EFFECT OF CONCENTRATION OF NEEM (*Azadirachta indica A.Juss*) LEAF AQUEOUS AND DYSDERCUS SPP POPULATION INFESTING ROSELLE (*Hibiscus sabdariffa L.)* IN KEBBI STATE, NIGERIA

Khadija Zubairu Umar[1], Prof. A. U. Yusuf[2]

Kebbi State University of Science and Technology, Aliero, Faculty of Agriculture, Department of Crop Science, Kebbi State, Nigeria

Bayero University Kano, Faculty of Agriculture, Department of Crop Science, Kano, Nigeria
zubairukhadija@gmail.com

ABSTRACT-*The study analyzed the efficacy of the Neem leaf extracts at different concentration levels on Dysdercus spp affecting Roselle (Hibiscus sabdariffa L.) varieties in Aliero and Jega, Kebbi State, Nigeria, the pest complex affecting its production and investigated the effect of Dysdercus spp infestation on yield of Roselle in the study areas. The treatment consisted of three varieties of Roselle Green as V1, Red as V2, deep red as V3 and three concentrations of Neem leaf extract (C1, C2, C3) and control (C0). The experiment was laid out in randomized complete block design (RCBD) in a split plot arrangement and replicated three times. Roselle varieties variable was assigned to the main plots, while the Neem leaf extract concentration (NLE) variable was assigned in the subplot. NLE was sprayed on the leaves of the Roselle plots when the plant reached stage of 50% flowering. Stands were tagged in each experimental plot, Dysdercus spp was determined 1-day before spraying (1 DBS) using sweep net methods in the evening when the temperature was lowered. The Dysdercus spp collected was placed inside vial containing 70% alcohol. Thereafter, the insects were taken to the laboratory of Crop Science Department, KSUSTA for identification. The same procedure was repeated at 1, 2, 3, 5 and 7 days after spraying with Neem leaf extract (NLE). Also, data was collected on fresh and dried calyx, fresh and dried leaf yields per hectare (kg/ha). Data collected was subjected to analysis of variance using SAS software. The treatment means was compared using Duncan Multiple Range Test. The results revealed that, Dysdercus spp, was identified as one of the pest complex affecting Roselle production. Furthermore, results also revealed the efficiency of the Neem leaf extracts at different concentration levels on pest affecting roselle, and showed that NLE at untreated control recorded the highest number of the insect from day 1 to day 7, and was significantly different among the treatment while 1 concentration recorded the least number of Dysdercus spp followed by 2 and 3 concentration respectively. Finally, on the investigation of the effect of Dysdercus spp infestation on yield of Roselle in the study area, and varietal interaction of Neem leaf extract (NLE) on the yield of Roselle plant findings from the field showed that there was no significant difference (P< 0.05) among all the treatments. It was observed that Neem is safe for workers with no handling risks and can be used throughout the entire crop production cycle.*

Keywords: Dysdercus spp, Neems, Extract, Roselle, Plants, Treament, Concentration

1.0 INTRODUCTION

Roselle (*Hibiscus sabdariffa L.*) is one of the most important traditional leafy vegetables (TLVs) in the tropics and sub-tropics. It belongs to the Malvaceae Family. It is believed to have originated from Africa (Grubben, 1977; Murdock, 1995; Grubben and Denton, 2004) The genus consists of about 300 species, some of which are

widely distributed as tropical herbs and shrubs (Heywood, 1978). Some of these are *H. sabdariffa, H. cannabinus, H. tiliaceus, H. surattensis, H. acetosella, H. physaloides H. lunarifolius* and *H. Scotellii*. More than half of these species originate in the warmer parts of central and eastern Africa, while the remainder came from tropical America, Asia and Australia (Schippers, 2000).

Several names have been attributed to roselle such as Sour-Sour, in the Indian subcontinent (especially in the Ganges Delta region) called meśta (or meshta, the *ś* indicating a *sh* sound) in the region such as India and Jamaica. It is sometimes called Red Sorrel, Bissap, and Karkade (Tindall, 1983: Norman, 1992: Schippers, 2000; Grubben and Denton, 2004). In Nigeria, both the leaves and calyxes are consumed by the people (Daudu *et al* 2015). Roselle is a rich sources of anti-oxidants, riboflavin, ascorbic acid, niacin, and carotene that are nutritionally important as well as amino acids and mineral salts (Anjah, 2012). The annual production of the crop worldwide is said to be very low; because of lack of improved varieties available for roselle farmers. In addition, the knowledge about the genetic diversity of the crop is scanty, and the data collected from the peasant roselle farmers, are unreliable. For these reasons, the crop has a great economic potential in Nigerian Crop Improvement Programmes (NCIP), which is aimed at the development of varieties with a high content of important phytochemicals for nutritional and medicinal purposes. These are of great economic value for income generation farmers in particular and government in general.

Roselle is native to the region that stretched from India to Malaysia and almost all parts of the crop including the fleshy fruits, leaves, stems, flowers (Calyces), seeds and fibre are important sources of feed, raw materials and foreign exchange (Schippers, 2000; Galaudu, 2006). Its antihypertensive properties and use in folk medicine as a diuretic, laxative and in food colourings have continued to attract the attention of food and beverages manufacturers, and pharmaceutical industries. Despite these medicinal and food values, roselle cultivation is limited in Nigeria and farmers plant the crop without due consideration to appropriate planting date (Futuless *et al*., 2010). Roselle is tolerant to dry weather, especially during the latter stages of growth and is sensitive to variation in length of days.

In Ghana, roselle is commonly found in the wild but domesticated cultivars are normally planted as a border crop and/or intercrop with arable crops such as maize and groundnuts. Norman (1992) indicated that it is often intercropped with yams and as a leafy vegetable crop, it is cultivated all year round. ICRA (2002) described roselle as an indigenous leafy vegetable that is considered as a minor crop in the production system and as a result little attention is paid to it in terms of labour and land allocation.

