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INFLUENCE OF SOME INERT DILUENTS OF NEEM KERNEL POWDER ON PROTECTION OF SORGHUM AGAINST PINK STALK BORER (*SESEMIA CALAMISTIS*, HOMPS) IN NIGERIAN SUDAN SAVANNA

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Abstract: Neem (*Azadirachta indica*) kernel powder (NKP) mixed 1:1 (weight basis) with some inert diluents (fine-sand, kaolin-dust, and saw-dust) were applied into the whorls of sorghum seedlings at 20, 30, 40, 50, days after sowing to provide protection against pink stalk-borer in field trials in 2002 and 2003. Carbaryl (Sevin 85) and untreated seedlings were used as check. Results showed that diluted NKP and carbaryl significantly ($p \leq 0.01$) reduced leaf puncturing, dead hearts, stalk and peduncle boring below the untreated check. Although sole NKP caused scorching of leaves (phytotoxicity), this was not observed on plants treated with diluted NKP and absent with carbaryl. Mean yield increases above the untreated check for the two seasons were: 40.0% (NKP + fine-sand), 36.4% (NKP + kaolin-dust), 35.5% (sole NKP), 35.3% (NKP + saw-dust) and 29.4 % (carbaryl). Cost-benefit analysis shows that it was financially most beneficial to use NKP + fine-sand to control *S. calamistis* on sorghum in Nigerian Sudan savanna.

Key words: inert diluents, neem kernel powder, stem-borer, *Sesemia calamistis*, cost-benefits.

INTRODUCTION

Several reports in the past three decades have shown that neem-based pesticide formulations were effective on agricultural insect pests. Some of these reports were by Jotwani and Srivastava (1984), Dreyer (1986, 1987), Heinrich (1987), Seshu-Reddy (1988), Heiberd (1990), Aldhous (1992), Kairie and Saxena (1993) and Hellpa (2000). Neem products used as pesticides are not known to be hazardous to non-target organisms (Ahmed and Grainge 1986; Anaso 1999; Ermel *et al*. 2002).

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Lepidopterous stalk borers are serious pests of cereal crops in sub-Saharan Africa. Among the several stalk borer species, pink stalk borer (*Sesemia calamistis* Homps) is the most important pest of sorghum in the Nigerian savannah (Ajayi 1998; Anaso and Thilza 2006). Grain yield loss of about 40% was reported in Nigeria (Ajayi 1997). It is possible that total crop loss may occur in farmers' fields where a piece of land is subjected to continuous cropping for several years.

Among the control measures recommended against cereal stalk borers, namely early sowing and other cultural practices, the use of resistant cultivars and application of pesticides, pesticidal treatment is the most popular treatment among Nigerian farmers. But in view of awareness of environmental and human hazard, rising cost of synthetic pesticides in the country and the desire of crop growers to use affordable and readily available alternatives, there is much interest on plant-based pesticides. Having determined the efficacy of crude neem extracts, the need for formulation becomes obvious. In this study, the use of inert diluents used in formulating neem kernel powder for the control of sorghum pink stalk borer is reported.

MATERIALS AND METHODS

Dry neem kernels (13% moisture content) were ground with wooden mortar and pestle and then pulverised with the Molinex brand blender (MX – 795N) to obtain the neem kernel powder (NKP). The NKP as well as the inert diluents, namely fine-sand (from river bank), kaolin-dust and saw-dust (from a timber market) were sieved with the Suplex Standard Test Sieves (Grade 2 500 μ).

Each diluent was first mixed with NKP (1:1 weight basis) with the hand and then homogenised with the blender. For comparison, carbaryl (Sevin 85) was used as treated check. The treatments therefore were as follows: sole NKP; NKP + fine- sand; NKP + kaolin-dust; NKP + saw-dust; carbaryl and untreated check.

The trial was established at the University of Maiduguri research farm in 2002 rainy season and repeated at the same location in 2003. The plot size was 5 x 5 m and high-yielding sorghum cultivar recommended for the Sudan savanna (KSV_4) was sown on the flat at 75 x 40 cm intra- and inter-row spacing respectively. Randomized complete block design (RCBD) was used in allocating the treatment to the plots and replicated four times. Before sowing, the seeds were dressed with metalaxyl (Apron Star 42 WS) at the recommended dose of 2.5 g a.s./ha (Syngenta 1999). This was meant to control pre- and post-emergence damping-off of seedlings and to prevent birds and ants from picking the seeds or destroying the seedlings.

