcium ammonium nitrate (26% N) was the source of nitrogen. Weed and disease control was done uniformly on all the plots. Insecticide was applied to the control plots (KD), where 'Bulldock' (a.i.- Beta-cyfluthrin, 025 EC) supplied by Bayer Ltd. was sprayed bi-weekly at the rate of 50 ml/ha. Data collection was confined within the inner area of 3.6m x 2.7m, leaving the outer plants as guard rows.

Aphid count on collard plants was done on a weekly basis, beginning the first week after the second split application of nitrogen until the experiment was terminated. On each data collection date, aphids were physically counted from three randomly selected plants in each sub-plot, a procedure described by Nyambo and Pekker (1995).

Weekly collard leaf picking began six weeks after transplanting and continued until termination of each study. The parameters of interest at each harvest were fresh marketable fresh leaf yields were later expressed as a percentage of the total fresh leaf yields.

At maturity, beans and onions were harvested. Onion yields were determined based on weight of marketable bulbs, while bean yields were based on seed dry weight, adjusted to 12% moisture.

Each season's data were subjected to analysis of variance and where F-test was significant at P≤ 0.05, mean separation was done using the Duncan's Multiple Range Test. Data on aphid counts were subjected to logarithmic transformation prior to analysis of variance. Data on percentage

Table 1. Rainfall distribution and mean temperatures for season 1 and season 2

	Season 1 (May 1999 – September 1999)		Season 2 (October 1999 – February 2000)	
Month	Rainfall (mm)	Temperature (^{0}C)	Rainfall (mm)	Temperature (^{0}C)
May	13.0	20.0	-	-
June	19.9	19.5	-	-
July	79.1	17.8	-	-
August	91.3	18.3	-	-
September	17.5	17.5	-	-
October	-	-	-	-
November	-	-	19.2	20.0
December	-	-	118.9	19.5
December	-	-	56.8	17.8
January	-	-	1.2	18.3
February	-	-	0	19.7

Table 2. Effects of cropping regime on aphid populations and yields of collard

Cropping Regime	No. of aphids/plant	Collard leaf yields: No. of collard leaves (in'000/ha)	Collard fresh leaf weight (mt/ha)	%marketable collard leaf nos.	% marketable collard fresh leaf weight
Season 1 (May – September 1999					
Collard intercropped Onion	17.1^{c**}	902.7^{n}	14.4^{r}	68.3^{v}	84.1^{z}
Collard intercropped with Beans	19.5^{b}	938.3^{n}	13.8^{r}	66.7^{v}	85.8^{z}
Monocropped Collard Sprayed with 'Bulldock'	3.8^{d}	1153.7^{m}	21.6^{q}	78.2^{u}	93.3^{y}
Monocropped Collard Unsprayed	33.3^{a}	1090.2^{m}	19.6^{q}	70.5^{v}	87.2^{z}
CV (%)	28.7	13.2	20.9	8.8	4.4
Season 2 (October 1999 – February 2000)					
Collard intercropped with Onion	22.6^{b}	459.7*	10.5^{m}	58.7	82.3
Collared intercropped With Beans	10.6^{c}	412.2	8.6^{m}	56.0	80.8
Monocropped Collard Sprayed with 'Bulldock'	10.1^{c}	504.6	12.3^{l}	60.2	82.9
Monocropped Collard Unsprayed	44.7^{a}	496.4	12.4^{l}	57.0	83.2
CV (%)	28.9	19.2	28.5	7.9	4.5

* Values not followed by a letter within a season and within a column, are not significantly different according to the F-Test at $P \leq 0.05$.

** Values followed by the same letter within a letter series and within a season and a column, are not significantly different according to the Duncan's Multiple Range Test at $P \leq 0.05$

marketability of collard leaf numbers and fresh leaf weights were subjected to arc sine transformation prior to analysis of variance. Values Presented are, however, the original means. Land Equivalent Ratios (LERs) for the different cropping regimes were computed using the formula:

$$LER = \frac{Y\ Intercrop\ 1}{Y\ Monocrop\ 1} + \frac{Y\ Intercrop\ 2}{Y\ Monocrop\ 2}$$

Where Y is the yield per unit area of either crop 1 or crop 2 in either monoculture or interculture. The highest yields of insecticide treated collard, beans and onions in monocrop for each season were used as denominators for computing the LERs.

Results and Discussion

Aphid population

Intercropping collard with either onions or beans significantly lowered aphid populations compared to unsprayed monocrop collard in both season (Table 2). Although spraying collards 'Bulldock' offered the best control in season 1, aphid populations recorded for this treatment were not significantly different from those recorded in collard-bean intercrop during the second season. Among the intercrop treatments, significantly lower aphid populations were recoded in collard – onion intercrop during the first season 2, however, aphid populations were lower in collard-bean intercrop compared to collard –onion intercrop.

Lower aphid populations in intercrop treatments compared to the unsprayed m0ncrop is attributed to the green background created by the intercrop components in intercrop treatments. Most aphid species have been shown to rely on colour clues to attack their targeted host, with a batter recognition of host plants that stand out against a bare soil (Root, 1973). Similarly, Costello and Altieri (1995) also reported lower aphid populations on broccoli undersown with living mulches compared with clean cultivation.

The difference in effectiveness of the bean intercrop in suppressing aphids in a collard bean intercrop observed season of the study. This larger canopy may have resulted in higher interference with the host finding ability of the aphids. The differences in bean canopy size observed between the two seasons was a result of the differences in rainfall distribution. Most rainfall of the second season was received during the first two months, while only a small amount of the rainfall was received at similar duration during season 1 (Table 1). Better rainfall received early during the second season facilitated high bean canopy development, thus offering a better ground cover. Hence, the low aphid population recorded for this treatment during the second season. Similar observations have been reported by Theunissen and de Ouden (1986) in brussel sprouts undersown with clover. In their study, cabbage aphid (*Brevicoryne brassicae*) infestation in brussel sprouts declined by 40-90% when 25 – 100% of the soil was covered by clover.

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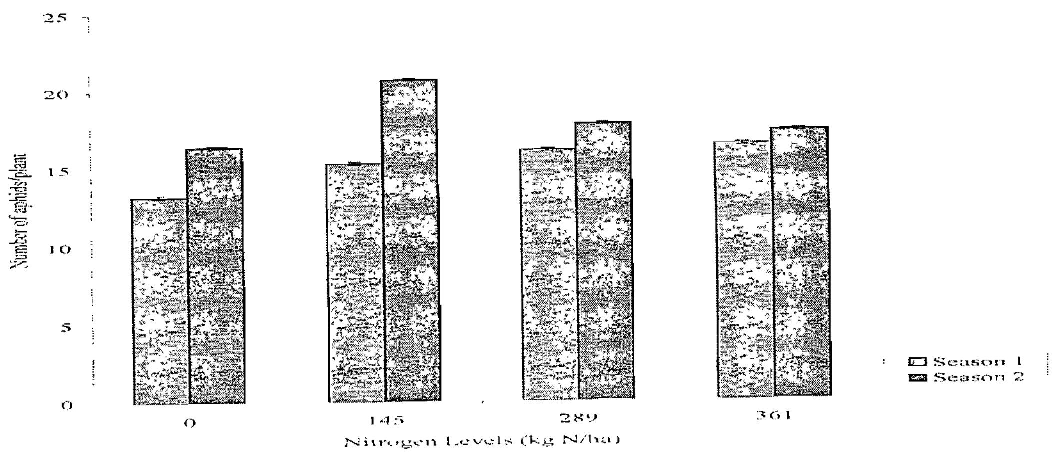

Fig. 1 Effect of nitrogen fertilization on aphid populations in collard

Nitrogen fertilization significantly increased aphid populations in both season of the study (Fig. 1). In season 1, aphid population increased with increase in nitrogen level with the highest aphid population recorded in collard that received 361 kgN/ha. In season 2, the highest aphid population was recorded in collard that received 145 kgN/ha with a decline in aphid populations recorded in collard tat received supplemental nitrogen is attributed to increased nitrogen levels in collard that received supplemental nitrogen is attributed to increased nitrogen levels in collard tissue (Fig. 2). Similar observations have been reported on potato by Jansson and Smilowitz

(1986) who found that population growth rate for *Myzus persicae* increased with the rate of nitrogen applied. The low aphid populations recorded in collard that received the higher rates of nitrogen (289 kg N/ha and 361 kgN/ha) compared to collard that received 145 kgN/ha during season 2 are attributed to low tissue nitrogen content in collard that received the higher nitrogen rates (Fig.2).