The use of this crop cannot be over emphasised because it is used for many different purposes, the most common of which are as a fibre crop, the young shoots and leaves and calyces are use in preparing soups and are eaten as cooked vegetables especially with soup (Fasoyiro *et al.*, 2005). The seeds are pounded into meal, which is used as oil, or sauce after roasting. Oil extracted from the seed is a substitute for castor oil while the residue is used in a fermented form as soup or cake "Daddawa" (Aliyu, 2000). The crop is used for making wine, juice, jam, jelly, syrup, gelatin pudding, cakes, ice cream, and dried and brewed into tea as well as flavours and carbonated soft drinks, other acidic foods, spice and used for butter, pies, sauces, tarts and other desserts (Walford, 1984; Qi *et al*., 2005). The ground leaves and seeds are added to curries as seasoning (Qi *et al.*, 2005). Also, according to Norman, (1992); Schippers, (2000); and Grubben and Denton, (2004) the leaves and young shoots are cooked as spinach in stews and soups and the enlarged succulent red or green acidic calyces are used in thickening soups and in the production of jelly, jam, chutney, syrup and non-alcoholic drink. The roselle leaves and calyces are high in ascorbic acid. Grubben and Denton, (2004) indicated that the dried red calyces are commonly used to prepare a tea, drunk hot or more commonly, cold after adding sugar. Atta *et al*., (2010) reported that the leaves of roselle have considerable economic importance because of their nutritional and medicinal uses. Again, Bolade *et al*., (2009) reported that in Nigeria, the production of non-alcoholic beverage from dried red roselle calyces is very popular.

There is increasing demand for TLVs due to their health promoting benefits. According to Tindall, (1983) they are rich sources of non-glycemic carbohydrates (i.e., dietary fibre) and contain small amounts of omega-3, an essential polyunsaturated fatty acid that the body needs to stay healthy. Drake, (1985) reported that roselle has many uses in traditional medicine as digestive and purgative agent, healing of abscesses, cancer and hypertension management. Tarwadi and Agte, (2003) explained that most of these leafy vegetables are inexpensive, easily cooked, and rich in several nutrients such as vitamins, proteins and phytochemicals having antioxidant properties.

Dari and Mahunu, (2010) reported that green leafy vegetables are herbaceous plants with different shapes which contain essential nutrients for growth and maintenance of the body. Grubben and Denton, (2004) reported that the fresh roselle leaves per 100 g edible portion contains about 86.6 g water, 180 KJ energy (43 kca), 3.3 g protein, 0.3 g fat, 9.2 g carbohydrates, 1.6 g dietary fibre, 213 mg Calcium, 93 mg Phosphate, 4.8 mg Iron, 4135µg β-carotene equivalent, 0.2 mg thiamin, 0.45 mg riboflavin, 1.2 mg niacin, and 54 mg ascorbic acid. The composition of fresh raw calyces per 100 g edible portion contain about 8.2 g water, 184 kJ (44 kcal), 1.6 g protein, 0.1g fat, 11.1 g carbohydrates, 2.5 g fibre, 160 mg calcium, 60 mg phosphate, 3.8 mg Iron, 285 µg β-carotene equivalent 0.04 mg thiamin, 0.06 mg riboflavin, 0.5 mg niacin, and 14 mg ascorbic acid.
Roselle is widely used for the treatment of diseases. Olaleye, (2007) used the aqueousmethanolic extract of roselle to investigate its phytochemical constituents, antimicrobial activity and cytotoxicity, and reported that the extract contained cardiac glycosides, flavonoids, saponins and alkaloids. It exhibited antibacterial activities against *Staphylococcus aureus, Bacillus stearothermophilus, Micrococcus luteus, Serratiamascences, Clostridium sporogenes, Escherichia coli, Klebsiella, pneumoniae, Bacilluscereus, Pseudomonas fluorescence*. The results support the use of this plant in the treatment of diseases like abscesses, bilious conditions, cancer and coughs in traditional medicine.

Currently approximately 15,000 metric tons of roselle enters international trade each year. Many countries produce roselle, but the quality markedly differs. China and Thailand are the largest producers and control much of the world supply. Thailand invested heavily in roselle production and their product is of superior quality, whereas China's product, with less stringent quality control practices, is less reliable and reputable (McCaleb, 2000).
The world's best roselle comes from the Sudan, but the quantity is low and poor processing hampers quality. Virtually all of Sudan's production is exported to Germany. US importers also prefer the Sudanese product, but due to a trade embargo, importers there were forcing to source this product through Germany at a considerable mark-up in price. As such, the Sudanese product is used much less in the US, and China and Thailand are the main suppliers. Mexico, Egypt, Senegal, Tanzania, Mali and Jamaica are also important suppliers, but production is mostly used domestically.
In Nigeria, the cultivation and intense utilization of the red and purple genotypes are found mainly in the Guinea and Sudan Savannah ecological zones of the country while the green genotype, hitherto ascribed little utility value, is found in the Southwest (Alegbejo, 2000).
The main areas of production in Nigeria are Kagara and Mokwa (Niger State), southern Jos (Plateau State), and around Ibadan (Oyo state). It is also widely grown in Kogi, Kwara, Kebbi, Sokoto, Zamfara, Katsina, Borno, Kaduna, Bauchi and Kano States (Dike, 1987; Alegbejo, 1998). In spite of its economic importance, and the fact that the crop originated in West Africa, not much research work has been conducted on it when viewed in relation to the amount of work undertaken on its closely related species, such as cotton (Kumar *et al.*, 1986; Dike, 1987). Relatively little has been reported on the agronomy of roselle in northern Nigeria.
Insect damage is minor; pests include stem borer, flea beetles, cotton bollworm and cutworm. Mealy bugs and leafhoppers are minor concerns, as is the cotton stainer. Use of natural enemies is recommended. Plant enemies usually do not compete in a cultivated field. Weeding can increase yield and calyx size but may also reduce profit for the farmer. Now that the calyx yield is considered as important as the ribbon yield of roselle, there is a need to understand the cheapest and affordable way of pest control using NLAE to minimize the cost of production.

