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Response of old and new cowpea varieties to insecticide spray regimes in the Sudan savanna of Nigeria

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Insect pests are major constraint to cowpea production in northern Nigeria causing yield losses up to 70%. Several cowpea varieties have been developed and delivered to farmers by IITA over the past four decades. These varieties have varying degrees of resistance to insect pest attacks. A field study was established in northern Nigeria to determine the response to insecticide spraying of old cowpea varieties developed in the late 1970s and new varieties developed in the 2000s in order to determine whether new varieties have lesser requirement for spraying with insecticides than the old ones. The result revealed that the new cowpea varieties developed in the 2000s require more spraying than the old varieties developed in the 1970s. Infestations by the insect pests, maruca (*Maruca virata* Fabricius) and flower thrips (*Megalurothrips sjostedti* Trybom) were significantly less at zero and 1 spray for old varieties than for the new varieties. Old varieties also produced significant higher grain yield at zero and 1 spray compared with new varieties. Newer varieties require more spray to maximise yield gain.

Keywords: cowpea; insect pest; insecticide spray regimes; grain yield

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the most important food and forage legumes in the semi-arid tropics and a valuable and dependable commodity crop for farmers and grain traders (Singh 2005; Timko and Roberts 2007). It is grown mostly by poor farmers in developing countries, with 80% of production occurring in the dry savannas of tropical West Africa (Singh 2005). Cowpea is well adapted to the semi-arid tropics due to its ability to tolerate drought. As a leguminous crop, cowpea improves soil fertility through its ability to fix atmospheric nitrogen (Sanginga et al. 2003). Due to all these characteristics, cowpea is an important component of the cropping systems of the dry savannas of sub-Saharan Africa (Carsky et al. 2001). According to FAO statistics, cowpea is grown on an estimated worldwide area of 14 million ha. Some 8 million ha of cowpea are grown in West and Central Africa,

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especially in Nigeria, Niger, Burkina Faso, Mali, Senegal and Cameroon. In Nigeria, the production trend of cowpea shows a significant improvement with an increase of some 440% in area planted and an increase of some 410% in yield over the period 1961–1995 (Ortiz 1998). According to Singh et al. (2003), Nigeria produces about 2 million tons of cowpea on 5 million ha of land. The production trend would have moved upwards with the availability of improved varieties and crop management practices exhibiting better advantages over the current ones.

Over the years, a great deal of progress has been made by IITA in breeding a range of high-yielding cowpea varieties with combined resistance to major diseases, insect pests, and parasitic weeds and drought tolerance. Previously, from 1970 to 1988, cowpea research at the IITA concentrated primarily on developing and distributing grain type cowpea varieties, which have been tested and released in many countries (Singh et al. 1997). Considering the importance of cowpea grain and fodder in West Africa, IITA began a systematic breeding programme in 1989 to develop dual-purpose cowpea varieties (Singh et al. 2003). This programme combined breeding for high yield potential for grain as well as fodder with resistance to major biotic and abiotic stresses. Through this effort, a significant progress has been made in breeding high-yielding dual-purpose cowpea varieties for the Nigerian Sudan Savannas. Kamara et al. (2011) reported that the average rate of increase in grain yield of cowpea has been 28 kg ha^{-1} per year over the past three decades, which corresponds to a genetic gain of 3.6%. Similarly, fodder yield ranged from 1363 kg ha^{-1} for a variety released in 1976 (TVX1836-0131) to 3346 kg ha^{-1} for IT98K-476-8 released in 1998 corresponding to a genetic gain of 1.96%.

Despite the potential for further yield increases, cowpea production faces numerous problems including insect pests attack, *Striga gesnerioides* parasitism, diseases and drought. Insect pests attack is a major constraint to production (Singh et al. 1990). Severity of each of these stresses can vary and sometimes lead to total yield loss. Yield losses up to 70%, from insect pests alone, have been reported (Rusoke and Rubaihayo 1994). In some areas, the losses caused by insect pests account for a reduction in grain yield as much as 80% (ICIPE 1980). Cowpea growers in northern Nigeria are at risk of losing the entire crop to insect pests in most growing seasons. The most damaging of all insect pests are those that attack during the flowering and podding stages (Jackai et al. 1985). Worldwide, insect pests, especially *Aphis craccivora* Koch, *Megalurothrips sjostedti* Trybom and *Maruca virata* Fabricius, and a complex of pod-feeding bugs cause the greatest yield reductions (Alghali 1992a; Omongo et al. 1997). In a recent study, Kamara et al. (2007) reported that flower thrips, the legume pod borer (Maruca) and a range of pod-feeding bugs were the major insect pests of cowpea in the dry savannas of Northeast Nigeria. Maruca larvae damage flower buds, flowers, green pods and seeds (Singh and Jackai 1985). Thrips start to attack at flower bud initiation, causing flower bud abortion (Akingbohungbe 1982). Adults and nymphs of pod bugs remove sap from green pods, causing abnormal pod and seed formation (Singh and Jackai 1985).

