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EVALUATION OF VARIETIES AND BIOPESTICIDE IN MANAGING MAJOR INSECT PESTS OF OKRO (*Abelmoschus esculentus* (L.) Moench) IN THE SUDAN SAVANNAH AGRO ECOLOGICAL ZONE OF NIGERIA

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ABSTRACT

Field trials were conducted at two locations in 2018 dry season at the Teaching and Research Farm, Faculty of Agriculture, University of Maiduguri and the Mohamet Lawan College of Agriculture Maiduguri to determine the effect of okra variety and insecticides in controlling Flea beetle, Mealy bug and Cotton bollworm. A factorial experiment was laid out in split plot design with variety in the main plot and insecticides as the subplot. There were three okra varieties: *Jere, Uba* and *Yar kwadan* and two botanical insecticides (Neem Seed Oil and ethanolic leaf extract of Cassia) and a check (Imidacloprid®) replicated three times. Data collected on damaged and undamaged flowers, fruits and number of insects. Imidacloprid® treated plants significantly ($P<0.05$) show fewer insect pests compared to ethanolic leaf extract of *Cassia*. The highest mortality of these insect pests was recorded with Neem Seed Oil extract in both locations. Significantly ($P<0.05$) higher number of these insect pests were recorded on variety Uba while Jere and Yar kwadan had fewer. Higher yield was recorded in plots treated with Neem Seed Oil and Imidacloprid® compared to ethanolic extract leaf of *Cassia* in both locations. Neem Seed Oil had significantly increased fruit yield compared to Imidacloprid® and ethanolic leaf extract of Cassia in both locations. Number of damaged flowers were significantly higher in variety Jere in both locations with a corresponding high fruit weight (560.24 kg/ha and 622.81 kg/ha). These results revealed that the performance of Imidacloprid® can be compared with Neem Seed Oil in controlling insect pests of okra. The best combination of variety and insecticide was Jere treated with Neem Seed Oil. From this study, it can be concluded that Neem Seed Oil can be a good alternative to synthetic insecticides against major insect pests of okra.

Keywords: Biopesticide; Okra; Neem Seed Oil; Cassia; Imidacloprid®

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the most widely known and utilized species of the family Malvaceae (Naveed *et al.*, 2009) and an economically important vegetable crop grown in tropical and sub-tropical parts of the world (Andras *et al.*, 2005; Saifullah and Rabbani, 2009). In 2014, the world total production of okra was 9,623,718 tons

with India producing 6,346,370 tons followed by Nigeria with about 2,390,500 tons representing 65.95% and 24.84% respectively of the world production (FAOSTAT, 2017). Its production worldwide is estimated at six million tons per year cultivated with an average yield of 6.39 t/ha (Konyeha and Alatise, 2013). The crop is multipurpose due to its various uses as fresh leaves, buds, flowers, pods, stems and seeds (Mihretu *et al.,* 2014). In Nigeria, the improved varieties grown include Clemson spineless, White velvet, Green velvet, Long pod, Lady's finger, Dwarf green pod (Udoh *et al*., 2006). Varieties grown in Borno State include Mboke, Jere, Chalawa, Uba, Kanuri local and Yar kwadan and Lady's finger (Askira and Degri, 2012). Okra is grown for its tender fresh pod and leaves which are rich in vitamins, minerals and protein (Mbah *et al*., 2009). Okra Pods and seeds are rich in phenolic compounds with important biological properties (Adetuyi and Osagie, 2011). The average nutritive value of okra is higher than that of tomato, eggplant and most of the cucurbits (Roy *et al.,* 2014). Okra has huge potential for enhancing livelihoods in urban and rural areas and to several stakeholders (Kumar *et al*., 2010). However, with all the potentials of being an important and cheap vegetable for the poor, its production is facing a serious problem of insect pests attack at its different growth stages (Mohammed *et al*., 2013; Halder *et al*., 2016).