1.1 Statement of the Research Problem

Roselle is an annual bushy shrub that grows to approximately 2.4 meters in one growing season. While it is relatively easy to grow, it is more difficult to produce consistently high quality. This is a function of seed stock, local growing conditions, harvest time, and postharvest handling, the drying process. The fleshy calyces are harvested after the flower has dropped but before the seedpod has dried and opened. It is not suitable for mechanized harvest and therefore, labor intensive to process. The more time the capsule remains on the plant after the seeds begin to ripen, the more susceptible the calyx is to sores, sun cracking, and general deterioration in quality.
Dysdercus spp infestation is one of the major factors militating against cultivation of roselle. Insects have reportedly attacked different phonologies of roselle. Among the insect pests, *Dysdercus spp* species cause economic damage, attacking the lamina of the young foliage and matured leaves, which result in reduction of the photosynthetic ability of the crop (Fasunwon and Banjo 2010). Komolafe (1979) observed that *Dysdercus*

spp did not only damage the leaves and flowers but caused premature falling of the pods. This insect also transmits mosaic virus resulting in 20-50% yield reduction (Fajinmi and Fajinmi, 2006). *Zonocerus variegatus* feed on wide range of crops including roselle (Idowu and Akinsete, 2001). The insect pest complex of roselle includes *Bemisia tabaci* (Genn.) *Aphis gossypii* Glover, *Earias insulana* (Boisd) and *Empoasca* spp (Abdel-Moniem and El-Wahab, 2006).

The poor resource farmers in Nigeria used pesticide to control arthropod pests, however, the problems of pesticide resistance, persistence of synthetic insecticides and negative effects on non-target organisms including man and the environment necessitated the idea of developing effective, cheap and easily biodegradable alternative products (Franzen, 1993). Botanical insecticide is a promising alternative in the protection of crops against insect pests. They are generally pest-specific and relatively harmless to non-target organisms (Kabaru and Gichia, 2001).The use of botanicals in the control of insect pest have been tested and proven effective. It is safe, cheap, environmental friendly, easily affordable hence, the need to carry out this study of the effect of different levels of Neem leaves extract on insect pest population affecting roselle.

1.2 Justification of the Study

Roselle (*Hibiscus sabdariffa L*.) is a plant that is widely grown in the tropics and its cultivation in Nigeria is highly concentrated in the North Eastern and Middle-belt regions of the country (Oboh and Elusiyan, 2004). Roselle is mostly cultivated for its leaves, seeds, stem and calyces which, the dried calyces are used to prepare tea, syrup, jams and jellies as beverages (Eslaminejad and Zakaria, 2011). Roselle is an annual plant which takes about six months to mature. Species grown for their fiber are tall, with fewer branches, sometimes growing to more than 3–5 m in height.

The utilization of the plant however goes beyond its area of gross cultivation while the parts of the plant that have been highly valuable to human race are the leaves and the calyces (flowers). The various uses to which roselle plant parts have been put include their uses in traditional medicine as a digestive agent, purgative and diuretic, among others (Osuntogun and Aboaba, 2004). The roselle plant parts have also been reported to be remedy for cancer, obesity, diabetes and hypertension (Hamdan, and Afifi, 2004; Odigie, *et al*., 2003). Other uses of the plant parts (particularly calyces) are in food production such as local non-alcoholic beverage, industrial wine, jam, marmalade and tea production (Mounigan, and Badrie, 2007; Aoshima, *et al*., 2007).

Plants extracts have been widely used to control agricultural pests to achieve an ecologically based pest management strategy. The plant extracts were effective in the control of the studied insects compared to untreated plants (control). The use of plant species to control pest insects has been in practice for centuries to a limited extent, the interest has been renewed in the pest management potential of natural products. Plants are natural chemical factories, providing the richest source of organic chemicals on earth. Approximately 42 families of plants carry some medicinal and insecticidal qualities. Plant products have several uses in insect control (Hashmi, 2001).

Neem (*Azadirachta indica*) has served as pest remedial for years in W. African subcontinent and is still a popular practice in remote areas for stored grains in various parts of the world (Lale and Mustapha, 2000; Ahmed *et al*., 2001). Azadirachtin is a major compound of Neem (Mordue and Blackwell, 1993) with insecticidal properties and has got the greatest attention in recent years (Parakash and Srivastava, 2008). However, several other compounds like deacetylazadirachtinol, meliantriol, vepol, salannin, sulfur compounds, etc. do have varying degree of insect deterrent, repellant, anti-feedant, anti-ovipositional activities.

The use of Neem in agriculture is not a new practice. In India, the traditional farming system employed Neem extracts for pest management and to supply nutrients to plants (Mossini and Kemmelmeier, 2005). Scientific research has shown that Neem is safe for workers, with no handling risks, and can be used throughout the entire crop production cycle (Boeke *et al*., 2004).

1.3 Aim and Objectives of the Study

The aim of this study was to evaluate the effect of different concentration levels of NLAEs against Dysdercus spp population affecting roselle. While the specific objectives were to:

i. determine the pest population affecting roselle production in Aliero and Jega LGAs of Kebbi State;
ii. determine the efficiency of the NLAEs at different concentration levels on insect affecting roselle.;
iii. determine the best combination of NLAE and Roselle variety for management of Dysdercus spp population; and
iv. Determine the effect of Dysdercus spp infestation on yield of Roselle in the study areas.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was carried out in two locations: Aliero and Jega Local Government Areas of Kebbi State North-west region of Nigeria. The zone has tropical weather conditions with three seasons: rainy, dry and hot. The annual rainfall is variable and declining, being 600 mm to 875 mm and on average 650 mm. The State possess two important agricultural lands namely: dry land (arid – prolong dryness) and Fadama (floodplains – significant alluvial clay particles) (Plate. II).

