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On-Farm Assessment of the Impact of Synthetic and Botanical Insecticides Spray Regimes in the Management of Maruca Vitrata in Cowpea Production in Kebbi State Of Nigeria

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Abstract: *The investigation aimed at finding alternatives or at least minimise farmers massive (10-8 times) use of broad spectrum chemical insecticides for the management of Maruca vitrata a major reproductive insect pest of cowpea in cowpea in Kebbi State of Nigeria. The experiments in RCB design were carried out in Manga village of Zuru local government area of the State using cowpea variety IT89KD-245-1. Volunteer farmers applied the insecticides (Cypermethrin + 250g/l Dimethoate and 5% neem kernel extract (nke) on both calendar (weekly) and scouting basis, using action threshold of 60% flower infestation/damage at 50% flowering stage. Larval infestation/flower damage, yield and yield components as well as economic returns of each insecticide spray regime were assessed. The result showed that neem on a calendar application provided effective control of M. vitrata larval infestation/damage. Nke scouting based application had significantly higher larval infestation/damage compared to calendar chemical insecticide application but, yield was similar. Economic returns were better using neem for control of M. vitrata than using chemical insecticide, especially if neem applications were based on scouting. Thus, neem demonstrated to be a better alternative to chemical control of M. vitrata.*
Keywords: *Botanical Insecticide, Cowpea Production, Maruca vitrata, On-farm, Synthetic Insecticide*

I. Introduction

Cowpea cultivation is an integral component of the farming systems of the savannah zones of Northern Nigeria, as a result of the role it plays as a source of protein to the people, as well as nourishing the poor soils with nitrogen [1] Nigeria is the leading producer of cowpea and the bulk of the production is carried out in the Northern part of the country, where insect pests such as *M. vitrata*,remain the major production constraint. Farmers apply chemical insecticide as many as 8 – 10 times during the season in order to achieve control of the pod borer [2]. Massive chemical insecticide usage on a calendar basis has been known to be uneconomical in addition to the hazards caused to farmers' health and to the environment. In Nigeria, insecticides recommended only for cotton have found their way into the hands of cowpea farmers who unknowingly poison the crop for the consumers [3]. Therefore, farmers need have to other safe and effective means of control such as the use of botanical pesticides. According to [4] "The process of change must occur at farmers' farm". Small scale farmers are hardly involved in the planning and investigations of new farming technologies and unless these farmers are directly involved in the research and development of these new farming technologies, it is unlikely that new technologies will be widely adopted [5]; [6]. Against this background therefore, this study seeks to use a farmer participatory approach assess the potential use of neem as a replacement chemical insecticide for the management of *M. vitrata* in cowpea in Kebbi State of Nigeria.

II. Material and Methods

The investigation was carried out in Manga Village of Zuru Local Government Area of Kebbi State of Nigeria between July and December 2012. The experiment was an on-farm type involving one factor which was insecticide of two types, commercial insecticide (Cypermethrin + Dimethoate) and 5% neem kernel extract (nke). The two types of insecticides were applied on calendar (weekly) and scouting (need) basis. The whole experiment was set up in Randomised Complete Block Design (RCB) (see appendix 8.5). Five volunteer farmers were used and the field plots of each farmer represented a block. The treatments were located within these bocks. The resistant cowpea variety improved Kanannado (IT-245) was used. Five treatments namely: 1. calendar based commercial insecticide application, 2. scouting based commercial insecticide application, 3. calendar based nke application, 4. scouting based nke application and 5. Unsprayed control, were randomly assigned to the sub plots of a replication. Each subplot measured 4m x 10m and contained four rows of cowpea spaced 1m apart. The spacing between stands was 0.3m. The subplots were separated 2m apart. Early planting was carried out on 17^{th} July 2008 [7]. Among the numerous advantages of early planting of cowpea is that the crop recovers from early season damage by pests without affecting yield [8]. Four cowpea seeds were planted per hill and later thinned to 2 per stand [9]. Weeding was carried out twice by the same persons (3 and 6 weeks after crop emergence).