Insect pests of okra includes shoot and fruit borer, *Earias vittella* (Fabricius), jassid, *Amrasca biguttula biguttula* (Ishida), whitefly, *Bemisia tabaci* (Gennadius), Aphid, *Aphis gossypii* (Glover). Defoliation due to flea beetle infestations has been reported to be up to 80 % and severity of damage varies in different places (Clementine *et al*., 2009). Flea beetles are responsible for the transmission of okra mosaic virus (OMV) observed in Nigeria, Kenya, Sierra Leone, Cote d'Ivoire which can reduce yields by 20 – 50 % (Fajinmi and Fajinmi 2010, Askira and Degri, 2012). Chemical control is relatively cheaper and a quick result giving method for controlling okra pests. Systemic insecticides have been found effective against the pests for a longer period of times (Ehisianya *et al.,* 2012). Imidacloprid® is a broad spectrum, systemic chloronicotinyl insecticide with low mammalian toxicity (Baig *et al.,* 2012). The compound is especially suited for sucking pests and is not affected by currently prevailing resistance mechanisms (Baig *et al.,* 2012). It selectively binds to 3 nicotinergic acetylcholine receptors on the post synaptic membrane (Baig *et al.,* 2012). But due to indiscriminate use of these synthetic pesticides, this has created several problems in the ecosystem such as direct toxicity to beneficial insects, fishes, and man (Stoll, 2001). Because of this emerging risk, it is necessary to devise a safe and environmentally friendly management strategy. For this purpose, resistant or tolerant variety and plant extracts have been employed (Stoll, 2001).

Azardirachtin derived from the neem tree (*Azadirachta indica* L.) has been reported as antifeedant, repellant, oviposition, deterrent, and insect growth regulator (Isman, 2008), an alternative method which helps to reduce the pest population with no hazard effect on human health. Cassia (*Seamea seamea*(L)) Flowers and fruits are used to treat skin diseases, fever, abdominal pain, and leprosy. Besides its pharmacological uses, its extract is also recommended for pest and disease control (Negahban and Moharramipour, 2007). This study therefore evaluated the efficacy of Neem seed oil, Cassia, Imidacloprid® and variety in managing the major insect pests of okra in Maiduguri, Sudan Savannah agro ecological zone of Nigeria.

MATERIALS AND METHODS

Experimental Location and Field Layout

Field trials were conducted at Teaching and Research Farm of the Faculty of Agriculture, University of Maiduguri (11^0 15' 0"N and 13^0 51' 0"E) and Mohamet Lawan College of Agriculture (11^{0}' 5"N and 13^{0}' 5"E) under irrigation during dry season. Both locations are in the Sudan Savannah agro ecological zone of Nigeria. The soil of the area is sandy loam (Chiroma *et al*., 2004).

The experiment was laid out in a split plot design with variety as mainplot factor and insecticides as the subplot factor. Treatments tested include two botanicals (Neem seed oil and leaf ethanolic extract of Cassia) and one synthetic insecticide (Imidacloprid®). Three okra varieties (Jere, Yar kwadan, and Uba) were used in the study, each treatment was replicated three times. There was a total of 21 treatment combinations each allocated to a plot measuring $4m^2$ (2×2 m) separated by a 0.5 m walking alley and 1m between blocks (replications). Three to four seeds were sown per hole at the spacing of 60 x 30 cm, giving a total of 15 stands per plot. Seedlings were thinned to two plants per stand three weeks after sowing. First and second weeding were done manually two and six weeks after sowing, respectively.

Source of Plant Material and its Preparation

Neem seeds was collected from neem trees in University of Maiduguri Campus and dried under shade for 7 days. The seeds were milled into powder and then boiled water was added and strayed with wooden spatula until there were oil. The oil extracted was fried to be purified.

Leaves of Cassia were collected at University of Maiduguri Campus and dried under shade for 4 days. The dried leaves were milled using pestle and mortar into fine powder, one hundred grams of the Cassia was measured using the Camry™ weighing balance in the laboratory unto which 500 ml of ethanol was added and then stirred. The supernatant of the plant material was left for four days, and thereafter, filtered through a filter paper (110mm) into medium size plastic bottles.

Imidacloprid® (250 ml) was obtained from a registered agrochemical store in Maiduguri Borno State. Seeds of Jere, Yar kwadan, and Uba varieties were purchased from Borno State Agricultural Development Program.