At 20 days after sowing (DAS), the treatments were applied by introducing approximately 5 g of each pesticide formulation into the whorl of sorghum plants. This was repeated at 10 days intervals; four such applications were made before 50% booting of the plants. The plants were grown to maturity following the recommendations for sorghum production in the Sudan savanna of Nigeria (BOSADP 1993).

The following data were collected from each plot: % of plant showing characteristic leaf puncturing by pink stalk borer at 30, 40, 50 DAS; % of plants showing dead heart at 35 and 45 DAS; % severity of scorching of leaf lamina (phytotoxicity) at 45 DAS; % of plants showing stalk borer holes; % of peduncles bored and number of holes per peduncle at harvest time. Phytotoxicity was assessed according to Anaso (1999): 0 = no scorching; 1 = few scattered necrotic lesions; 2 = several small necrotic lesions; 3 = large necrotic lesions on lamina; 4 = severe scorching resulting in yellowing and early death of leaves. Severity of phytotoxicity was computed as follows:

$$\% \text{ severity} = \Sigma n \times 100/N \times 4$$

where: n = individual scores, N = number of scores taken, and
4 = the highest score on the scale.

At hard dough stage, the sorghum panicles were cut with harvesting knife and sun-dried for 10 days before threshing to obtain grains. All data obtained were analysed statistically and means separated using least significant difference (LSD) according to Zar (1999). The cost-benefits of the treatments were computed using the means of 2002 and 2003 production costs and grain yields.

RESULTS AND DISCUSSION

Following whorl application of the pesticides, differences in percentages of plants with leaf puncturing were not significant at 30 DAS in both years, but were highly significant ($p \leq 0.01$) at 40 and 50 DAS (Table 1). The percentage of plants with leaf puncturing in check plots was significantly higher than in treated plants. Among treated plants, there was no difference between plants treated with carbaryl and those treated with neem-based formulations. A similar observation was made on percentage of plants with dead heart except that the differences observed in 2002 at 30 DAS were not significant. Table 2 shows the percentages of plants bored and number of exit holes at harvest; in these the values of untreated check were significantly higher than the values of treated plants and the differences among treated plants were not significant.

A significant reduction in percentage of plants with leaf puncturing, stalk boring, dead heart formation, number and percentage of peduncle bored (Table 2) strongly suggests that NKP formulations were effective in reducing the symptoms of *S. calamistis* attack of sorghum. This effectiveness of neem-based formulations against pink stalk borer agrees with the results obtained from the use of unformulated products against several insect pests in India by Grainge *et al*. (1985), Grainge and Ahmed (1988), Lee *et al*. (1991), and Aldhous (1992). In Nigeria Danka (2000) also reported drastic reduction of *S. calamistis* with sole NKP. The present study shows significant reduction of symptoms of attack of *S. calamistis* in plants treated with sole NKP, NKP mixed with diluents and carbaryl below the level of untreated check.

Table 2 also shows that percentage severity of phytotoxicity was significantly ($p \leq 0.01$) higher on plants treated with sole NKP than other formulations. Phytotoxicity was not observed on plants treated with carbaryl, NKP + saw-dust and check. Although phytotoxic effects of NKP products were more severe at the site the pesticides were introduced, this undesirable effect should be borne in mind in future research work.

Due to highly significant reduction of symptoms of attack by *S. calamistis* with neem based formulations and carbaryl, there were highly significant grain yield increases above the untreated check (Table 3). In Kenya, Seshu-Reddy (1988) and Maiki (1997) reported higher grain yield and lower stalk borers (*Busseola fusca* F. and *S. calamistis*) on maize following treatment with NKP. It would therefore seem that on the basis of grain yield. Table 3 shows that NKP + fine-sand had the highest percentage yield increase above check.

Table 1. Percentage of leaf puncturing and dead heart in sorghum plants protected with neem-based formulations and carbaryl in 2002 and 2003