Measures were taken to avoid biasness in all the farm operations. Farmers were experienced in weeding operations. The same persons did both first and second weeding. The researcher personally supervised the quality of the weeding by ensuring weeds are properly removed with including their roots especially the perennial ones, or covered with earth in such a manner as to prevent regrowth. Care was taken to ensure that weeding was done during dry and sunny weather conditions to allow weeds to die after weeding. Measures were also taken to avoid bias in harvest. Farmers were experienced people who could distinguish between matured ripened pods and un- ripened ones. Edge effect bias was avoided by demarcating plots and harvesting the entire plot in order to determine plot yield. All experiment plots received same cultural treatment on the same date.

2.1 Data collection

A simple sampling square (Plate 2) 1m x 1m made of elephant grass stalks was constructed locally and made use of in sampling damaged flowers, flower buds and pods. This was done because the interlocking nature of the spreading cowpea varieties made it difficult to distinguish individual plant stands. A sample of 25 flowers/flower buds was randomly selected from each of the two sampling units per plot and these were opened and examined on the spot for larval presence/damage. This rapid visual estimate method (RVE) was used to determine flower damage as a result of larvae feeding indicated by dirty frass or exit holes [10]. An action threshold of 60 percent larval infestation/damage [11] was used to indicate the need for pesticide application in the case of need based control strategy. Percentage larval infestation/damage was determined by dividing the number of flowers/flower buds infested/damaged by the total number of flowers sampled and multiplying the value obtained by one hundred. In the case of pod damage assessment, 25 pods were collected from each of the two sampling units using the sampling square, and examined for pod borer damage indicated by stitching together of pods using silky material or the presence of exit holes or dirty frass or in-pod feeding larvae. Seed damage data was collected by threshing the sampled pods and the seeds showing signs of larval feeding were counted as damaged.

The sampling operation was carried out at weekly starting from 3rd November 2012 which corresponded with 50% flowering stage and ended on 17th November 2012. Yield data was obtained by harvesting pods from each individual plot; threshing and weighing to obtained plot yield in kg which was later converted to kg/ha. The benefit/cost ratio was calculated in line with [10] whereby: "Yield increase (Kg/ha) = yield of spray treatment less yield of no-spray. Value of yield increase in Naira = Yield increase multiplied by the market value of a kilo of cowpea grains at harvest (N200.00/kg), Profit = Value of yield increase less total pest control cost. Benefit-Cost ratio = Value of the increase yield divided by cost of pest control of that treatment". Partial budgeting was used so costs of land preparation, weeding and harvesting were not included. It was assumed that yield increase was due to insecticide application. Straight line Depreciation value was calculated following [12]: Annual Depreciation = cost less salvage value divided by years of useful life. The purchase cost of the sprayer was N9000.00. The useful life of Knapsack sprayer was determined following [13]. The salvage value or scrapped value was determined locally and found to be N500.

III. Results

3.1 Larval infestation/damage, yield, pod, and seed damage

Treatments had a significant effect on larval infestation/damage, pod and seed damage and were associated with yield increase (Fig.1-4). Spraying commercial chemical insecticide and nke, on both a calendar and scouting basis, reduced larval infestation/flower damage, pod damage and seed damage, when compared to the unsprayed controls. Highly significant difference was found when the mean of these parameters from the treated plots were compared with those of the unsprayed controls ($P \leq 0.001$) (Fig.1). Lower larval infestations/flower damage were recorded in plots sprayed on a calendar basis compared to those sprayed on scouting basis but the scouting-based treatment required only two spray applications after pest infestation/damage reached 60%. The larval infestation/flower damage of the scouting based nke treated plots was significantly ($P \leq 0.001$) higher than those of the calendar based chemical insecticide treated plots (Fig.2). Similar result was obtained when the larval infestation/flower damage of the scouting based commercial insecticide treated plots was compared with that of the calendar based commercial insecticide treated plots (Fig. 2). Although a significant difference existed between the larval infestation/flower damage of scouting based nke treated plots and those of similar spray regime of commercial insecticide ($P \leq 0.05$) (Fig 10.2), there was no significant difference between those of the calendar based nke treated plots and those of the same spray regime of commercial chemical insecticide ($P \geq 0.05$) (Fig.2).