The insecticide (Imidacloprid®) 1ml per plot (4 m^2) was applied. Neem Seed Oil extract was applied at the rate of 10 ml per plot (4 m^2) of the formulation and leaf ethanolic extract Cassia 50 ml per plot (4 m^2) of solution was applied. All insecticides were sprayed in the evening using a pressurized hand-held sprayer, at 7 days interval for 6 weeks making a total of six sprays during the growing period.

Data Collection

Determination of Damaged and Undamaged Flowers: The number of flowers produced was counted weekly. Damaged and undamaged flowers were separated by observing for a sign of damage by insects which include presence of larva, frass or entrance and exit holes.

Number of Damaged and Undamaged Fruits per Plant: Damaged (those with larval entry or exit holes) and undamaged fruits collected were counted separately and recorded.

Weight of Damaged and Undamaged Fruits: From weekly harvest, damaged and undamaged fruits per plot were separated and weighed using the Camry™ weighing balance. Weight of damaged and undamaged fruits was summed to obtain the total weight of fruits per plot.

Number of Flea beetle, Mealy bug per Plant: The number of Flea beetle and Mealy bug were counted using tally counter on five randomly selected tagged plants per plot. Counting was done early in the morning by 7.00 am when the insects were less active. Insects were collected in sample bottles and preserved in 70% ethanol and later taken to the Insect Museum of the Department of Crop Protection, Institute for Agricultural Research Ahmadu Bello University Zaria for identification.

Number of Cotton bollworm on Fruit per Plot: All fruits at the time of harvest that were damaged are collected. Cotton bollworm larval entry or exit holes on okra fruits were counted to determine the larval population. Counts were done immediately after fruit harvest early in the morning, a day before spraying and seven days after spray.

Data Analysis

Data collected were subjected to the Analysis of Variance (ANOVA) using Statistix Version 8.0. The difference between treatments means was separated using the Least Significance Difference (LSD) at 5% probability level of significant (Gomez and Gomez, 1984).

RESULTS

Effects of Variety and Insecticide on the Population of Flea beetles and Mealy bugs on Irrigated Okra per Plant

Results from Mohamet Lawan College of Agriculture Demonstration Farm showed significant ($p<0.05$) difference in the population of Mealy bugs between varieties Jere and Uba whereas, there were no significant ($p>0.05$) difference in variety Yar kwadan and Uba. However, there were no significant ($p>0.05$) difference in the mean population of Flea beetles in variety Jere and Yar kwadan. Similarly, there were significantly lower population of Flea beetles in variety Jere when compared to Uba (Table 1).

Similarly, there were significantly ($p<0.05$) lower population of Flea beetles on variety Yar kwadan compared to Uba. The results also showed no significant ($p>0.05$) difference in the mean population of Mealy bugs on variety Yar kwadan and Uba but were significantly ($p<0.05$) different from each mean population of Mealy bugs on variety Jere at the University of Maiduguri Teaching and Research Farm.

There was significant ($p>0.05$) difference between treatments means with respect to the population of Flea beetles and Mealybug. However, significantly fewer populations of Flea beetles and Mealy bugs were recorded on plants treated with Imidacloprid® than those treated with Cassia ethanolic leaf extract. Plots treated with Neem Seed Oil had significantly

(P<0.05) lower population of Flea beetles and Mealy bugs compared to Imidacloprid treatment plots in both locations.

Table 1: Effects of variety and insecticide on the population of flea beetles and mealy bugs on irrigated okra per plant

Treatment	Population of Flea beetles			Population of Mealy bugs		
	College	Unimaid	Mean	College	Unimaid	Mean
Variety (A)						
Jere	22.19	24.62	23.41	22.10	37.76	29.93
Yar kwadan	27.67	13.81	20.74	27.86	19.57	23.71
Uba	32.48	25.76	29.12	32.67	19.52	26.10
LSD	8.42ns	5.74s	6.11s	7.02ns	10.22s	9.11ns
Insecticide (B)						
Cassia	30.44	24.00	27.22	33.44	32.44	3456
Imidacloprid®	15.67	14.11	14.89	16.00	13.56	14.00
NSO	11.67	9.78	10.72	13.00	8.89	10.67
LSD	10.79s	8.77s	9.17s	12.73s	8.54s	9.47s