Year	Treatment	[%] leaf puncturing			[%] dead heart	
		30 DAS	40 DAS	50 DAS	35 DAS	45 DAS
2002	NKP+	0.84 (5.26)	1.36 (6.55)	2.19 (8.53)	0.84 (5.26)	1.51 (7.04)
	NKP + fine-sand	0.68 (4.73)	1.01 (6.02)	2.03 (8.15)	0.84 (5.26)	1.18 (6.30)
	NKP + Kaolin	0.84 (5.26)	1.18 (6.30)	2.02 (8.13)	1.01 (6.02)	1.35 (6.70)
	NKP + Saw-dust	0.83 (5023)	1.49 (6.98)	2.16 (8.40)	1.00 (5.74)	1.66 (7.35)
	Carbaryl	0.84 (5.26)	1.51 (7.04)	2.35 (8.72)	1.71 (7.49)	2.25 (8.60)
	Check	1.00 (5.74)	6.84 (15.13)	11.68 (19.98)	1.50 (7.03)	8.05 (16.50)
	Mean	5.24	8.00	10.31	6.13	8.74
	S.E.(±)	0.64	0.55	0.48	0.64	0.52
	LSD	NS	1.63**	1.44**	NS	1.52**
2003	NKP+	0.49 (4.01)	0.97 (5.65)	1.70 (7.48)	0.65 (4.62)	1.14 (5.80)
	NKP + fine-sand	0.50 (4.05)	0.50 (4.05)	1.50 (7.04)	0.65 (4.62)	1.00 (5.74)
	NKP + Kaolin	0.67 (4.69)	1.00 (5.74)	1.84 (7.78)	0.84 (5.26)	1.00 (5.74)
	NKP + Saw-dust	0.49 (4.01)	1.15 (6.15)	1.97 (8.10)	0.66 (4.66)	1.51 (7.04)
	Carbaryl	0.49 (4.01)	0.97 (5.65)	1.70 (7.53)	1.14 (6.02)	2.44 (8.91)
	Check	1.00 (5.74)	5.96 (14.18)	9.77 (18.17)	1.34 (6.35)	6.94 (15.23)
	Mean	4.41	6.90	9.35	5.31	8.08
	S.E.(±)	1.07	0.68	0.53	0.57	0.67
	LSD	NS	2.00**	1.57**	1.21*	1.96**

+ – neem kernel powder, NS – not significant, * – significant at $p \leq 0.01$ Means in parenthesis are arc-sine transformed values

Table 2. Percentage of plants and their panicles bored by *S. calamistis* at harvest, number of exit holes in stem and panicles and severity of scorching due to whorl application of neem-based pesticides and carbaryl in 2002 and 2003

Year	Treatment	[%] plants bored	No. exit holes	[%] panicles bored	No panicle exit holes	[%] severity of scorching
2002	NKP+	15.03	2.21	17.40	1.94	21.70
	NKP + fine-sand	12.70	2.13	18.37	2.18	14.70
	NKP + Kaolin	14.40	2.25	18.88	2.11	12.73
	NKP + Saw-dust	15.78	2.27	19.75	2.26	0.00
	Carbaryl	18.93	2.48	21.15	2.32	0.00
	Check	37.02	4.66	38.53	3.21	0.00
	Mean	18.97	2.66	22.34	2.33	8.18
	S.E.(±)	1.74	0.24	1.02	0.32	0.29
	LSD	5.11**	0.71**	2.99**	0.69*	0.86**
2003	NKP+	13.65	1.79	15.85	1.21	17.13
	NKP + fine-sand	12.70	1.67	16.35	1.26	10.78
	NKP + Kaolin	15.15	1.79	16.85	1.38	9.20
	NKP + Saw-dust	15.15	1.92	17.90	1.26	0.00
	Carbaryl	17.73	2.00	19.78	1.85	0.00
	Check	34.38	4.03	35.83	1.92	0.00
	Mean	18.12	2.20	20.42	1.48	6.18
	S.E.(±)	1.57	0.33	1.15	0.12	0.27
	LSD	3.04**	0.97**	3.39*	0.36**	0.79**

+ – Neem kernel powder, * – significant at $p \leq 0.05$, ** – significant at $p \leq 0.01$

Table 3. Effect of whorl application of neem-based pesticide and carbaryl used for protection against *S. calamistis* on grain yield in 2002 and 2003

Treatment	Grain yield [kg/ha]		Mean	[%] increase above check
	2002	2003		
NKP	1852	2022	1937	35.5
NKP + fine-sand	2038	2122	2080	40.00
NKP + Kaolin	1884	2056	1970	36.64
NKP + saw-dust	1850	2012	1931	35.37
Carbaryl	1712	1824	1768	29.41
Check	1200	1296	1248	–
Mean	1756	1888		
S.E.(±)	64	86		
LSD	196**	254**		

Table 4. Cost benefits of using neem pesticides and carbaryl for protection of sorghum against *S. calamistis* in 2002 and 2003

Production Activity/Income	Cost/ha (₦)[I]					
	NKP	NKP + fine-sand	NKP + kaolin	NKP + saw-dust	Carbaryl	Check
Land preparation, 15 man day (MD) at ₦100/MD	1500	1500	1500	1500	1500	1500
Planting, 10MD at ