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Effect of intercropping and few biorationals in eco-friendly management of major pest Okra

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Abstract
Okra (*Abelmoschus esculentus*), the world's most important crop, is frequently harmed by a variety of pests and diseases. Present-days chemical pesticides are being used to address major pests and diseases of the okra plant. In spite of the fact that chemical pesticides are frequently useful, repeated use of these substances often leads to insects becoming resistant to them, fewer natural enemies, less effective natural control, and damaged eco-systems. Therefore, the management of okra pests and illnesses through biological methods, such as intercropping with sprays of biorational insecticides has become increasingly popular due to increased environmental awareness about sustainable crop production. Intercropping with the support of biorational sprays will increase overall yield and productivity while also offering major economic benefits. By altering the biological structure and surrounding environment, creates an unfavourable environment for pests. Intercropping okra with other crops also increases the population of natural enemies and decreases the incidence of pest population in the field. It helps reduce pests by boosting the population of predators and parasitoids. Bio-rational insecticides, viz., Neem baan, Spinosad, NSKE 5%, and extracts of several botanical plant parts (Neem leaves, garlic cloves, red chillies, and lemon grass leaves, etc.), are being used simultaneously with intercropping to manage pest populations. However, the goal of this study is to evaluate the performance of intercropping with a biorational pesticide combination as a means of reducing major okra pests, as well as the appropriate management system of intercropping with a suitable biorational spray.

Keywords: Okra, Major insects pest, intercropping, Biorational insecticides

Introduction
Okra (*Abelmoschus esculentus*) is a very important vegetable crop grown all over the countries specially in tropics and subtropics of the world. It can be grown in all the season but most favourable season for its growth is summer season. Okra is also known as lady's finger, bamia or gumbo. With a production of 5784.00 tonnes from an area of 498.00 hectares (APIDA). It comes in fifth place in terms of area under vegetables in the nation, right after tomato.

Fig 1: Healthy Okra Plant

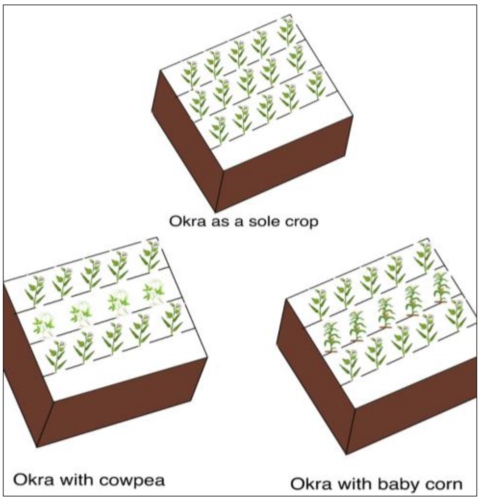
Okra first appeared in tropical and subtropical Africa. It is originated by the north-eastern countries of Ethiopia and Sudan. Nowadays, it is grown in almost all countries, especially in India, America, Japan, Asia, etc. The plant is grown for its young and soft fruits, which are cooked and used in soups and curries. Due to its high fibre, vitamin C, and folate content, okra is a well-liked healthy food. The strong antioxidant content of okra is another well-known benefit. Okra is also a rich source of calcium and potassium. The mature okra seed has a significant nutritional value and is a rich source of protein and oil (Oyelade *et al.*, 2003). It is also useful for the treatment of goiter and a good source of iodine.

Fig 2: Jassid on Okra leaf

This vegetable crop provides a good source of revenue to farmers. The greatest obstacle in okra production is the pest issue. Production of okra in India is hampered by the incidence of sucking pests, defoliating insects as well as viral infections. Almost 72 insect species attack the okra plant in total, with 13 species causing significant damage in various countries around the world (Rao and Rajendran, 2002) [43]. The major destructive sucking pest viz., aphid (*Aphis gossypii),* leaf hopper (*Amrasca biguttula biguttula*), white fly (*Bemisia tabaci),* mite (*Tetranychus cinnabarinus)* etc and major pest is shoot and fruit borer (*Earias vittella)* which causes considerable damage to the crop. Farmers use toxic pesticides on a regular basis to control this damaging pest to protect their crops from it, but frequent use of these chemicals causes pest resistance, revival, and pesticide residues, which are hazardous to beneficial fauna and the environment (A Mohammad; 2018) [29]. For this reason, it is important to find alternative approaches for pest management other than the use of chemical insecticides. Instead of synthetic chemical-based insecticides, intercropping can be used as an eco-friendly tool in IPM. To lessen the load of synthetic insecticides, intercropping systems can be supported by sprays with biorational products and eco-friendly chemicals such as Neembaan and Spinosad for reducing the incidence of pests from okra crops.

