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Research Article

Effect of intercropping on the incidence of Jassid (*Amrasca biguttula biguttula* Ish.) and Whitefly (*Bemesia tabaci* Guen.) in Okra (*Abelmoschus esculentus* L. Moench)

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ABSTRACT

Okra is one of the most important summer vegetables in South Asian countries including Nepal. However, the damage by insects like Jassid (*Amrasca biguttula* Ish.) and whitefly (*Bemisia tabaci* Guen) has resulted in significant reduction of its production. An experiment was conducted based on intercropping taking okra (*Abelmoschus exculentus* L. Moench) as the main crop in Arghau, Lekhnath-27, Kaski, Nepal from March 4 to May 24, 2018. The intercrops used were coriander (*Corriander sativum),* carrot (*Daucas carota)*, fennel (*Foeniculum vulgare*) and parsley (*Petroselinum crispum)*. The population of jassid and whitefly was recorded from three leaves representing the different strata (bottom, middle and top) of the vegetative parts; and related yield parameters were also observed to correlate with the level of population incidence of these pests. Least numbers of jassids (5.50±0.29, 6.94±0.43, 8.00±0.41 and 3.69±0.76) were observed respectively at 30, 40, 50 and 60 days after sowing (DAS) in okra+ coriander. Likewise, okra + coriander intercropping was effective in inhibiting the population of whitefly (7.50±0.59, 8.56±0.19, 10.25±0.66 and 7.06±0.42) at 30, 40, 50 and 60 days after sowing (DAS) respectively. In contrary, the highest number of jassids and whiteflies were observed in okra + parsley and control (okra only). Both pod length (cm) and yield (t/ha) were the highest (17.92±0.57 and 28.20±0.49 respectively) in okra + coriander and were the lowest (16.42±0.21 and 27.58±0.39 respectively) in okra + carrot. The benefit-cost ratio was in order okra + coriander > okra + carrot > okra + fennel > okra + parsley > control (okra only). Among the different intercrop combinations, the okra + coriander was found most effective that could be suggested as one of the alternative strategies to limit the population of pests; jassid and whitefly in okra.

Key words: Okra, Intercropping, Jassid, Whitefly

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INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is one of the most important summer vegetables. The fruit contains some essential vitamins (vitamin C) and mineral salts such as calcium, magnesium, potassium and iron including water at varying proportion (Shippers, 2000). Among many major insect pests of okra, jassid (*Amrasca biguttula biguttula* Ish.*)* and whitefly (*Bemesia tabaci* Guen,) are major constraints to decrease the productivity. These insects suck the leaves of okra and acts as vector to transmit viral diseases which decline the yield of okra. The population of these insects multiplies rapidly and cause severe infestation that had led to use of perilous chemical pesticides. The chemical pesticides are hazardous to both human health and environment. Therefore, to reduce these hazards sustainable insect pest management must be adopted. The diversification of cultivation through intercropping could repel and suppress the insect pest population. Intercropping brings about increases diversity in an agro-ecosystem. It minimizes environmental impacts of agriculture through reduced pesticide requirements (Reddy, 2017). Several cultural practices are known to promote diversity and stability on the farm, including the Intercropping (Ouma & Jeruto 2010). This practice increased the distance between plants of the same species which leads to complicate migration of pests or transmission of diseases from one plant to another in the same field. In crop protection generally there is a base crop and one or more associated plants grown within, acting as repellent or attractant for certain pests. Attractant species are mainly used as trap plants to reduce pest infestation on the base crop. Once pests are lured from the main crop on to the trap plants, they can be controlled in limited area with minimum cost. (Gautam & Chhaya, 2017) Some plant combinations, for instance, with non hosts reduce the spread of pest within crops (Degri *et al.*, 2014). Non host plant in such mixture may emit chemical or odors that adversely affect the pests, thereby conferring some level of protection to the host plant (Reddy 2012). Wszelaki (2014) reported that the use of intercropping can provide benefits to a management system, including decrease insect pest pressure, reduced need for external inputs, increase in biodiversity, enhanced production and lower economic risk. Separation susceptible plants with non host species provides a physical barrier to insect pest movement, limiting spread and decreasing livelihood of damage to susceptible varieties. (Gautam & Chhaya, 2017). The use of intercropping system is one of alteration to insecticide. It is a non-chemical cultural practice that has the potential to reduce pest infestation because it increases crop diversity (Sullivan, 2003; Woomer *et al.*, 2004; Degri *et al.*, 2012; Degri *et al.*, 2014). Crop intercropping or mixing as a traditional agricultural technique for preventing crop yield decrease from plant disease and pest infestation in different world geographical area can also increase biodiversity in field to encourage environmentally sustainable agriculture production with low inputs of pesticide (Ghaley *et al.*, 2005) The broader objective of research was to screen the suitable intercrop to reduce the incidence of jassid and whitefly in okra whereas the specific objectives include accessing the population of jassid and whitefly, calculating the yield differences and B: C ratio in different intercropping systems.