NSO = Neem seed oil; Unimaid = University of Maiduguri; Cassia = *Seamea seamea;* College = Mohamet Lawan College of Agriculture

Effects of Variety and Insecticide on the Population of Cotton bollworm on Irrigated Okra per Plant

Table 2 showed that there was no significant (p>0.05) difference in the mean population of Cotton bollworm on variety Yar kwadan (26.62) and Uba (31.14) in Mohamet Lawan College of Agriculture Demonstration Farm but there was significant (p<0.05) difference in the mean population of Cotton bollworm on variety Jere (18.76). Similarly, there were no significant difference in the mean population of Cotton bollworm in all the varieties (Jere, Yar kwadan, and Uba) in University of Maidugur, Teaching and Research Farm.

The effectiveness of various insecticide to overcome Cotton bollworm revealed that there was significant difference (p<0.05) between Cassia ethanolic leaf extract and Imidacloprid® in Mohamet Lawan College of Agriculture Demonstration Farm. The results show that there were significantly lower population of Cotton bollworm in plots treated with Imidacloprid®compared to plots treated with Neem Seed Oil. However, there were significantly higher populations of Cotton bollworm in leaf ethanolic extract of Cassia. In University of Maiduguri Teaching and Research Farm, there were significant (p<0.05) difference in the population of Cotton bollworm in plots treated with leaf ethanolic extract of Cassia and Imidacloprid®. Similarly, there were significantly (p<0.05) higher population of Cotton bollworm in plots treated with Cassia ethanolic leaf extract compared to plots treated with Neem Seed Oil.

Table 2: Effects of variety and insecticide on the population of cotton bollworm on irrigated okra per plant

Treatment	Population of Cotton bollworm per plant		
	College	Unimaid	Mean
Variety (A)			
Jere	18.76	30.33	24.98
Yar kwadan	26.62	21.75	18.43
Uba	31.14	19.57	29.86
LSD	6.88s	11.48ns	5.56s
Insecticide (B)			
Cassia	23.78	23.56	23.67
NSO	19.00	16.44	17.72
Imidacloprid®	10.89	10.00	10.44
LSD	7.99s	12.95ns	10.20ns

NSO = Neem seed oil; Unimaid = University of Maiduguri; Cassia = *Seamea seamea*; College = Mohamet Lawan College of Agriculture

Effects of Variety and Insecticide on the Number of Damaged and Undamaged Flowers on Irrigated Okra per Plant

The number of damaged flowers was significantly lower on variety Yar kwadan (25.76) and Uba (20.38) compared to variety Jere (29.86) table 3. There were however, no significant ($p>0.05$) difference in the number of undamaged flowers in all the varieties (Yar kwadan, Jere and Uba) in Mohamet Lawan College of Agriculture Demonstration Farm. In University of Maiduguri Teaching and Research Farm there were significantly lower number of damaged flowers was recorded on variety Yar kwadan (16.86) and Uba (11.00) in contrast to variety Jere (26.19). However, there were no significant ($p>0.05$) difference in the number of undamaged flowers on variety Jere (11.71) and Yar kwadan (14.38) compared to variety Uba (20.57).

Table 3: Effects of variety and insecticide on the number of damaged and undamaged flowers on irrigated okra per plant

Treatment	Damaged flowers			Undamaged flowers		
	College	Unimaid	Mean	College	Unimaid	Mean
Variety (A)						
Jere	29.86	26.19	28.03	21.38	11.71	16.55
Yar kwadan	25.76	16.86	21.31	27.48	14.38	20.93
Uba	20.38	11.00	15.69	26.38	20.57	23.48
LSD	4.70s	5.78s	2.28s	5.71ns	5.94s	5.83ns
Insecticide (B)						
Cassia	25.56	17.78	21.67	23.22	12.33	20.11
Imidacloprid®	16.67	9.78	13.22	26.22	15.67	12.11
NSO	11.44	4.78	8.11	55.11	39.00	47.06
LSD	13.48ns	5.60s	7.48s	12.73s	6.56s	8.60s