3. Methods and materials

3.1. Intercropping



Intercropping is a historic agronomic technique for increasing crop output and profitability [1] (Rao and Mathuva 2000; Singh and Ahlawat 2011, 2014; Lopes *et al*. 2016; Himmelstein *et al*. 2017; Kumar *et al*. 2017; Singh *et al*. 2017) [47, 38, 23, 16]. Growing of two or more crops simultaneously on the same piece of land is called intercropping, example: Okra + baby corn + cowpea (2:1:1). This approach has been adopted for a number of reasons, including weed management, yield enhancement, insurance against total crop failure, and large financial rewards. This cultural practice is much more effective than a monocropping system because it increases crop diversity, the population of natural enemies and pest control. It will have an impact on insect herbivore population dynamics in agriculture as well as their predators and parasitoids. Intercropping help to reduce pest damage by suppressing their population, therefore; chemical spray can be reduced and it will be compatible with ecologically friendly and long-term production method. Furthermore, intercropping can increase plant diversity and cause higher and additional stable crop productivity and multiplied economic advantages. Intercrop is also used for another physical factors like- protection of main crop from wind; provide shading to main crop; sheltering; prevention of dispersal; alteration of colour of leaves (Andow, 1991 and Theunissen, 1994) [6, 49].

3.2. Biorational insecticides

Insecticides that effectively control insect pests but are less hazardous to nontarget creatures (including people, animals, and natural enemies) and the environment are known as biorational or "reduced risk" insecticides (Hara., 2000) [17]. Biorational pesticides are an essential part of organic farming and other rapidly evolving sectors of agriculture (Reddy and Chowdary, 2021) [37]. These elements are easily available for pest management with little negative impact on the environment and for resource-poor farmers in many regions due to their cheaper cost and easy access (Pavela and Benelli, 2016) [34]. Instead of using chemical insecticides, farmers can use bio-rational insecticides, which is an alternative promising approach. It is harmful for targeting insects and it has no harmful effects on natural enemies. Biorational pesticides are a type of pesticide made from natural resources such as minerals, plants, animals, and other organic materials. One well-known example of a biorational pesticide is delta-endotoxins, produced by the Bacillus thuringiensis bacteria, which are toxic to certain insects. Another popular botanical pesticide is azadirachtin, extracted from neem tree seeds, used to control a variety of insect pests in vegetables and other crops. Additionally, Spinosad, a natural chemical produced by a soil bacterium, is toxic to insects and has been used to control a wide range of pests. Another biological insecticides, abamectin, affects the brain and nervous system of insects, leading to paralysis. The use of botanical insecticides can help to reduce reliance on synthetic pesticides and be a key component of insect of insect control program.