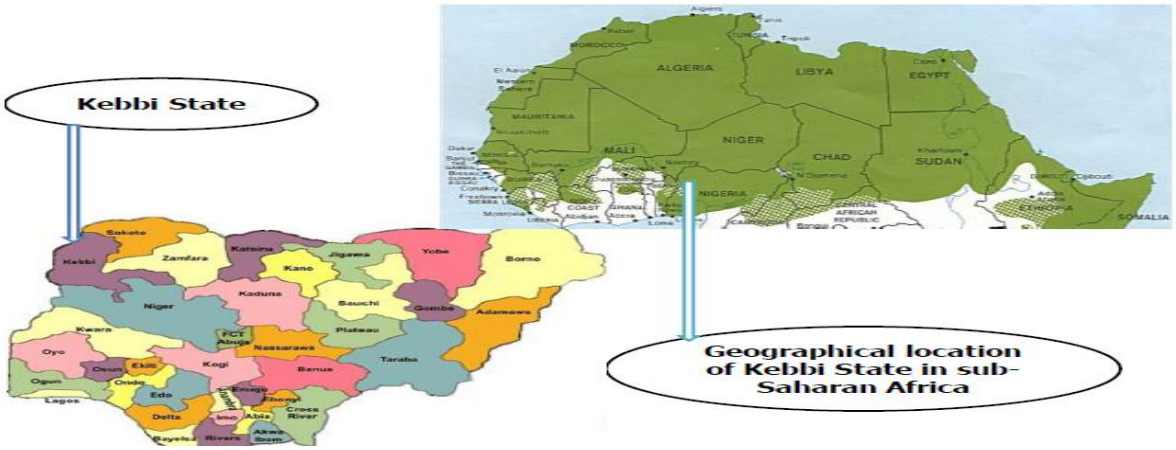

Figure 1: Shows the Map of Kebbi State located in Nigeria from sub-Saharan African. Source: Adapted and modified after Perry-Castañeda Library Map Collection (2011).

The study was conducted during rainfall season at the Teaching and Research Farm of the Kebbi State University of Science and Technology in Aliero town and Jega town Orchards, respectively. Aliero is located in the southeast of Kebbi State and lies on Latitude 12°16′42″N and Longitude 4°27′6″E in the Savannah region of Nigeria. Aliero has elevation of about 225 meters height, above sea level. The temperature ranges between a minimum of 20°C and a maximum of 43°C with relative humidity of about 83%. The area has a mean annual rainfall of about 2500 mm. However, Jega is situated at 12° 17' 20.2884" N 12.22° North latitude, 4.38° East longitude and 242 meters elevation above the sea level which is equal to approximately 794 feet. The temperature ranges between a minimum of *27°C* and a maximum of *40°C.* Jega experiences *extreme* seasonal variation in the relative humidity, unlike temperature, which typically varies significantly between night and day, dew point tends to change more slowly, so while the temperature may drop at night, a muggy day is typically followed by a muggy night. The area has Mean *annual rainfall* of about 800 mm.

2.2 Land Preparation and Planting

The experimental area was harrowed to a fine tilth and ridged 60 cm apart. The land was then marked into blocks and each block was divided into subplot measuring 3x3m, each subplot consisted of five rows, 0.60 m in between. Four seeds that were untreated with any insecticide was planted per hill on a depth of 3 cm and the distance between the hill was 50 cm at spacing of 50 cm within rows and 60 cm between rows. The emerged seedlings ware later thinned down to two plant per stand at four weeks after sowing bringing the plant population to 25 stands per block (Plate. IV). Weed control was carried out manually and all other practices were done as needed.

Figure 2: Shows experimental design. Source: this study

2.3 Treatments Experimental Design

The treatment consisted of three varieties of roselle
(V1 as green variety, V2 as red variety, V3 as deep red variety) and three concentrations of NLAE (C1, C2, C3) and control (C0). The experiment was laid out in randomized complete block design (RCBD) in a split plot arrangement and replicated three times. roselle varieties variable was assigned to the main plots, while the NLAE concentration variable was assigned to the subplot.

2.4 Collection of Neem Leaf and Extract Preparation

Neem leaves were collected from trees in Kebbi State University of Science and Technology, Aliero campus. One kg of Neem leaves was chopped using motar and pistol and soaked in 3 litres of water and left for seventy two hours (3 days). Then in the morning, the content was filtered using green Muslin cloth of fine mesh and each litre was diluted with 1.5, 2.5, and 3.5 litres of clean water in order to make three concentration levels. Five mls of liquid soap was added to each concentration as an adjuvant and mixed thoroughly before spraying on the leaves of the roselle plots when the plant reached stage of 50% flowering.

2.5 Data Collection

2.5.1 Insect pest Collection

Stands were tagged in each experimental plot, Dysdercus spp was collected from the 3x3 most central plant of each plot, they were determined 1 DBS using beat sheet method and flying insect was collected through sweep net and tiny insect are collected using suction tube methods, hand picking and by visual observation in the evening when the temperature was lowered. The insects collected were placed inside vial containing 70% alcohol. Thereafter, the insects were taken to the laboratory of Crop Science Department, KSUSTA for identification. The same procedure was repeated at 1, 2, 3, 5 and 7 DAS with NLAE.

2.5.2 Fresh Calyx Yield

Data were collected on fresh calyx yield (kg/ha) by hand plucking the head flower when the calyces are wide open from the 3x3 most central plant of each plot, each data from each plot were weighed using electronic balance and recorded.

2.5.3 Dried Calyx Yield

Data on dried calyx yield (kg/ha) were obtained after the fresh calyx were shade dried, they were then weighed, and recorded.

2.5.4 Fresh Leaf Yield

Fresh leaf yield (kg/ha), were collected from the 3x3 most central plant of each plot, and weighed using electronic balance and recorded.