Despite significant genetic gain recorded (Kamara et al. 2011), much progress has not been reported for the resistance of cowpea to insect pests (Oghiakhe et al. 1995). Although earlier breeding emphasis have been on breeding for grain type of cowpea that has some resistance or tolerance to insect pests (Singh and Jackai 1985), target breeding for insect pests resistance has not been very successful. The application of insecticides is the most widely known form of pest control method in cowpea

(Matteson 1982). According to Jackai et al. (1985), it is not feasible to grow cowpea commercially without the use of insecticides. Farmers could improve the yield of cowpea by 10-fold if insecticides are correctly used (Singh and Jackai 1985). Previous studies have shown that the application of insecticides once at flowering increased grain yield by 75% and the application at both the flowering and podding stages significantly reduced insect pest population and increased grain yield by 126% in the Nigerian Savannas (Kamara et al. 2007). In Kenya, Kyamanywa (1996) got a 15-fold increase in cowpea grain yield after the application of insecticide. However, in some countries, abuse of the use of insecticides chemical has been reported. For example, farmers in northern Nigeria have over-relied on the use of insecticides which has resulted into the indiscriminate use of insecticides (Kamara et al. 2007). In addition to the high cost, such indiscriminate use would have harmful effects on human health and the environment.

To reduce the heavy dependence on insecticides in cowpea grain production, the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, and its research partners in the West African sub-region initiated a research programme in the late 1970s to develop high-yielding cultivars with resistance to various field insect pests of the crop (Amatobi 1995). According to Singh and Jackai (1985), the most realistic approach to insect pest management in cowpea is to combine insecticide spraying with the cultivation of insect-resistant varieties. Oghiakhe et al. (1995) found eight cultivars of cowpea to be resistant to the legume pod borer (*Maruca virata* Fabricius), but exposure of the cultivars to the entire pest complex without protection from insecticides gave zero yields. In the early 1990s, breeding focus shifted to developing dual-purpose cowpea varieties that can produce high grain and fodder yield (Singh et al.1990; Kamara et al. 2011), which resulted into a significant genetic gain for both determinate and semi-determinate cowpea (Kamara et al. 2011). There is, however, no documented information on the performance of the high-yielding new varieties when compared with the old varieties when subjected to different insecticide spraying regimes. The objective of present work was to determine the response to insecticide spraying of old cowpea varieties developed in the late 1970s and new varieties developed in the 2000s as well as to determine whether the new varieties have lesser requirement for spraying with insecticides than the old ones.

Materials and methods

Experimental site

The field experiments were conducted under rain-fed conditions in 2010 and 2011 at the research farm of the International Institute of Tropical Agriculture (IITA), Minjibir (lat 12° 08′N, long 08° 32′E, elevation 500 m asl) in the Sudan savanna (SS) of Nigeria. The location has an average annual rainfall of 690 mm and a growing period of about 120 days; soils are classified as typic Utipsamments and are loamy sands (Craufurd 2000). The soil at the time of experimentation had organic matter content of 3.1 g kg^{-1}, N 0.18 g kg^{-1}, P 4.1 mg kg^{-1}, K 0.26 Cmol kg^{-1} and pH of 5.5.

Mean monthly maximum and minimum temperatures for 2010 and 2011 are presented in Table 2. Average minimum (21.3°C in 2010 and 21.2°C in 2011) and maximum (34.8°C in 2010 and 34.9°C in 2011) temperatures were not different for both years. The average temperatures were optimal for cowpea growth. Rainfall distribution differed between the two years. Total rainfall was 16% higher in 2010 than in 2011. Total rainfall of 999.2 mm in 2010 was more evenly distributed during crop growth than the 856.7 mm recorded in 2011. In previous years, prior to the time trial was established, the plot was under cowpea cultivation.