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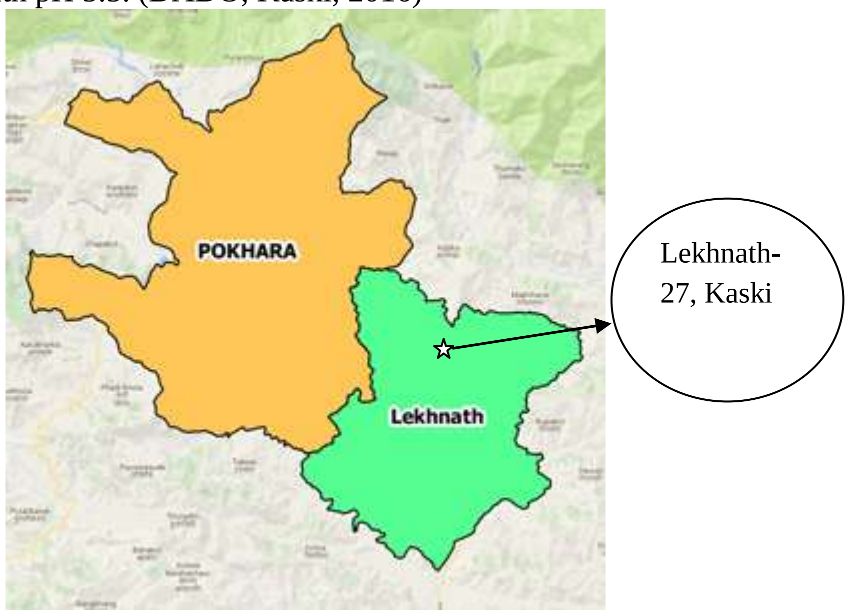
MATERIALS AND METHODS

Experimental site

The research was conducted during summer season 2018 in Lekhnath-27, Kaski, Nepal. It is situated in North East from Pokhara city between 28º 9' 38" N latitude to 84º 5' 27" E. It is located in midhills about 15.3 km away from Pokhara city (DDC, 2017). The test report shows the soil as sandy loam with pH 5.5. (DADO, Kaski, 2016)



Source: English.ratopati.com

Figure 1. Map of Pokhara-Lekhnath Municipality showing the study site

Climatic observation

The research was conducted in spring season. The average temperature during the experimental period was 24^{o}C. (AccuWeather, 2017)

Selection of intercrops

The intercrops chosen were less vigorous, dwarf and less exhaustive than okra.

Experimental design and details of treatment

The research was conducted in Randomized Complete Block Design with plot size 2m×1.8m. The treatments were five and replications were four. The main crop okra was sown in recommended spacing 50 cm (R-R) × 25 cm (P-P) and intercrops were sown at 25 cm from the rows of okra alternatively with four rows of okra/plot and three rows of intercrops/plot. The intercrops used were coriander (*Corriander sativum),* carrot (*Daucas carota),* Fennel (*Foeniculum vulgare*) and parsley (*Petroselinum crispum)*. The varieties used were Arka Anamika (okra), New Karuda (carrot), Curly Leaved parsley (parsley) and local variety (fennel and coriander).The treatment T_1 consisted of okra only, T_2 okra and coriander, T_3 okra and carrot, T4 okra and fennel and T_5 okra and parsley, respectively.

Cultural practices

The land preparation was done two weeks before sowing. All the crops were directly sown while the intercrops were sown continuously and thinned at 25 DAS. The application of recommended dose of fertilizer was basal and nitrogen was applied in split doses. The weeding and irrigation were done as per requirement.