2.5.5 Dried Leaf Yield

Dried leaf yield (kg/ha) were determine after the fresh leaf were shade dried, then weighed, and recorded.

2.6 Data Analysis

Data collected were subjected to analysis of variance as described by Snedecor and Cochran (1967) using SAS software (SAS Institute, 1999). The treatment mean were compared using Duncan Multiple Range Test (Duncan, 1955).

3.0 Effects of Neem Leaf Aqueous Extract (NLAE) on the Insects Population

Table 1 shows the effects of NLAE on population of *Dysdercus spp* on three varieties of Roselle in Aliero. The results revealed that, there was no significant difference ($P<0.05$) among all treatments on the population of the *Dysdercus spp* except at 5 DAS where the untreated control recorded significantly higher number of *Dysdercus spp* than other treatments. Generally on both treated and untreated plots, the number of *Dysdercus* spp decrease with time and did not exceed 0.7 at 5 and 7 DAS.

The varietal effect of NLAE on the population *Dysdercus spp* on roselle plant showed that, the red variety had the highest population of *Dysdercus spp* at 1 DBS among all the treatments while the green variety had the least although there was no significant difference (P < 0.05) among treatments on the population of the insect pest.

There was no significant interaction between the NLAE concentration levels and the varieties on *Dysdercus spp* among all the sampling days.

3.1 Result

Table 1 Effects of NLAE on Population of *Dysdercus Spp* on Roselle Plant in Aliero

Treatment	**1 DBS**	**Days after spray (DAS)**				
		1	2	3	5	7
Conc. of NLAE(kg/ltr)						
0	8.39	7.06	1.39	1.39	0.67a	0.17
1	8.89	7.22	0.94	0.94	0.00b	0.00
2	8.94	6.44	1.61	1.61	0.00b	0.00
3	8.67	6.33	1.44	1.44	0.22b	0.11
SE±	0.69	0.57	0.30	0.30	0.09	0.07
Variety						
Green	3.67	2.21	0.29	0.29	0.13	0.00
Red	12.78	9.83	1.96	1.96	0.21	0.21
Deep Red	10.46	8.25	1.79	1.79	0.33	0.00
SE±	0.59	0.49	0.26	0.26	0.09	0.06
Interaction						
C×V	NS	NS	NS	NS	NS	NS

Means with the same letter are not significantly different at 5% probability level according to Duncan multiple range test. 1 DBS stands for a day before spraying of treatment, where no letter exist differences were not significant.

Table 1 shows the effects of NLAE on population of *Dysdercus spp* on three varieties of Roselle in Aliero. The results revealed that, there was no significant difference (P<0.05) among all treatments on the population of the *Dysdercus spp* except at 5 DAS where the untreated control recorded significantly higher number of *Dysdercus spp* than other treatments. Generally on both treated and untreated plots, the number of *Dysdercus* spp decrease with time and did not exceed 0.7 at 5 and 7 DAS.

The varietal effect of NLAE on the population *Dysdercus spp* on roselle plant showed that, the red variety had the highest population of *Dysdercus spp* at 1 DBS among all the treatments while the green variety had the least although there was no significant difference (P < 0.05) among treatments on the population of the insect pest.

There was no significant interaction between the NLAE concentration levels and the varieties on *Dysdercus spp* among all the sampling days.

Table 2 Effects of NLAE on Population of *Dysdercus Spp* on Roselle Plant

Treatment	**1 DBS**	**Days after spray (DAS)**				
		1	2	3	5	7
Conc. of NLAE(kg/ltr)						
0	12.44a	9.67a	7.44	5.89	4.22	3.56a
1	11.67ab	6.78b	6.78	6.78	3.67	0.44b
2	11.11ab	7.11b	7.11	7.11	3.78	1.56b
3	9.67b	6.67b	6.89	6.89	4.67	1.89b
SE±	0.75	0.63	0.68	0.71	0.88	0.48
Variety						
Green	6.67c	4.17c	3.75c	3.17c	4.50	1.83
Red	16.17a	11.17a	10.58a	10.00a	3.67	1.75
Deep Red	10.83b	7.33b	6.83b	6.83b	4.08	2.00

SE±	0.65	0.55	0.58	0.62	0.76	0.41
Interaction						
C×V	NS	NS	NS	NS	NS	NS

Means with the same letter are not significantly different at 5% probability level according to Duncan multiple range test. 1 DBS stands for a day before spraying of treatment, where no letter exist differences were not significant.

.Table 2 shows the effects of NLAE on population of *Dysdercus spp* on roselle plant in Jega. The result revealed that, at one DBS, there was significant difference (P< 0.05) among treatments on the population of the insect pest. The untreated control had the highest number of *Dysdercus spp* (12.44) while concentration 3 had the least population. At 1 DAS, there was significant difference between the untreated control (9.67) and the treated plots (6.67). However, the treated plot did not differ significantly for one another at 2, 3 and 5 DAS there was no significant difference among the treatments. But at 7 DAS, there was significant differences among the treatments, the untreated control also had significantly the highest number (3.56) of *Dysdercus spp* and concentration 1 recorded the lowest population (0.44) of *Dysdercus spp.*

The varietal effect of NLAE on the population of *Dysdercus spp* on roselle plant showed that, the red variety had the highest population (16.17, 11.17, 10.58, 10.00) of *Dysdercus spp* at 1 DBS, 1, 2, and 3 DAS which were significantly different from the other varieties. The corresponding figures for the green variety were (6.67, 4.17, 3.75, 3.17) of *Dysdercus spp* at 1 DBS, 1, 2, and 3 DAS, respectively.