A reduction in pod damage of 91% and 69% below that of the unsprayed controls was obtained from calendar based commercial chemical insecticide and nke applications. Scouting based application of commercial chemical insecticide and nke, reduced seed damage by 82% and 62% respectively below those of the unsprayed controls respectively. No significant difference was found in the mean number of pods and seeds damaged between all calendar based spraying of both chemical insecticides and nke, in comparison with those of the scouting based spraying of the same pesticides ($P \geq 0.05$) (Fig.3 & 4). All spray interventions increased yield above the unsprayed control. A highly significant difference was observed in the mean yield of calendar based commercial insecticide treated plots in comparison with the unsprayed controls ($p \leq 0.001$) (Fig.1). The same result was obtained when the mean yield of the scouting based commercial insecticide treated plots was compared with those of the unsprayed control plots. No significant difference was observed in the mean yield of scouting based nke treated plots when compared with those of the calendar based commercial insecticide treated plots ($P \geq 0.05$) Fig. 1). Yield increases over unsprayed control (85% and 81%) were obtained as a result of calendar spraying both commercial chemical insecticide and nke respectively while those of scouting based of the commercial chemical insecticide and nke application are 83% and 78% respectively. The benefit-cost ratio (B.C) of the scouting based nke application was superior (19.2 at 60% action thresholds) to the rest of the treatments (Table 10.5). There was a correlation between flower damage and larval infestation (R^2= 0.5449) (Fig. 10.3).

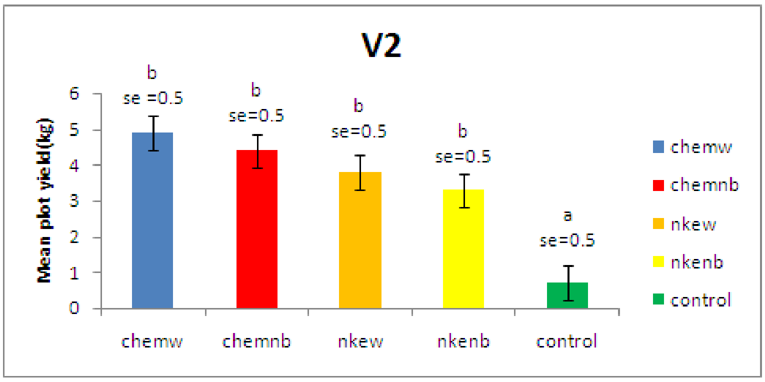

Fig 1 Effect of commercial chemical insecticide and neem on seed yield (kg) of Improved Kanannado cowpea variety. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$). Plot size = 4m x 10m.

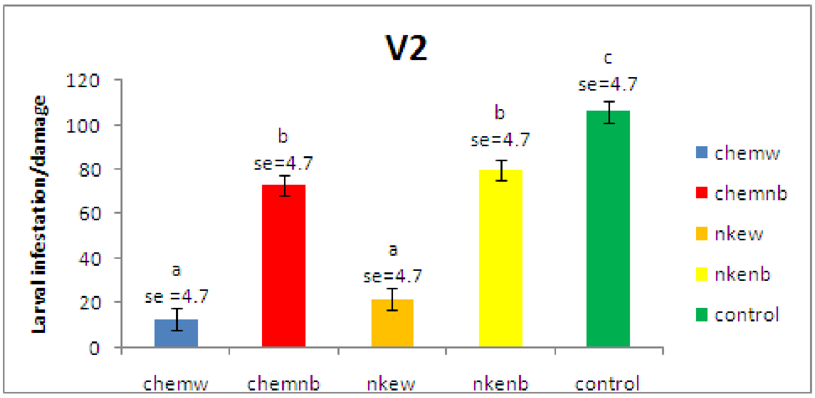

Fig. 2 Effect of commercial chemical insecticide and neem on larval infestation/damage of the Improved Kanannado cowpea variety. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$). (chemw = weekly application of chemical insecticides, chemnb = scouting based chemical insecticide application, nkew = weekly application of neem, nkenb = scouting based neem application and control = unsprayed).