Cowpea varieties, insecticide treatments and experimental design

Four cowpea varieties (two old varieties and two new ones) and four insecticide spray regimes were compared in a split-plot factorial experiment laid out in randomised complete block design with three replications. The old varieties were VITA 5 and TVX1836-013J developed in the 1970s and the new ones were IT03K-316-1 and IT04K-321-2 developed in the 2000s. The insecticide spray regimes employed were: (1) no spraying (zero spray), (2) spraying once at the onset of flowering (1 spray), (3) spraying once at the onset of flowering and once at podding (2 sprays) and (4) spraying at the onset of flowering, at 50% flowering and at podding (3 sprays). The main plot consisted of spray regimes. Cowpea varieties were assigned to the subplot. Each subplot consisted of four, 5-m-long rows and 0.75 m apart. The main plots were separated by 2-m alleys. Hung along these alleys during spraying were polythene sheets to protect plots that were not sprayed from insecticide drift.

Cultural practices

The trial field was disc-harrowed and ridged. Three seeds of the cowpea varieties were planted at an intra-row spacing of 0.20 m and thinned to two plants per stand two weeks after planting (WAP). At planting, 15 kg/ha each of N, P and K in the form of NPK 15:15:15 and 50 kg/ha of P_2O_5 in the form of SSP were applied. At planting, a mixture of pendilin (500 g/l pendimethalin manufactured by Meghmani Industries Limited, India) and paraquat (1:1-dimethyl-4, 4-bipyridinum dichloride) at a rate of 1 L/ha was applied using a knapsack sprayer. This was followed by hoe-weeding just before flowering. Insecticides, karate (50 g/l lambda-cyhalothrin manufactured by Syngenta Crop protection AG, Switzerland) mixed with Nugor (40% w/v dimethoate manufactured by United Phosphorus Limited, India) at a rate of 1 L/ha was sprayed and delivered with a knapsack sprayer during each time of spraying to control insect pests.

Measurements

The two middle rows were used for data collection and sampling insects in each plot. Number of plants per net plot was determined at the onset of flowering. Ten days after the insecticide application in each spray treatment, 20 flowers were picked from each plot during the morning and were placed in vials containing 30% ethanol and brought to the lab at IITA to determine the number of flower thrips and maruca. The flowers were dissected; maruca larvae and thrips nymphs and adults were identified and counted. At pod maturity, a quadrat measuring 1×1 m^2 was used to harvest a sub-sample from a portion of the two middle rows. The pods were sun-dried and threshed to determine the number of seeds in the subsample expressed as seeds per m^2. Plants in the remaining net plots were counted and pods were harvested and sun-dried to a constant weight. Fodder from the remainder net plot were rolled up together and left on the plot to sun-dry to a constant weight. The weight of the dry fodder was added up to that of the sub-sample oven-dried leaf and stem to obtain fodder per net plot. This was calculated as fodder yield in kg ha^{-1}. Similarly, the weight of the grain in the sub-sample and the remainder in the net plot were added up to obtain grain yield per net plot. Percentage moisture content of grains was determined using Farmex MT-16 grain moisture tester. Grain yield was adjusted to 14% moisture and converted grain per hectare.

Statistical analyses

All data collected were subjected to statistical analysis of variance (ANOVA) using the PROC Mixed procedure of SAS (SAS 2011). Block was treated as a random effect, while spray regimes and cowpea varieties were treated as fixed effects in determining the expected mean square and appropriate *F*-test in the ANOVA. Variability of means is presented as standard error of the difference between means (SED) at 5% level of significance.

Results

Maruca

Year and spray regime significantly influenced maruca infestation of the cowpea plants. Varietal effect was, however, not significant. The effects of year × variety and spray × variety interactions were significant (Table 1), suggesting that varietal performance varied with year and spray. There was a significant reduction in maruca infestation with increase in the number of insecticide sprays (Table 2). However, there was no significant difference between 2 sprays and 3 sprays. The variety Vita 5, an old variety released in the late 1970s, had the lowest mean number of maruca infestation in the flowers (4.88/20 flower) count, while IT04K-321-2, a new variety released in the 2000, had the highest (7.5/20 flower) mean count for maruca. At zero spray, TVX1836-013J had the lowest number of maruca in the flowers (7.33/20 flower) than the other varieties. The number of maruca did not significantly differ between 1 and 2 sprays for this variety. There was a significant reduction of maruca infestation in VITA 5 at all spray regimes. Maruca infestation did not, however, significantly differ between 1 and 2 sprays for the variety (Table 2). At zero and 1 spray, the old varieties recorded the lowest levels of maruca population per 20 flowers than the new varieties. As the spraying regime increased from two to three, there was no consistent trend among the varieties. However, there was a significant

Table 1. *F* probability of ANOVA of selected characteristics of the response of new and old cowpea varieties to insecticide sprays in the savannas of Nigeria.