4.0 DISCUSSION

4.1 Effects of insect pest population on Roselle Plant in Aliero

Findings from the field of study to determine the pest complex affecting roselle production in Aliero, Kebbi State revealed that *Dysdercus spp, was* identified as the pest complex affecting roselle production in Aliero, Kebbi State. The present findings corraborates that of Fasunwon and Banjo (2010) who reported that among the insect pests attacking roselle plant, *Dysdercus spp,*. cause economic damage, attacking the lamina of the young foliage and matured leaves which result in reduction of the photosynthetic ability of the crop. Komolafe (1979) observed that *Podagrica species* did not only damage the leaves and flowers but caused premature falling of the pods. This insect also transmit mosaic virus resulting in 20-50% yield reduction (Fajinomi and Fajinmi, 2006). *Zonocerus variegatus* feed on wide range of crops including roselle (Babatunde Idowu and Akinsete, 2001). According to (Abdel -Moniem and El-Wahab, 2006), the insect pest complex of roselle also includes *Bemisia tabaci* (Genn.) *Aphis gossypii, Glover, Earias insulana* (Boisd.) and *Empoasca spp.*

4.2 Effects of Neem Leaf Aqueous Extract (NLAE) on insect pest population in Aliero

Experimentals trialsin Aliero, Kebbi State revealed that the efficacy of the NLAEs at different concentration levels on pest affecting roselle, and it showed that NLAE at untreated control had the highest number of *Dysdercus spp,*, and brown stink bug from day 1 to day 7, while concentration 1 recorded the least number of *Podagrica spp* followed by 2 and 3 to untreated control respectively. The populations of the insect pest *Dysdercus spp, Mylabris spp, Leptoglossus spp,* and *Nezara viridula* at one DBS and 1,2,3,5 and 7 DAS were similar to each other.

4.3 Effects of insect pest population on Roselle Plant in Jega

The result from the study showed that in Jega location, *Dysdercus spp,* is one of the major insects of roselle at flowering stage. *O. hyalinipennis* and their nymph destroyed the calyces and leaves of the plant as reported by Hill (1983) where he stated that *O. hyalinipennis* nymph and adult feed extensively on the calyces and seeds of roselle. The percentage loss of leaves, calyces and seeds due to damage by these insect pests has not been reported partially due to report by some researchers that insect pest damage is a minor problem in roselle. (Annecke and Moran, 1982; Erichsen and Schoeman, 1993). Also, *Dysdercus spp,* fed voraciously on the lamina and young leaves of the plant. The study corroborates the findings of Fasunwon and Banjo (2010) who reported that among the insect pests attacking roselle plant, *Dysdercus spp,* cause economic damage, attacking the lamina of the young foliage and matured leaves which result in reduction of the photosynthetic ability of the crop.

4.4 Effects of Neem Leaf Aqueous Extract (NLAE) on insect pest population affecting Roselle Plant in Jega

In Jega location, the efficacy of the NLAEs at different concentration levels on pest affecting roselle, indicated that the higher the concentration level, the lower the number of *Dysdercus spp*, and brown stink bug from day 1 to day 7. Kabaru and Gichia (2001) argued that botanical insecticide is a promising alternative in the protection of crops against insect pests. They are generally pest-specific and relatively harmless to non-target organisms. Azardirachtin derived from the Neem tree (*Azadirachta indica L.*) has been reported as antifeedant, repellent, oviposition deterrent and insect growth regulator (Isman, 2008; Naumann and Isman, 1995; Prijono and Hassan, 1993). This evergreen, fast-growing plant known as the Indian lilac offers immense antifeedant properties due to its efficacy in suppressing the feeding sensation in insects, at concentrations even less than 1 parts per million (Isman *et al.*, 1990).

4.5 Effects of Neem Leaf Aqueous Extract (NLAE) on Yield of Roselle Plant

The effect of pest infestation on yield of roselle in the study areas showed that in both Aliero and Jega respectively, there was a reduction in the leaves and poor production of calyces. The reduction in the percentage calyx damage and calyx loss could be attributed to the effects of the NLAE applied. This was also the results when NLAE was applied, which clearly reduced the population of *O. hyalinipennis. O. Hyalinipennis*is which is among the major insect pest of roselle in the area attacking the flower bud and blossoming flowers causing scars, holes and sometimes-complete abortion. This implies that NLAE could be used to control *O. hyalinipennis* and reduce calyx yield loss.

Similarly, concentration of NLAE did not affect the yield of roselle plant Boeke *et al*. (2004) observed that Neem is safe for workers, with no handling risks, and can be used throughout the entire crop production cycle.

5.0 SUMMARY,

5.1 Summary.

The study was carried out in two locations: Aliero and Jega local government areas of Kebbi State North-west region of Nigeria in order to determine the effect of concentration levels of neem (*Azadirachta indica)* leaf extract on insect pests population affecting roselle (*Hibiscus sabdariffa* Linn.) varieties. The treatment consisted of three varieties of roselle V1 as green variety, V2 as red variety, V3 as deep red variety and three concentrations of NLAE (C1, C2, and C3) and control (C0). The experiment was laid out in randomized complete block design (RCBD) in a split plot arrangement and replicated three times. The study recorded *Dysdercus spp*, as the main insect pest discovered. The result revealed that there was effect of the NLAE at different concentration levels on pest affecting roselle, and it showed the untreated control recorded the highest number of pest complex from day 1 to day 7, and was significantly different from other treatments while concentration 1 recorded the least number pest complex in Aliero location. Also, the result in Jega location revealed that, there was no significant difference ($P < 0.05$) among treatments on the population of the insect pest *Dysdercus spp*, and at one DBS and 1,2,3,5 and 7 DAS (DAS).

The effect of pest infestation on yield of roselle in the study area showed that in Aliero, there was no significant difference ($P < 0.05$) among all the treatments on population of the insect. The varietal effect of NLAE on the yield of on roselle plant showed that there was no significant difference ($P < 0.05$) among all the treatments on the population of the insect pest. Also, in Jega location, there was no significant difference ($P < 0.05$) among all the treatments on population of the insect. The varietal effect of NLAE on the yield of on roselle plant also recorded that there was no significant difference ($P < 0.05$) among all the treatments on the population of the insect pest in Jega farm. It was observed that Neem is safe for workers, with no handling risks, and can be used throughout the cultivation period.