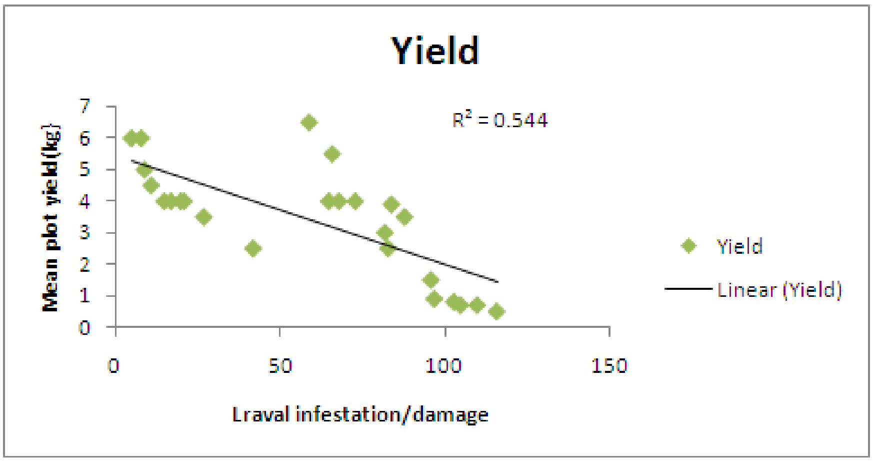

Fig.3 Relationship between yield loss and flower damage in the on-farm experiment.

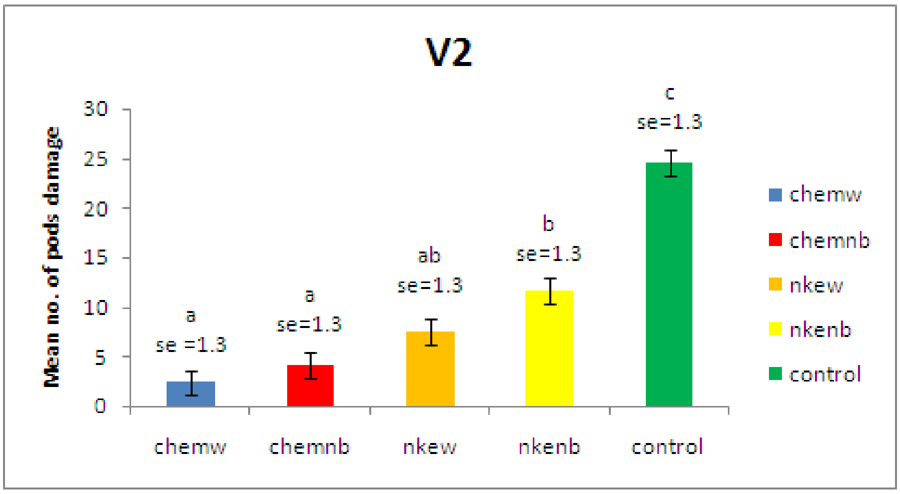

Fig. 4 Effect of commercial chemical insecticide and neem on pod damage of the improved Kanannado cowpea variety Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Fig.1Use of sampling square