3.3. Interaction of intercropping and biorational on insect pest

Interaction between intercropping and biorational products plays a major role in managing the major pest of okra plants. In this review paper we will discuss the best crop combination with some biorational treatments that have been found by severer researchers. We can cultivate many crops as an intercrop with okra. Baby corn, sorghum, black gram, and cluster bean are used as an intercrop with okra. Leaf hopper (*Amrasca biguttula biguttula*), white fly (*Bamasia tabaci*), red spider (*Tetranichus cinnabarinus*) and other sucking pests can be effectively controlled by intercropping with baby corn (*Zea mays* L.), sorghum (*Sorghum bicolor*), urdbean (*Vigna mungo* L.) and cluster bean (*Cymopsis tetragonolob* L.) around the main crop supported by sprays with eco-friendly chemicals, i.e., neem baan and spinosad. Many researches have demonstrated that intercropping different vegetable crops offered significant benefits and higher profitability than vegetables cultivated as solitary crops (Willey, R. 1979; Sharaiha, R, and Haddad, N. 1985; Nursima, K. 2009) [45]. Bush bean, okra, lettuce, and squash were four vegetable crops that were planted in six different combinations. In the open field, each combination was planted in four distinct row patterns (1:1, 1:2, 2:1, 2:2). Intercropping of lettuce with the main crop gave significantly better yields when planted with between under all row arrangements, with an average increased yield of 45% and 66%, respectively. However, when bean was intercropped with okra, the output was substantially higher (16.66 tonne ha1) than when okra was grown alone (13.63 tonne ha1). The flea bettle is the other major pest of okra in the semi-arid zone. Many study concluded that sole crop Okra was attacked by flea beetles, which had an impact on its development, fruit production, weight, and yield. Intercropping with sorghum with okra is a very effective IPM tool for significantly reducing the flea beetle population. Many researchers concluded that maize, sorghum, and cowpea can be used as an intercrop with okra and some biorational insecticides, viz., Bacillus thuringiensis, emamectinbenzate, spinosad, chlorofenapyrs, Beauveria bassiana, neem, and Verticillium lecani, which are very effective against *Earies vittella. Euaries vitella*, a shoot and fruit borer, is a serious pest of okra which directly attacks tender fruits. Okra+cowpea fallowed by okra+sorghum is a more suitable combination than okra+maize for managing shoot and fruit borer. According to Mohanasundaram *et al*., (2012) [17, 20], the least amount of fruit damage caused by *E. vitella* was seen while intercropping of okra and cluster beans with spray of biorational insecticides, viz., Neem baan and Spinosad. Sujayanand *et al*., found the best management system of E. vitella is intercropped with marigold + okra, followed by okra + coriander in the winter season. Many researchers have experimented with different crop combinations and biorational pesticides. These are listed below.

Table 1: Some crop combination with some Bio-rationales insecticides

No.	Intercrop	Biorational Insecticides
1	Okra+ Baby corn (2:1)	Neem Baan and Spinosad
2	Okra+ Sorghum(2:1)	Neem Baan and Spinosad
3	Okra + Urdbean	Neem Baan @ 3 ml/l and Spinosad 45% SC @ 75 gm
4	Okra + Cluster bean	Neem Baan and Spinosad
5	Okra + Bean (1:1), (2:1), (1:2), (2:2)	-
6	Okra + Lettuce (1:2), (1:1), (2:1), (2:2)	-
7	Okra + Squash (1:1), (1:2), (2:1), (2:2)	
8	Okra + Maize	NSKE 5 %
9	Okra + Coriander	NSKE 5 %
10	Okra + Marigold	NSKE 5 %
11	Okra + Mint	NSKE 5 %
12	Maize + Okra + Cowpea	Neem extract + Garlic extract + Red chili extract + Cow urine (NGCC)
13	Okra + Cowpea	Azadirachtin and Beauveria bassiana
14	Okra + Indian spinach	Neem oil
15	Okra + Red Amaranth	Neem oil
16	Okra + Jute	Neem oil
17	Okra + Black gram	NSKE 5 %
18	Okra + Sunflower	-
19	Okra + Baby corn	Azadirachtin (0.03%EC) and Beauveria bassiana (1.15% SC) @2.5 ml/l