Effect	Grain yield	Fodder yield	Thrips count at 50% flowering	Maruca count at 50% flowering	No. of seed number/m^2
Year	0.2027	< 0.0001	< 0.0001	0.0001	0.0006
Spray	< 0.0001	0.0038	< 0.0001	0.0003	< 0.0001
Year × spray	0.0014	0.8307	< 0.0001	0.2675	0.0020
Variety	< 0.0001	< 0.0001	0.1349	0.0754	0.0068
Year × variety	0.0001	0.2733	0.1349	0.0031	0.0664
Spray × variety	< 0.0001	0.7307	0.0754	0.0509	0.0096
Year × spray × variety	0.0968	0.2266	0.2581	0.4090	0.3141

reduction in population levels of maruca in VITA 5 (old variety). Average across insecticide application schedules, the lowest population of maruca was recorded among the old varieties than the new varieties

Thrips

Year and spray significantly influenced thrips number per 20 flowers. Spray × year interaction was significant suggesting that the differences between spray regimes varied with year. However, there was no significant interaction between spray and variety suggesting that the variety responded similarly to different spraying regime. The population levels of thrips were generally higher in the unsprayed treatment especially among the old varieties compared with the new varieties. In relation to the unsprayed treatment, one application of insecticides significantly reduced thrips number per 20 flowers in all the varieties (Table 3). When insecticide application was increased to 2 and 3 sprays, there was no significant difference among the varieties. Average across spraying regimes, the new varieties recorded less number of thrips counts than the old varieties.

Seed number per m²

The three-way interaction effect of year × spray × variety was not significant for number of seeds per m^2. Similarly, there was no significant year × variety

Table 2. Effect of variety and insecticide sprays on maruca infestation (number\20 flowers) of old and new varieties of cowpea.

Variety	No spray	One spray	Two sprays	Three sprays	Mean
IT03K-316-1	10.67	8.50	6.00	3.67	7.21
IT04K-321-2	11.83	9.33	4.17	4.67	7.50
TVX1836-013J	7.33	5.50	6.50	7.33	6.67
VITA 5	10.33	4.33	2.83	2.00	4.88
Mean	10.04	6.92	4.88	4.42	
SED spray (S)			0.83		
SED variety (V)			0.83		
SED S × V			1.66		

Table 3. Effect of variety and insecticide sprays on number of thrips per 20 flowers of old and new varieties of cowpea.

Variety	Zero spray	One spray	Two sprays	Three sprays	Mean
IT03K-316-1	8.83	6.00	1.50	1.67	4.50
IT04K-321-2	11.33	5.00	2.50	2.33	5.29
TVX 1836-013J	19.00	7.83	1.00	1.33	7.29
VITA 5	13.83	10.50	2.00	0.33	6.67
Mean	13.25	7.33	1.75	1.42	
SED spray (S)			1.26		
SED variety (V)			1.27		
SED S × V			2.54		

interaction (Table 4). Significant interactions were observed between year and spray regime, and spray regime and variety. Year and spray significantly influenced number of seed per m^2. Seed number per m^2 increased with an increase in insecticides spray. At zero and 1 spray, the old varieties recorded the highest number of seed per m^2 than the new varieties. There was no significant difference in the number of seed per m^2 between 2 sprays and 3 sprays (Table 3). At 2 sprays, IT0K-321-2 had the highest number of seed per m^2 while at 3 sprays TVX 1836-013J recorded the highest number of seed per m^2. However, average across spraying regimes, the old varieties recorded the highest number of seed per m^2 compared with the new varieties.

Grain yield

Grain yield was significantly affected by spray and variety. The effects of spray × year and spray × variety interactions were significant suggesting that the differences between the spray regimes changed with year and variety (Table 1). Spraying with insecticides significantly increased grain yield (Table 5). Spraying once increased grain yield by 151%, twice by 373% and thrice by 489%. With zero spray, grain yield differences between old and new varieties were not consistent. The new variety IT04K-321-2 produced the least grain yield. When sprayed once at onset of flowering, the new varieties IT03K-316-1 and IT04K-321-2 produced grain yields that were significantly lower than the older varieties, TVX 1836-013J and VITA 5. When sprayed twice (once each at onset of flowering and podding stages) or thrice (once each at onset of flowering, full bloom and podding stages), yield increased for

Table 4. Effect of variety and insecticide sprays on number of seed per m^2 of old and new varieties of cowpea.