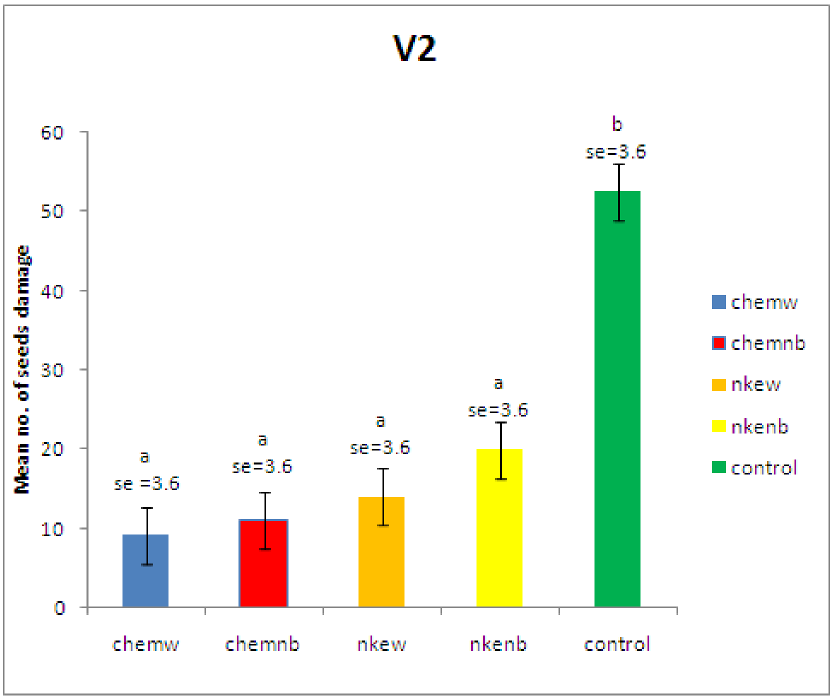

Fig 5 Effect of commercial chemical insecticide and neem on seed damage of the Improved Kanannado cowpea variety. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Fig. 2 Flower damage assessments with volunteer farmers

Table 1 Benefit/Cost analysis, of the various control options used in the on-farm experiment.

item	nke weekly costs	nke scouting 60% costs	chem. weekly costs	chem. scouting60% costs
Seed dressing material (N)	300.00	300.00	300.00	300.00
Labour for seed dressing (N)	200.00	200.00	200.00	200.00
Insecticides/nke	6300.00	1800.00	17500.00	5000.00
Sprayers (N)	1700.00	1700.00	1700.00	1700.00
Sprayings (N)	490.00	140.00	490.00	140.00
Scouting (N)	Nil	3000.00	Nil	3000.00
Mortar and pestle (N)	145.00	145.00	Nil	Nil
Total costs (N)	9135.00	6785.00	20190.00	10840.00
Average Yield (kg/ha)	950	825	1225	1100
Yield Increase (kg/ha)	775	650	1050	925
Value of yield (N) increase	155,000.00	130,000.00	210,000.00	185,000.00
Profit (N)	140,865.00	123,215.00	189,810.00	174,160.00
Benefit/Cost ratio	17.0	19.2	10.4	17.1

NB: chem. scouting 60% = chemical pesticide application at 60% flower damage action threshold, nke scouting, Average plot yield = 175kg/ha.

IV. Discussions

Commercial chemical insecticide sprays applied on a calendar basis outperformed all the other insecticide applications in decreasing the *M. vitrata* larval infestation/flower damage on the cowpea variety tested (improved Kanannado). Similar findings were also documented by [14]. [15] whose work using cypermethrin on both calendar (7 days interval) and monitored sprays, also showed highly significant difference between the two spray regimes (calendar and scouting) in terms of larval infestation/flower damage. Previous works such as those of [16] obtained better control (69% reduction) of the pod borer larval infestation with calendar sprays which was started at the seedling stage (5 sprays at 7days interval) compared to 44% larval infestation reduction obtained by 3 sprays of chemical insecticide which was started at the flower budding stage. However, using pheromones as a monitoring device, application of synthetic insecticides was found to be more effective in reducing *M. vitrata* larval infestation/flower damage in cowpea, compared to spraying based on crop growth stage (Calendar) [17]. Although the concealed feeding nature of the larvae sometimes makes it difficult for farmers to achieve full control with minimal or monitored insecticide applications, such intensive use of chemical insecticide as done on the calendar based sprays, is known to adversely affect the natural enemies' population thereby promoting pest resurgence. In addition to the long term effect on the farmers' health and that of the consumers, this type of spraying is known to be uneconomical and makes food production expensive [18]. Also, it has been observed that in many instances, the economic cost of this type of multiple sprays can even be greater than the cost of damage done to crop by pests [19].