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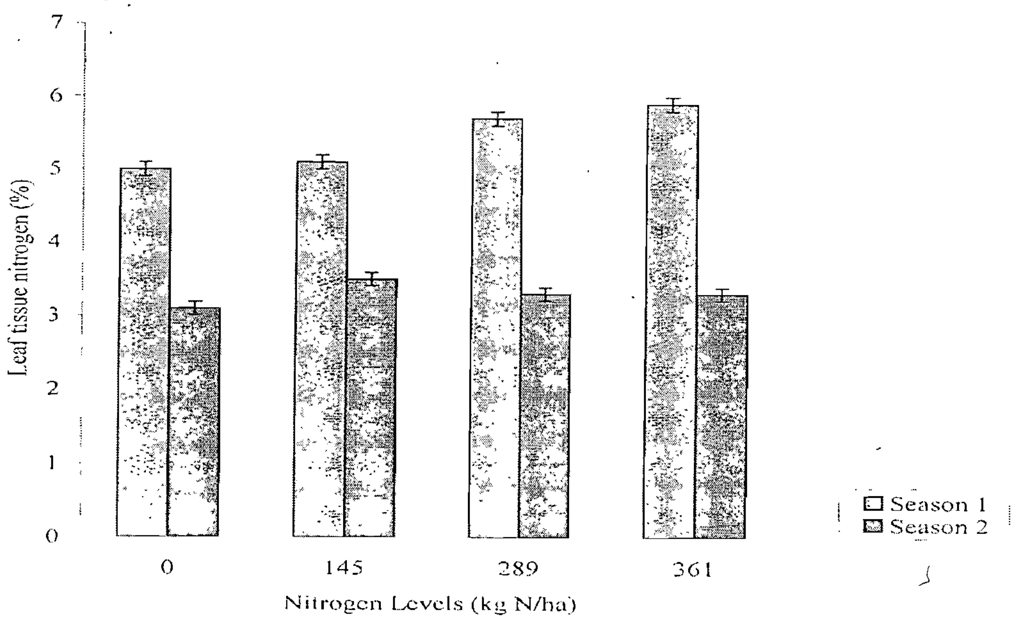

Fig.2. Effect of nitrogen fertilization on collard leaf tissue nitrogen content

Collard Yields

Intercropping collard with beans or onion significantly ($P \leq 0.05$) effect on marketable collard leaf numbers in season 1 (Table 2). In season 2, however, marketable collard leaf numbers recorded for the various cropping regimes were not significantly different at $P<0.05$. In both seasons, nitrogen fertility levels had no significant ($P<0.05$) effect on marketable collard leaf numbers (Table 3).

Table 3. Effects of nitrogen levels on marketable collard leaf yield

	Collard leaf yields			
Nitrogen level (kg N/ha)	No. of collard leaves (in '000/ha)	Collard fresh leaf weight (mt/ha)	%marketable collard leaf nos.	%marketable collard fresh leaf weight
Season 1 (May - September 1999)				
0	930.6*	13.0	66.5	84.5
145	1036.7	16.7	75.0	89.2
289	1099.9	19.6	73.0	89.3
361	1017.6	17.1	69.2	87.6
CV (%)	13.2	20.9	8.8	4.4
Season 2 (October 1999 – February 2000)				
0	456.2*	10.9	59.7	83.7
145	524.7	12.5	60.0	84.7
289	421.0	9.7	54.8	83.2
361	471.1	10.6	57.3	80.8
CV (%)	19.2	28.5	7.9	4.5

*Value not followed by a letter are not significantly different according to the F-Test at $P \leq 0.05$

Intercropping with either onions or beans in season 1 significantly reduced collard fresh leaf weight (Table 2). However, in season 2, intercropping collard with onions did not significantly affect collard fresh leaf weight, while intercropping collard with beans significantly reduced collard fresh leaf weight (Table 2). In both seasons, nitrogen fertility levels had no significant effect on the marketable fresh leaf weight of collard (Table 3).

In season 1, spraying with 'Bulldock' produced the highest percentage of both marketable collard leaf numbers and fresh leaf weight (Table 2). In season 2, both spraying and intercropping had no significant effect on the percentage of marketable collard yields (Table 2). In both seasons, nitrogen fertility levels had not significant effect on the percentage of marketable collard yields (Table 3).

The differential response of collard yields to intercropping with onions or beans observed in the individual seasons of this study is attributed to the differences in rainfall distribution pattern experienced in the two seasons and its subsequent effects on the growth pattern of the crop. Most of the rainfall was received later in the season during season 1, while in season 2, most of the rainfall was receceived early during the season (Table 1). Beans in season 2, therefore grew more vegetative and formed a large canopy early in the season, which resulted in shading of collard plants. The vegetative growth of collard plants in the collard-bean intercrop was, therefore, affected due to the shading effect of the bean canopy on the collard plants. Hence, the significantly lower collard yields recorded for this treatment during this season. In season 1, rainfall was low early in the season, and therefore beans were unable to form a large canopy, resulting in less shading on the collard plants. Hence, the better collard yields realized from the collard-bean intercrop plots during this season.

In the collard – onion intercrop plots, the growth of collard and onion plants was reduced early during the season in season 1 due to the low moisture conditions that prevailed. When rainfall increased in the middle of the season, onion plants recovered and grew more vegetative, imposing more competition for moisture. Hence, the low collard yields recorded for this treatment during this season. On the other hand, during the second season, moisture was abundant early in the season. Collard plants took advantage of the available moisture before the onion crop was well established and grew more vegetative. Thus, producing more leaves that boosted the leaf numbers and fresh leaf weights for this treatment compared to those recorded for the collard-bean intercrop during this season.