Data Collection

Recording the pest population

In each treatment four sample plants of okra were selected randomly form the middle two rows of okra. The number of jassids and whiteflies were counted on the basis of visual observation from three strata of vegetative parts (one upper, one lower and one bottom leaves) of sample plants of okra.

Recording yield attributing characters of okra

The fruits were harvested four times from 50 DAS to 80 DAS at weekly intervals. The pod length (cm) of bigger and smaller pod on each harvest was recorded and average of each sample plant was calculated. This data was recorded on each harvest and average pod length (cm) of sample plant was calculated at last.

The number of fruits per sample plant and yield per sample plant was recorded on each harvest and average was calculated. The yield per plot was later converted to tons per hectare.

Statistical analysis

The collected data were entered in MS- Excel, 2010 and were analyzed using R-STAT software at 5% level of significance and the significant differences between treatments were determined using least significant difference (LSD) test at probability level of 0.001, 0.01 or 0.05 where the effects of the treatments were significant at 0.1%, 1% or 5% level of probability, respectively (Dahiru, 2008; Kunwar & Shrestha, 2014).

RESULTS AND DISCUSSION

Population build-up of *Amarasca biguttula biguttula Ish.* in the intercropping system

The number of jassids was significantly different in all the treatments at 30, 40, 50 and 60 DAS. The number of jassids per three leaves per plant of okra was significantly lower in okra intercropped with coriander than other treatments. At 30 DAS the number of jassids per three leaves per sample plant was the lowest (5.50) when okra was intercropped with coriander. The highest number (10.81) of jassids per three leaves per sample plant was observed in control followed by okra intercropped with parsley (9.75).

At 40 DAS number of jassid per three leaves per plant of okra was significantly lower (6.94) when okra was intercropped with coriander. The highest population (12.50) of jassid was found in control followed by okra intercropped with parsley (11.63) which was at par to okra intercropped with carrot (10.63). At 50 DAS number of jassids per three leaves per plant of okra was significantly lower (8.00) in okra intercropped with coriander. The highest number (14.94)

of jassids per three leaves per plant of okra was observed in control followed by okra intercropped with parsley (13.63) which was statistically similar to okra intercropped with fennel (12.56).The number of jassids per three leaves per plant of okra when okra was intercropped with fennel (12.56) and okra intercropped with carrot (12.38) was at parity. At 60 DAS the number of jassids per three leaves per plant of okra was significantly lower (3.69) when okra was intercropped with coriander. The number of jassids per three leaves per okra plant was at parity in all other treatments. The population of jassid increased with plant age was mentioned by Ragumoorthi and Kumar (2000) who stated in the vegetative phase, population was comparatively less okra (*A. esculentus*) in near maturing crop (60 day). This may be due to the thinner veins of early stage crop, which further developed into thicker vein and thereby favored more number of jassid on leaf. Similarly as the age of the plant increase, increase in the size of leaf lamina, decreases the hair density and increases the population of jassid. The lowest number of jassids per three leaves of okra plant when okra was intercropped with coriander in all the observations might be due to pest repellent nature of coriander due to presence of volatiles and increase in number of coccinelids with largest Shannon-Wiener indices in treatment where coriander was used as intercrop (Sujaynand *et al.,* 2015). He also stated that the volatiles from coriander likely acted to repel leafhoppers, resulting in smaller populations than the sole crop. Similarly, Wagan (2015) stated that natural enemies control the pest population, also the same time agro ecosystem encourage the activities of predators.

Table 1. Population build-up of *A. biguttula biguttula* Ish. in different intercropping system

Treatments	Number of jassids per three leaves			
	30DAS	40DAS	50DAS	60DAS
Okra only	$10.81^{a}\pm 0.84$	$12.50^{a}\pm0.65$	$14.94^{a}\pm0.67$	$9.31^{a}\pm0.85$
Okra+ Coriander	$5.50^{d}\pm0.29$	$6.94^{c}\pm0.43$	$8.00^{c}\pm0.41$	$3.69^{b}\pm0.76$
Okra+ Carrot	$8.63^{bc}\pm0.38$	$10.63^{ab}\pm0.69$	$12.38^{b}\pm0.38$	$10.50^{a}\pm0.5$
Okra+ Fennel	$8.00^{c}\pm0.00$	$10.38^{b}\pm0.68$	$12.56^{b}\pm1.03$	$9.50^{a}\pm0.29$
Okra+ Parsley	$9.75^{ab}\pm0.37$	$11.63^{ab}\pm0.63$	$13.63^{ab}\pm0.24$	$9.94^{a}\pm0.78$
F test	***	***	***	***
$L.S.D_{0.05}$	1.16	1.81	1.93	2.22
CV (%)	8.80	11.29	10.17	16.79

DAS: Days after sowing, LSD: Least significant difference, CV: Coefficient of variation, Value with same letters in the column is not significantly different at 5% by DMRT and figures after ± indicates standard error. ***Significant at 0.1 % probability level.