3.4. Impact of biorational and intercropping in reducing the pest incidence

According to many research, biorational and intercropping have a favourable impact on lowering insect incidence. When okra was planted with any intercrop, the populations of leafhopper, whitefly, and red spider mites were lower than on a sole crop of okra. Balasubramanian *et al*., observed that the infestation of leafhoppers was reduced due to the presence of diverse intercrops such as cluster bean, moog bean, and urdbeen in the cotton crop. The population of leafhopper in pigeon pea was also decreased by sorghum as an intercrop (Sekhar *et al*., 1997). After evolution of the effects of intercropping systems with neem oil treatment, they got a very good impact on plants compared to the monoculture of okra. They used jute, Indian spinach, and red Amaranthus *s.p* as an intercrop in the okra field. When they did intercropping without neem oil spray, they got better results than the monoculture. But the best result they observed was from the okra with neem oil treatment. Some intercropped plants contain chemical compounds that are not suitable for other organisms (like insects and pests) that keep insect pests away from the crop. According to Saeed *et al*., (2008), garlic contains some allicin compounds which can repel the infestation of pests from cabbage fields. Onions and garlic are being used as intercrops to reduce the incidence of insect pests, and they also have anti-bacterial and anti-fungal properties. Sunflower is an excellent trap crop which can be used as an intercrop with okra. That will help to increase the incidence of pollinators and natural enemies like parasites or predators (e.g., ladybird beetles, big-eyed bugs, lacewings, ants, lynx spiders, etc). Researchers observed, cowpea used as an intercrop in the field of okra has given the best results for management of shoot and fruit borer. According to Mohanasundaram *et al*., (2012) [17, 20] the shoot and fruit borer of okra have been successfully controlled by the intercropping of okra and cluster beans with the spray of some eco-friendly chemicals, e.g., Neembaan and Spinosad. They also received maximum productivity from the intercrop combination of okra and cowpea followed by okra and sorghum rather than a sole crop of okra. On the other hand, it was observed that the impact of intercropping of okra and maize was less effective for pest management than a sole crop. Ram Kumar *et al.*, observed that the incidence of whitefly was not minimised as per his expectation after using maize as an intercrop of Okra. But, Mohanasundram *et al*., observed some different results after using baby corn as an intercrop of okra with some sprays of bio-rational pesticides, e.g., Neem Baan and Spinosad. He received positive impact than sole crop because he used intercrop with some biorational spray, which helped to manage the incidence of whitefly. On the other hand, other researchers (Asawalm, 2012; Sujayanand *et al*., 2016) [27] observed good results after sowing ginger and marigold as intercrops with okra for control of the whitefly population. Intercrop of sorghum in okra fields was also associated with the reduction of flea beetle, increased photosynthetic activity and overall intercrop production. Nowadays, border crops are also being used with intercrops simultaneously. The number of leafhoppers was controlled by using coriander as an intercrop and maize as a border crop. The incidence of whitefly and fruit borer was also reduced by the sowing of marigold as an intercrop with okra and maize used as border crops. Emamectinebenzoate, Beauveria bassiana, Neem, Bt, Spinosad, Chlorofenapyrs etc; These are common biorational pesticides used to help intercrop systems reduce pests and increase the prevalence of natural enemies. Among those biorational pesticides, Emamectin benzoate is more suitable and effective against fruit borers, followed by Spinosad. Different plant extracts, namely-neem, garlic bulb, lemon grass, chilli, etc., are very effective for controlling whitefly, jasside, and blister beetles. Entomopathogenic microorganisms (namely, bacteria, fungi, nematodes, and viruses) are being effectively used as biopesticides in the control of pests. Control in okra. Bacillus spp., Clostridium spp., Paenibaillus, Beauveria bassiana, Entomophthora musca, Heterorhabditis spp., NPV, GV, and other pathogens have a strong impact on sucking pest control in okra.

4. Conclusion

This review provides a summary of previous work and new advancements in pest management. After studying several research papers, it is concluded that intercropping with biorational pesticides is regarded as a very promising IPM practise for the prevention and management of pest. It is associated with organic farming and sustainable agriculture. It is observed that damage caused by insect-pest was far less in intercropping crops than in the solitary crop of okra. Therefore, intercropping of cereal crops with vegetables is beneficial for farmers with limited resources. The majority of the researchers discovered that intercropping with biorational pesticides reduces the severity of pest, disease, and weed interference with plant growth (Ijoyah and Jimba, 2012; Ijoyah and Fanen, 2012; Uddin II and Odebiyi 2011). The other side benefit of intercropping is that it gives the underprivileged insurance for farmers against failed crops. If one crop fails for any season, the farmer can recover his loss through the other crop. However, it is expected that more research will be done with the combination of vegetables and cereal crops of different families in various places during various seasons.

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