NSO = Neem seed oil; Unimaid = University of Maiduguri; Cassia =*Seamea seamea;* College = Mohamet Lawan College of Agriculture

Insecticides significantly (P< 0.05) reduced *the* number damaged flowers in all the treated plots in both locations. Imidacloprid® and Neem seed oil extract performed better than plots sprayed with leaf ethanolic extract of Cassia but Neem Seed Oil was comparable with plots treated with the recommended rate of Imidacloprid®. Number of damage flowers was significantly lower in plots treated with Neem Seed Oil compared with Cassia ethanolic leaf extract. Similarly, significant higher (P< 0.05) number of undamaged flowers was observed in plots sprayed with the above two insecticides in both locations.

Effects of Variety and Insecticide on the Number of Damaged and Undamaged Fruits on Irrigated Okra per Plant

In Mohamet Lawan College of Agriculture Demonstration Farm, the number of undamaged fruits was significantly (p< 0.05) lower in variety Uba (149.63) than the other two varieties. However, the highest number of undamaged fruits was recorded in variety Jere (370.80). Similarly, there were no significant difference in the number of damaged fruits in all the varieties (Jere, Yar kwadan and Uba) but variety Jere (26.05) had higher number of damaged fruit than variety Uba (24.00). However, there were no significant (p>0.05) difference in the number of undamaged fruits in variety Yar kwadan and Uba but were significantly (p<0.05) different from the number of undamaged fruits in variety Jere in University of Maiduguri Teaching and Research Farm. The highest number of undamaged fruits was recorded in variety Jere (537.84) while the lowest number of undamaged fruits was recorded in variety Uba (193.58). Similarly, there were no significant (p>0.05) difference in the number of damaged fruits in variety Jere and Yar kwadan compared to Uba, but the lowest and highest number of damaged fruits was recorded in variety Yar kwadan (21.81) and Uba (31.24) respectively (Table 4).

Similarly, the effect of different insecticide treatments on the damaged and undamaged fruits in both locations showed that Neem Seed Oil recorded significantly (p<0.05) least number of damaged fruits compared to the other treatments. The Cassia ethanolic leaf extract, however, recorded significantly (p<0.05) higher number of damaged fruits. Similarly, higher number of undamaged fruits was recorded on Neem Seed Oil than Imidacloprid® treated plants.

Table 4: Effects of variety and insecticide on the number of damaged and undamaged fruits on irrigated okra per plant

Treatment	Number undamaged fruits per plot			Number damaged fruits per plot		
	College	Unimaid	Mean	College	Unimaid	Mean
Variety (A)						
Jere	370.80	537.84	454.32	26.05	23.62	23.81
Yar kwadan	257.57	235.45	451.15	25.24	21.81	23.53
Uba	149.63	193.58	192.54	24.00	31.24	28.65
LSD	55.89s	91.19s	39.43s	7.51ns	7.00s	7.26ns
Insecticide (B)						
Cassia	217.08	123.87	127.04	34.33	31.22	604.66
Imidacloprid®	256.54	537.69	377.38	17.33	20.00	213.77
NSO	738.47	754.76	746.61	11.22	16.11	55.92
LSD	63.50s	116.07s	62.59s	4.69s	10.39s	82.97s

NSO = Neem seed oil, Unimaid = University of Maiduguri, Cassia = *Seamea seamea*, College = Mohamet Lawan College of Agriculture

Effects of Variety and Insecticide on the Total Weight of Okra Fruits per Plot Grown in Dry Season

Table 5 shows that weight of okra fruit treated with either Imidacloprid® or Neem Seed Oil had significantly ($p<0.05$) higher total weight of okra fruits compared to when treated with Cassia ethanolic leaf extract in both locations. Also, there were significantly lower total weights of fruits treated with Cassia ethanolic leaf extract. There was no significant ($p>0.05$) difference in the total weight of fruits in variety Jere and Yar kwadan but were significantly different from the total weight of okra fruits in variety Uba. Variety Jere (560.24) had significantly higher total weight of fruits than the other two varieties in Mohamet Lawan College of Agriculture Demonstration Farm. However, there were significant ($p<0.05$) difference on the total weight of okra fruits in all the varieties (Jere, Yar kwadan and Uba). Similarly, variety Jere (622.81) had higher total weight of okra fruits in University of Maiduguri Teaching and Research Farm.