Population build-up of *B. tabaci* Guen. in the intercropping system

The number of whiteflies was significantly different in all the treatments at 30, 40, 50 and 60 DAS. The population of whitefly was significantly lowest when okra was intercropped with coriander. At 30 DAS, the lowest number (7.50) of whiteflies per three leaves per okra plant was found when okra was intercropped with coriander. The highest population (12.56) of white fly was found when okra was intercropped with parsley which was statistically similar to control (11.81) and okra intercropped with carrot (11.25). At 40 DAS, the lowest number (8.56) of whiteflies per three leaves per okra plant was found when okra was intercropped with coriander.

The highest population (14.63) of whitefly was observed when okra was intercropped with parsley followed by control (13.06) which was at par with okra intercropped with carrot (13.38).

At 50 DAS, the lowest number (10.25) of whiteflies per three leaves per okra plant was observed when okra was intercropped with coriander. The highest population (15.31) of whitefly was observed when okra was intercropped with parsley which was statistically similar to control (15.13), okra intercropped with carrot (12.81) and okra intercropped with fennel (14.25). At 60 DAS, the lowest number (7.06) of whiteflies per three leaves per okra plant was observed when okra was intercropped with coriander. The highest population (12.31) of whitefly was found in control which was statistically similar to okra intercropped with carrot (12.00), okra intercropped with parsley. (11.56) and okra intercropped with fennel (11.50). At each observation the number of whiteflies per three leaves per plant of okra is found lowest in okra intercropped with coriander which can be supported by Tongi *et al.* (2010), who demonstrated that intercropping tomato with coriander reduces the incidence and severity of damage caused by whitefly. He further suggested that coriander constitutive volatiles interferes host plant selection of whitefly. Mann *et al.* (2010), reported that Linalool and alfa-pinene are major volatiles found in coriander which might be reason for decrease in population of insects in plot where coriander is used as intercrop. Ngoh *et al.* (1998), Ukeh *et al.* (2007) and Sfara *et al.* (2009) reported that Linalool and alfa-pinene have reported to repel or kill several herbivore insects including Hemipterians. Hilje and Stansly (2008) and Togni *et al.* (2009) found coriander plants have been successfully intercropped with tomatoes to manage whiteflies by reducing the number of incoming adults.

Table 2. Population build-up of *B. tabaci* Guen. in the intercropping system

Treatments	Number of whitefly per three leaves			
	30DAS	**40DAS**	**50DAS**	**60DAS**
Okra only	$11.81^{a}\pm 0.64$	$13.06^{b}\pm0.42$	$15.13^{a}\pm0.31$	$12.31^{a}\pm0.87$
Okra+ Coriander	$7.50^{b}\pm0.59$	$8.56^{c}\pm0.19$	$10.25^{b}\pm0.66$	$7.06^{b}\pm0.42$
Okra+ Carrot	$11.25^{a}\pm0.25$	$13.38^{ab}\pm0.24$	$14.81^{a}\pm0.28$	$12.00^{a}\pm0.207$
Okra+ Fennel	$11.44^{a}\pm0.31$	$12.25^{b}\pm0.05$	$14.25^{a}\pm0.37$	$11.50^{a}\pm0.29$
Okra+ Parsley	$12.56^{a}\pm0.53$	$14.63^{a}\pm0.38$	$15.31^{a}\pm0.43$	$11.56^{a}\pm0.32$
F test	***	***	***	***
$L.S.D_{0.05}$	1.51	1.36	1.38	1.93
C.V (%)	9.28	7.12	6.43	11.54

DAS: Days after sowing, LSD: Least significant difference, CV: Coefficient of variation, Value with same letters in the column is not significantly different at 5% by DMRT and figures after ± indicates standard error. ***Significant at 0.1 % probability level.