5.2 Conclusion

The present study revealed that *Dysdercus spp, was* identified as the pest complex affecting roselle production in Aliero and Jega, Kebbi State respectively. Secondly, the NLAE was effective against *Dysdercus spp,*. Finally, Pest infestation does affect the yield of of roselle in the study areas. The environmental risks associated with the continuous use of synthetic pesticides have prompted the use of plant based insecticidal components that provide selective toxicity to insects with minimum off target effects. The use of botanical pesticides offers eco-friendly pest control strategy to aid the agricultural practices. Among the various herbs, Neem plant based insecticides has been the most accepted bio-pesticides, due to the presence of multiple limonoids in Neem plant extracts and oil that not only provides a sustainable pest control mechanism but also prevents plant disease resistance, from various synthetic insecticides.

5.3 Recommendation

The use of NLAE on roselle plant showed that there was a reduction of insect pest population after treatment application on the plant. Roselle is a very important crop that has a great potential in the future industrial market for its fibre, medical, domestic and commercial purpose. As such farmers need to be sensitized to the use of NLAE in order to replace synthetic insecticides because it is easily accessible, very affordable, easy to use with zero handling risk and eco-friendly. Also development of standardized formulation and certification of the Neem-pesticide products is even more crucial and highly recommended. Further studies need to be carried out to increase the NLAE application at different stages of growth of the plant other than at 50% flowering stage as it is in this study. Furthermore, the efficacy of these pesticidal ingredients of Neem can be augmented by encapsulating them in nanocarriers that may facilitate sustained and controlled release of phytochemicals along with site targeted delivery, thus increasing the productivity and yield of crops.

References

A. S. H. Abdel-Moniem Dr and T. E. Abd El-Wahab (2006). Insect pests and predators inhabiting roselle plants, *Hibiscus sabdariffa* L., a medicinal plant in Egypt, Archives of Phytopathology and Plant Protection, 39:1, 25-32,

Adebooye, O.C. (2011). African indigenous vegetables resources in a changing world. In: International Conference on Sustainable Development of Natural Resources of Africa, 5-8 December, 2011, Accra, Ghana.

Adebooye, O.C., Ajayi, S.A., Baidu-Forson, J.J. and Opabodi, J.T. (2005). Seed constraints to cultivation and productivity of African indigenous leaf vegetetables. *African Journal of Biotechnolog*y. 4(13), 1480-1484.

Adegbite, A.A., Agbaje, G.O.and Abidoye,J.(2008). Assessment of yield loss of roselle (*Hibiscus sabdariffa* L.) due to root-knot nematode, (*Meloidogyne incognita*) under field conditions. *Journal of Plant Protection*.48 (3):268-273.

Alarcon-Aguilar FJ, Zamilpa A, Perez-Garcia MD, Almanza-Perez JC, Romero-Nunez and E, Campos-Sepulveda EA, (2007). Effect of *Hibiscus sabdariffa* on obesity in MSG mice. Ethnopharmacolog: 114:66-71.

Alarcón-Alonso J, Zamilpa A, Aguilar FA, Herrera-Ruiz M, Tortoriello J, Jimenez- and Ferrer E, (2012). Pharmacological characterization of the diuretic effect of *Hibiscussabdariffa* Linn (Malvaceae) extract. Journal of Enthnopharmacology; 139 (3):751-6.

Alegbejo, M.D. (1998). The potential of roselle as an industrial crop in Nigeria. A paper by programme leader Horticulture Crops Research programme and joint co-ordinator NCRP (Horticulture) for Northern-western and North Eastern Nigeria. Pp: 1-6

Alegbejo, M.D., (2000). Processing utilization and nutritional values of okra and roselle. Noma Mag., 14: 43-45.

Amusa NA, Adegbite AA, and Oladapo MO. (2005). Vascular Wilt of roselle (*Hibiscus sabdariffa*L. var.*sabdaeiffa*) in the Humid Forest Region of South-western Nigeria. Plant Pathology; 4(2):122-5.

Amusa NA, Kogbe JOS and Ajibade SR. (2001). Stem and foliar blight in roselle in the tropical forest region of South Western Nigeria. Biotechnolgy; 76:681-4.

Amusa NA. (2004). Foliar blight of roselle and its effect on yield in tropical forest region of southwestern Nigeria. Mycopathologia; 157(3):327-31. Epub 2004/06/08.

Annecke, D.P. and Moran, V.C. (1982). Insects and Mites of Cultivated Plants in South *Africa*.Durban: Butterworths. 383 p

Aoshima, H., S. Hirata and S. Ayabe, (2007). Antioxidative and anti-hydrogen peroxide activities of various herbal teas. Food Chem., 103, pp 617-622.

Atta, S.,Diallo, A.B.,Bakasso, Y.,Sarr,B.,Saadou, M. and Glew, R.H.(2010). Micro-element contents in roselle (*Hibiscus sabdariffa* L.) at different growth stages.*African Journal of Food Agriculture Nutrition and Development.*10 (5):1-14.

Augstburger F, Berger J, Censkowsky U, Heid P, Milz J, and Streit. C. (2000) Organic Farming in the Tropics and Subtropics, Exemplary Description of 20 Crops. Vanilla: Grafelfing, Naturland.

Babatunde Idowu, A. and Akinsete, A. (2001). The attraction of Zonocerus variegatus (Orthoptera: Pyrgomorphidae) to different types of lure. *Revista de biologia tropical*, 49, pp 673-678.

Babatunde, F.F., Oseni, T.O, Auwalu, B.M., and Udom, G.N. (2002). Effect of sowing dates, intra-row spacings and nitrogen fertilizers on the productivity of red variant roselle (*Hibiscus sabdariffa* L.) *Pertanica J.Trop.Agric.Sci*.25 (2):99-106.