Variety	No spray	One spray	Two sprays	Three sprays	Mean
IT03K-316-1	353.0	356.2	694.6	973.2	594.3
IT04K-321-2	116.1	335.2	1216.1	1185.3	713.2
TVX1836-013J	624.0	885.2	846.7	1255.1	902.8
VITA 5	498.0	703.1	1074.0	951.2	806.6
Mean	397.8	569.9	957.83	1091.22	
SED spray (S)			88.42		
SED variety (V)			86.31		
SED S × V			176.84		

Table 5. Effect of variety and insecticide sprays on grain yield.

Variety	Zero spray	One spray	Two sprays	Three sprays	Mean
IT03K-316-1	210.2	326.5	722.9	962.2	555.5
IT04K-321-2	55.4	397.6	1408.0	1720.8	892.5
TVX 1836-013J	338.5	667.6	728.3	1036.5	692.7
VITA 5	172.8	561.2	821.1	857.3	603.1
Mean	194.2	488.2	920.1	1144.2	
SED spray (S)			52.5		
SED variety (V)			52.4		
SED S × V			104.9		

all cultivars with IT04K-321-2 producing yield that was significantly higher than the other varieties.

Fodder yield

Year, spray and variety significantly influenced fodder yield. Interactive effects among year, spray and variety were, however, not significant (Table 1). There was a decline in fodder yield with increase in the number of spraying with insecticides (Table 6). Spraying once reduced fodder yield by 16%, spraying twice reduced by 32% and spraying thrice reduced by 24%. At all spray regimes, fodder yield of the new varieties IT03K-316-1 and IT04K-321-2 were significantly higher than the older varieties. TVX 1836-013J produced the least fodder yield at all spray regimes.

Discussion

This study examined the response of old cowpea varieties developed in the late 1970s and new varieties developed in the 2000s to insecticide spray regime in Sudan savanna. This information is relevant in order to determine whether varietal development was associated with the improvement in resistance to two important insect pests of cowpea. The results showed that spraying regime had a significant effect on both old and new varieties. Maruca and thrips infestation levels varied significantly across spraying regimes. Infestation by maruca and thrips was reduced by spraying twice or thrice suggesting that to control maruca and thrips, it would require more than one spray at the onset of flowering. This corroborates findings of Kamara et al. (2007, 2010) and Alghali (1992b) who reported a significant reduction in maruca and thrips infestation with increase in spraying regimes in the West African dry savannas. Differences in years observed in this trial means that environmental effects could influence infestation of maruca and thrips in cowpea. The effect of spraying regimes in the present study was, however, dependent on the variety with a strong influence on the year of release. Old varieties had lower number of maruca than the newer ones particularly at zero or no spray. On the other hand, newer varieties had significantly lower number of thrips than the older ones. This may be due to the fact that the cowpea breeding programme at IITA laid much emphasis on screening cowpea varieties for resistance to maruca. Research programmes were directed at reducing maruca damage through breeding for resistance in order to reduce the application of insecticides which were deemed harmful to the environment (Jackai and Adalla 1997). Hence, varieties were selected

Table 6. Effect of variety and insecticide sprays on fodder yield (kg/ha).

Variety	Zero spray	One spray	Two sprays	Three sprays	Mean
IT03K-316-1	3824.54	3232.31	2428.41	3476.67	3240.48
IT04K-321-2	4715.91	4920.14	3616.70	3863.77	4279.13
TVX 1836-013J	3074.54	2457.70	1787.15	2180.11	2374.88
VITA 5	3820.67	2282.96	2577.92	2247.01	2732.14
Mean	3858.92	3223.28	2602.54	2941.89	
SED spray (S)			339.11		
SED variety (V)			338.12		
SED S × V			678.23		

without much application of insecticides. Most of the varieties developed during that period were the grain types that produced less fodder (Singh 1987). In the late 1980s, attention shifted to breeding dual-purpose cowpea for food and fodder when it was realised that one cannot have a cowpea variety that is completely resistant to maruca. The results show that although the older varieties had less maruca than newer ones, grain yield was still over 70% lower when no insecticide was applied compared with 2 or 3 sprays. Number of thrips was higher in the old varieties than the new ones suggesting that there was some improvement in the resistance of cowpea varieties to thrips as the grain yield was improved. However, the number of thrips on these new varieties was still higher when no insecticide was applied.