Bean Yields

Bean seed yield response to intercropping with collard varied with seasons (Table 4). Intercropping beans with collard significantly increased bean seed yield during the first season of the study, while during the second season, intercropping beans with collard significantly lowered bean seed yield. It was noted that the monocropped beans suffered more severe attack by ashy stem blight, a fungal disease caused by *Microphomina phasiolina*, than intercropped bean in season 1. Hence, the low bean seed yield recorded from monocrop beans during the first season. The low bean seed yield recorded from bean-collard intercrop treatment observed during the second season of the study in attributed to competition for growth factors in these plots. Itulya (1995) similarly recorded low bean yields in kale-bean intercrop plots compared to monocrop bean plots. In both seasons, nitrogen fertility had no significant effect on bean seed yield.

Table 4. Effects of cropping regime on bean seed yield and onion bulb yields

Cropping Regime	Bean seed yield Mt/ha	Onion bulb yield
Season 1 (May – September 1999)		
Beans intercropped with Collard	0.32[a]**	
Monocropped Beans	0.18[b]	
Onion intercropped with Collard		
Monocropped Beans		
Onion intercropped with Collard		7.41*
Monocropped Onion		9.93
CV (%)	11.2	24.5
Season 2 (October 1999 – February 2000)		
Beans intercropped with Collard	0.20[f]	
Monocropped Beans	0.32[e]	
Onion intercropped		2.93[k]
Monocropped Onion		6.98[j]
CV (%)	17.1	23.3

* Value not followed by a letter within a season and within a column, are not significantly different according to the F-Test at $P<0.05$.

** Values followed by the same letter within a letter series and within a season and a column are not significantly different according to the Duncan's Multiple Range Test at $P \leq 0.05$

Table 5. Land equivalent ratios (LERs) as influenced by nitrogen fertility level and intercropping collard with either beans or onion

N level (kg N/ha)	Season 1 Relative yield: Collared	Bean	Onion	LER	%increase	Season 2 Relative yield: Collard	Bean	Onion	LER	%increase
0	0.39	1.50	-	**1.89**	89	0.69	0.38	-	**1.07**	7
145	0.40	1.19	-	**1.59**	59	0.85	0.59	-	**1.44**	44
289	0.51	1.23	-	**1.74**	74	0.70	0.54	-	**1.24**	24
361	0.50	1.00	-	**1.50**	50	0.63	0.62	-	**1.25**	25
0	0.39	-	0.63	**1.03**	3	0.52	-	0.33	**0.85**	-15
145	0.56	-	0.66	**1.22**	22	0.65	-	0.38	**1.03**	3
289	0.74	-	0.71	**1.45**	45	0.49	-	0.48	**0.97**	-3
361	0.49	-	0.53	**1.02**	2	0.70	-	0.38	**1.08**	8

Onion Yields

Intercropping onions with collard lowered onion bulb yields in both seasons (Table 4). The reduction was, however, significant only in season 2. The lower yields in intercropped onions are attributed to competition for growth factors especially moisture, which was more limiting in season 2 than in season 1 (Table 1). In both seasons, nitrogen fertility did not significantly onion bulb yields.

Land equivalent ratios

Intercropping collard with beans or onions was beneficial in increasing food output per unit land area (Table 5), depending on the nitrogen fertility level. Increases in food output per unit land area as a result of intercropping collard with beans ranged from 50% to 89% in season 1 and from 6 to 44% in season 2. Intercropping collard with onions, on the other hand, resulted in a 2 to 45% increase in food output per unit land area in season 1, and a – 15% to 8% increase during the second season.

In addition to suppressing aphid populations in collard, the results of this study show that intercropping collard with beans in beneficial in increasing food output per unit land area while the benefits of intercropping collards with onion may vary from negative to positive. In both seasons, higher benefits were realized from intercropping collard with beans than intercropping collard with onions at most nitrogen levels. Realized benefits were generally higher in season 1 than in season 2, which is attributable to the higher rainfall amount received during season 1. Itulya (1995) and Itulya and Aguyoh (1998) reported similar results. In both studies, intercropping kale with beans increased food output per unit land area with higher benefits recorded in seasons that received more rainfall.

Conclusions

From the observations made in this study, it can be concluded that intercropping collard with beans or onions is beneficial in suppressing aphid populations in collard with better suppression achieved when moisture levels are adequate for good growth of the intercrop. Intercropping collard with beans increases food output per unit area of land where as intercropping collard with onions may increase or decrease the output per unit land area depending on other factors likes amount of nitrogen applied and prevailing moisture condition. Increasing nitrogen fertility levels in the growth medium increases aphid populations in collard.

Acknowledgements

We wish to acknowledge Egerton University, Njoro- Kenya for financial support and provision of research facilities and Bayer (K) Limited for supplying the insecticide ('Bulldock').

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