Effect of intercropping in yield parameters

Effect of intercropping on average pod length(cm) of okra

The pod length was significantly different among all the treatments. The highest average pod length (17.92 cm) was obtained when okra was intercropped with coriander. The average pod length in all other treatments was statistically similar.

Effect of intercropping on average number of fruits per plant

The average number of fruits per plant was highly significant in all the treatments. The highest average number of fruits per plot (15.75) was observed when okra was intercropped with coriander. The lowest average number of fruits per plant (12.25) was found when okra was intercropped with carrot. The highest yield of okra in treatment when okra was intercropped with coriander may be due to less damage of insects to okra leaves.

The least yield was observed in treatment where carrot is used as intercrop. Ofosu-Anim and Limbani (2007) observed the 60% yield reduction in bulb of onion when intercropped with carrot and the reduction of yield could have been caused by the intercrop competition for nutrients, water and light.

Effect of intercropping on yield per plot(t/ha)

The yield of okra per plot was significantly different in all the treatments (Table 3). The highest yield (28.20t/ha) was found in okra intercropped with coriander which is followed by okra intercropped with fennel (27.97 t/ha). The lowest yield per plot (27.77 t/ha) was found in control followed by okra intercropped with parsley (27.66 t/ha) and okra intercropped with carrot (27.58 t/ha). Abdelkader and Mohsen (2016) found that intercropping pattern of 1 coriander: 2 onions gave the highest values of onion NPK uptake and protein content per bulb. The highest yield per plot in coriander used as intercrop is due to decreased pest attack than other treatments.

Table 3. Effect of different intercropping system in average pod length (cm), average number of fruits per plant and yield per plot (t/ha)

Treatments	Average pod length(cm)	Average number of fruit per plant	Yield per plot (t/ha)
Okra only(control)	16.96^{b}±0.44	14.50^{b}±0.65	27.77^{bc} ±0.48
Okra + Coriander	17.92^{a}±0.57	15.75^{a}±0.48	29.20^{a}±0.49
Okra + Carrot	16.42^{b}±0.21	12.25^{c}±0.48	27.58^{c} ±0.39
Okra+ Fennel	16.75^{b}±0.32	14.25^{b}±0.48	27.97^{ab}±0.46
Okra+ Parsley	16.74^{b}±0.26	14.00^{b}±0.41	27.66^{c}±0.51
F test	*	***	**
$LSD_{0.05}$	0.943	0.783	0.288
CV (%)	3.60	3.592	0.672

DAS: Days after sowing, cm: centimeters, LSD: Least significant difference, t/ha: tons per hectare, CV: Coefficient of variation, Value with same letters in the column is not significantly different at 5% by DMRT and a figure after ± indicates standard error. * , ** and ***, significant at 5 % , 1 % and 0.1% probability level.

Benefit-cost ratio in different intercropping system

Economics of production was calculated for each treatment. The total revenue is the sum of revenue from both okra and intercrops. The cost incurred in Labor and Fertilizer was same for each treatments. However, the cost of seed was different in different treatments except the main crop. The cost and returns were based on Local and standard market price at Pokhara-Lekhnath Municipality on 10th July, 2018.Total revenue collected from each treatments, cost incurred in each treatment and Benefit cost ratio is presented in Table 4.

The highest benefit cost ratio (3.00) was obtained in okra intercropped with coriander followed by carrot (2.09). The lowest benefit cost ratio (0.81) was obtained in control.

Table 4. Total revenue, Total cost and benefit cost ratio in different intercropping systems

Treatments	Total revenue (Rs)	Total cost (Rs)	B:C
ra only	1381222.222	1710438	0.81
Okra + Coriander	3136319.444	1043771	3.00
Okra + Carrot	2067083.333	988215.5	2.09
Okra+ Fennel	1795868.056	1015993	1.76
Okra+ Parsley	1802777.778	1571549	1.14

CONCLUSION

When okra vegetable was intercropped with coriander the number of insects (jassids and whiteflies) was significantly lower than other intercrop combinations. The yield of okra was also the highest when it was intercropped with coriander with highest benefit cost ratio. So, it is recommended to grow okra with coriander to minimize the incidence of jassid and whitefly and hence to minimize the application of pesticides on okra crop.

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Author Contributions

A.S designed the plot, collected data and prepared the manuscript; K.R.N prepared the research methods; R.R and R.C.N helped in analysis of data.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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