Table 5: Effects of variety and insecticide on the total weight of okra fruits per plot grown in dry Season

Treatment	Total weight of okra fruits per plot in kg/ha		
	College	Unimaid	Mean
Variety (A)			
Jere	560.24	622.81	591.53
Yar kwadan	428.41	368.05	398.23
Uba	105.98	155.81	130.90
LSD	174.73s	104.14s	139.44s
Insecticide (B)			
Cassia	269.66	157.89	213.77
NSO	612.64	596.68	604.66
Imidacloprid®	772.63	879.67	826.15
LSD	102.10s	166.36s	82.97s

NSO = Neem seed oil; Unimaid = University of Maiduguri; Cassia = *Seamea seamea;* College = Mohamet Lawan College of Agriculture

DISCUSSION

Neem Seed Oil and Cassia ethanolic leaf extract significantly reduced the population of Flea beetles and Mealy bugs compared to the Cassia ethanolic leaf extract which has the highest population of Flea beetles and Mealy bugs. However, Neem Seed Oil treated plots had the lowest populations of these insect pests. These findings are in accordance with the result of Channa (2017) who treated jassid population on okra plants in pots, the pots treated with neem oil extract used for foliar application was significantly effective. Khan *et al*. (2013) tested the efficacy of some plant products against the cotton pests. They concluded that *Datura solanacae* and neem oil were most effective and caused significant reduction in the population of jassid, thrips and whitefly at different time intervals. Sharma *et al*. (2014) recorded 25% larval mortality of diamond back moth when these were fed on foliage treated with oil and leaf extracts of neem. Similarly, different preparations of neem were found relatively safe against *Chrysoperla carnea* and *Trichograma chilonis* compared with chemical pesticides and could contribute to preserve the natural enemy biodiversity in crop

ecosystem (Rao and Raguraman, 2003). Asogwa *et al.* (2010) emphasized on the use of *A. indica* which is a biodegradable pesticide for the control of brown coca mirids, *Sahlbergella singularis* which caused major damage to coca in Nigeria. The high yielding character displayed by Jere among the two varieties could have been due to its natural ability of compensating for insect pests damaged by producing more flowers and pods and by resistance to major insect pests, through acquired defensive mechanism against insect. Sharma and Ortiz (2002) reported that antixenosis form of resistance affect the behavior of the insect pest and usually express as non-preference of the insect pest for resistance plant compared with a susceptible plant. This result was observed in both locations and their combined mean, indicating that variety Uba is susceptible to infestation by major insect pests of okra. The significant effect of Neem seed oil extract in increasing yield in the present study agreed with the finding of Satti and Nasr (2008), Pun *et al.* (2005) and Adilakshmi *et al.* (2007). According to Satti and Nasr (2008) Neem extract when applied as pesticide was found to give better yield than conventional pesticides. Similarly, Pun *et al.* (2005) reported that Neem seed kernel extract not only significantly reduced the whitefly population but also increased its yield. Adilakshmi *et al.* (2007) also found significant yield increase with Neem seed kernel extract. Rashid *et al*. (2012) who recorded that plot treated with 1.5% and 2% of neem oil and 3% of neem seed water extract produced higher seed cotton yield. Mochiah *et al.* (2011) also observed that okra in which botanicals were applied produced the highest mean fruit weight and fruit numbers (yield) of okra and eggplant.

CONCLUSION

From this study, it can be concluded that variety Jere which suffered high leaf and flower infestation and damage than other varieties and had the highest fruit yield may be considered as the desirable variety for management of Flea beetles, Mealy bugs and Cotton bollworm. Similarly, because of non-adaptability and variability of variety Uba in fruit yield, it may not be considered as a desirable variety in the study area. However, Neem Seed Oil proved to be the most promising plant extracts with minimum population of insect pests and minimum fruit damage. Thus, these indigenous plants could be better alternate to conventional insecticides (Imidacloprid®) for the management of insect pests attack in the Sudan savannah agro ecological.

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