Foliar insect damage is only sporadic in the savannah zones in Nigeria and more than 70% of total loss in yield of cowpea occurs at the reproductive stage, making any spray at the vegetative state (36 days after planting) as is done on calendar basis, unwarranted [10]. Generally nke application on both calendar and scouting had a positive effect in the reduction of the larval infestation/flower damage. [20] also demonstrated that the use of nke at 5% concentration could give good control of larval infestation/flower damage in cowpea as a result of its inflicting 85% mortality on the pest populations. However the work of [21] goes contrary to the findings of this research work due its inability to detect any significant difference between treatment and controls in terms of larval infestations/flower damage when nke at 5% concentration was used. This could have possibly been caused by low pest pressure in Egbo's study [22]. Although both chemical pesticide and nke applications on scouting basis did reduce larval infestation/flower damage below the level obtained in the unsprayed controls, the relatively higher pest infestation/flower damage in comparison with the calendar based counterparts, could have occurred due to the delayed nature of the scouting based spray regimes until the infestation/flower damage reached the 60% action threshold.

Although both larval infestation/flower damage and the number of pods damaged with the calendar and scouting based commercial chemical insecticide treatments were significantly lower than those of the scouting based nke treatments, this did not result in any significant difference in seed damage and grain yield. Yield was not affected possibly due to the use of manure by the farmers and the indeterminate nature of the varieties used. Animal manure contains phosphorus [23], which according to [24] is known to enhance speedy crop recovery after insect damage. This enhanced crop recovery coupled with the staggered flowering nature of the cultivars and some measure of insecticide protection given could have caused yield to be less affected in the scouting experiment. The result however goes contrary to the findings of [25] who found that application of 5% nke solutions adequately protected cowpea pods from damage by *M. vitrata* larvae but application of synthetic insecticide (Mixture of cypermethrin and dimethoate) gave significantly higher reduction of seed damage and higher yields. The differences between nke and synthetic insecticides detected by [25] could have occurred due weather conditions such as rainfall and sunlight that could reduce the efficacy of nke. It has been reported that nke is liable to photo degradation due to non-standardization [26]. The result of this research work is also in conflict with the findings of [17] that the use of botanical insecticides (neem inclusive) combined with monitoring using pheromones, proved inferior to the conventional farmers calendar spraying of synthetic insecticides in protecting the yield of cowpea. However, pheromone catches can be reduced by many factors, such as faulty trap design or female moths out-competing the traps. These factors may lead to the under estimation of moth populations thereby causing delay in the application of insecticides which in turn will cause more damage to the crop and higher yield reduction in the monitored farms.

The highest cost-benefit from spraying was obtained by the scouting based nke application. This is also in agreement with the work of [27] whose study using different concentration of nke and a synthetic insecticide (25g/L lamda-cyhalothrin) against the major insect pest of cowpea, showed that the best cost-benefit ratio was obtained by 5% nke application. Costs in using neem-based sprays are kept to a minimum by using locally available materials and family labour.

V. Conclusions

There was less difference between chemical insecticide and neem with respect to their effect on crop damage and seed yield than there was on pest infestation. Scouting can be used to decrease the number of sprays applied but results in less effective control of *M. vitrata* larval infestation/damage than calendar-based spraying. Economic returns were better when using neem for control of *M. vitrata* than using calendar based chemical insecticide, especially if neem applications were based on scouting. Therefore neem can be considered as a better replacement alternative to chemical control of *M. vitrata* in Kebbi State of Nigeria especially when applied on scouting basis.

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