Bangerth, F. (1989). Dominance among fruits/sinks and the search for a correlative signal.*Physiol.Plant.*76:608-614.

Barzgaran, T. (2011). Effects of irrigation and planting date on agronomic traits and yield of roselle. Unpublished M.Sc thesis, Dept. of Agriculture, Islamic Azad Univ. Birjand Branch, Iran. Pp 111.

Benge, M. (1986). Neem: The Cornucopia Tree. S and T/FENR Agro-Forestation Technical Series No. 5. Agency for International Development, Washington, D.C.

Berzsenyi, Z. and Lap, D.Q. (2001). Effect of sowing time and N fertilisation on the yield and yield stability of maize (*Zea mays* L.) hybrids between1991–2000. *Acta Agronomica Hungarica*, 50, pp 309–331.

Beveridge, C.A., Ross, J.J., Murfet, I.C.and Rameau, C. (1994). Branching mutant *rm-2* in *Pisum sativum*.*Physiology*.95:104-959.

Blackwell, A. (1993). Azadirachtin, an update. *J. Insect Physiol*., 39, pp 903-924.

Boeke SJ, Boersma M.G. and Alink GM, (2004). Safety evaluation of neem (Azadirachta indica) derived pesticides. J Ethnopharmacol.; 94(1):25–41. doi:10.1016/j.jep.2004.05.011.

Bolade, M,K.,Oluwalana, I.B.and and Ojo,O.(2009). Commercial practice of roselle beverage production by hot water extraction and sweetness level. *World Journal of Agriculture Sciences*.5 (1):126-131.

Cline,M.G.(1991). Apical dominance. *The Botanical review*.57:318-358.

Cline, M.G. (1994). The role of hormones in apical dominance-New appropriates to old problem in plant development. *Physiologia Plantarum*.90:230-237.

Cline,M.G.(1997). Concepts and terminology of apical dominance. *American Journal of Botany*.84 (9):1064-1069.

D'Heureux, F. and Badrie, N. (2004) Consumers acceptance and physicochemical quality of processed red sorrel/roselle (*Hibiscus sabdariffa* L.) sauces from enzymatic extracted calyces. Food Serv. Technol. 4: 141-148.

Dari, L. and Mahunu, G.K. (2010). Nutritional assessment of some indigenous leafy vegetables in Northern Ghana. *Ghana Journal of Horticulture*.8:112-115.

Daudu O.A.Y., Falusi O.A., Dangana M.C., Abubakar A., Yahya S. A., Abejide D. R., (2015). Collection and Evaluation of roselle (*Hibiscus sabdariffa L*.) Germplasm in Nigeria. *African Journal of Food Science*, 9(3), pp. 92-96.

Dike, M.C. (1987). Insect pests of kenaf and roselle in the Zaria area of northern Nigeria. A paper presented at the 17th Annual Conference of the Nigerian Society for Plant Protection. University of Nigeria,

Okosun, L.A. (2000). Effect of plant density, sowing date and fertilizer on the growth and yield of roselle (*Hibiscus sabdariffaL*.) in the sudan savannah. Ph.d thesis presented to the postgraduate school, Usman Danfodio University, Sokoto, Nigeria. Pp: 186.

Diouf, M., Gueye, M., Faye, O., Dieme, O. and Lo. C. (2007). The commodity systems of four indigenous leafy vegetables in Senegal. *Water SA*.Vol.33 (3), 343-348.

DON-PEDRO, K.N. (1985). Toxicity of some citrus peels to Dermestes maculatus Deg and *Callosobruchus maculatus*. J. Stored Product Research, 21(1): 31-34.

DON-PEDRO, K.N. (1989b). Insecticidal activity of some vegetable oils against *Dermestes maculatus*, Degeer (Coleoptera: Dermestidae) on dried fish. J. Stored Product Research, 25(2): 81-96.

Drake, Y.A.(1985). Handbook of medicinal herbs.13th edition, Livingstone Group Ltd.Endingburgh.pp:228-229.

Dun, E.A.,Fergurson,B.J.,andBeveridge,C.A.(2006). Apical dominance and shoot branching: divergent opinions or divergent mechanisms. *Plant physiology*, 142:812-819.

Duncan, D. B. (1955). "Multiple range and multiple F tests". Biometrics. 11: 1–42. doi:10.2307/3001478

Edmond, J.E, Senn,T.L.,Andrews, F.S. and Halfacer, R.G.(1977). *Fundamental of Horticulture* (4th edition) Tata McGraw Hill Publishing Co.Ltd.pp.15-45.

El Naim, A.M., Khaliefa, L.H.,Ibrahim, K.A.,Ismaeil, F.M.and Zaied, M.B.(2012). Growth and yield of roselle (*Hibiscus sabdariffa* L.) as influenced by population in arid and tropical Sudan under rain fed, *International Journal of agriculture and forestry* 2(3):88-91.

Erichsen, C. And Schoeman, A.S. (1993). *Monoleptaapicalis* SAHLBERG (Coleoptera:Chrysomelidae): A New Addition to the Avocado Pest Complex. *South African Avocado Growers' Association Yearbook*. 16:123-124.

Eslaminejad T, and Zakaria M. (2011). Morphological characteristics and pathogenicity of fungi associated with roselle (*Hibiscus Sabdariffa*) diseases in Penang, Malaysia. Microbial Pathogenesis. 51(5):325-37.

Facciola SC. (1990). Cornucopia. A source book of edible plants. : Kampong Publications, Vista, CA.

Fajinmi, A.A. & Fajinmi, O.B. (2006) Incidence of okra mosaic virus at different growth srages of okra plants (Abelmoschus esculentus L. Moench) under tropical condition. *Journal of General and Molecular Virology*, 2, pp 028-031.

Falusi OA (2007). Cultivation and Use of roselle (*Hibiscus sabdariffa L*) in Nigeria. PAT. 3(2):129-134