The two old varieties showed low levels of maruca infestation and significantly higher number of seed per m^2 at zero and 1 spray. Higher infestation by thrips and maruca usually increases flower abortion thereby reducing the number of pods per plant. Therefore, the increased number of seeds per m^2 could have resulted from reduced level of maruca infestation on the two varieties. Seed number per unit area is an important indicator of grain yield attribute of cowpea and is highly correlated with cowpea grain yield (Ajeigbe 2003). These traits showed a significant response to insecticide sprays. Significantly higher number of seed per m^2 was recorded for the old varieties (TVX 1836-013J and VITA 5) developed in the mid-1970s compared with new varieties developed in the 2000s when no insecticide was applied or when insecticide was applied only once at the onset of flowering. Even at 2 sprays, VITA 5 produced higher number of grains per m^2 than one of the new varieties, IT03K-316-1. Higher number of seeds per m^2 was, however, recorded for the new varieties when insecticides were sprayed three times confirming the superiority of the new varieties at higher number of sprays. This findings support earlier study which indicated that it is impossible to produce cowpea commercially without insecticide protection of the crop from insect pest particularly maruca pod borers, thrips and pod sucking bugs (Jackai et al. 1985). This is particularly true for the new varieties. For some of the varieties, there was no significant difference between 2 and 3 sprays, which indicates that two strategic insecticide sprays may be enough to control maruca and thrips during the crop life cycle. This supports recommendation by several researchers (Asante et al. 2001; Ajeigbe and Singh 2006; Kamara et al. 2010) who recommended two strategic insecticide sprays at flowering and podding stages for the integrated pest control in cowpea. While the old varieties performed better than the new varieties under the zero and 1 spray, the new varieties responded better to higher number of sprays suggesting that to grow the new dual-purpose varieties successfully, there is need to spray at least two times with insecticides.

To obtain higher yield potential of the new varieties, there is a need for adequate protection which was reflected in higher grain yields obtained by the new varieties at 2 and 3 insecticide sprays treatments. For example, 2 sprays had a significant yield advantage of 179% over 1 spray and 333% yield increase at 3 sprays for the new variety (IT04K-321-2). The yield advantage of new variety over old variety was 36% at 2 sprays and 51% at 3 sprays. This suggests that spraying the new varieties three times will give more yield than the old varieties. In the present study, spraying cowpea with insecticides considerably increased grain yield in most of the varieties. However, yield produced by VITA 5, after spraying three times did not differ significantly from yield produced after spraying twice. This suggests that a third spray may not be necessary for this variety. Fodder yield generally declined with increase in insecticide spray regimes for all the cowpea varieties. This is because insect damage to flowers and pods was higher at zero or 1 spray regimes which mean reduction in sink for the translocation of photosynthates to the pods. With few pods, very little photosynthates are translocated from the leaves. The older varieties produced lower fodder yield than the newer varieties. This is because the new varieties were developed for grain type and fodder (dual purpose), while the old varieties were grain type and early maturing (determinate growth habit).

For small-scale famers who have limited resources, recommending 3 sprays may be expensive because it requires additional cost to purchase chemical insecticide. Farmers with limited resources may attempt to conserve the yield potential of old varieties with resistance to insect pest that require minimum spray and produced appreciable yield. Continued genetic improvement on this trait through indirect selection for yield components like seed number per m^2 is expected to reduce the production cost, contribute to the conservation of natural resources and lessen adverse impacts from chemicals on human health, environment and water streams.

Conclusion

The study revealed that spraying insecticides on cowpea three times would result in higher yield advantage for new varieties developed in 2000s than those varieties developed in the mid-1970s. The old varieties performed better than the new varieties under the zero and 1 spray. Varieties developed in the mid-1970s had consistent levels of resistance to maruca, higher seed number per m^2 under zero and 1 spray. This is because breeding strategy in the 1970s emphasised selection for grain type and insect resistance under low insecticide protection while the new varieties were selected for grain type and higher fodder yields under maximum insecticide protection. The new varieties respond better to higher sprays and produced higher grain yield than old varieties. For those farmers who either cannot afford chemical insecticide or do not have access to spraying materials, we recommend planting old varieties that were developed in the mid-1970s. There is great potential to select these materials as parental lines that may provide an untapped source of resistance genes that can be incorporated into cowpea varieties with desirable agronomic and end-user quality traits. They can also be used for broadening and diversifying the genetic base of resistant germplasm to develop suitable cowpea varieties with resistance to maruca adaptable to different production farming systems.

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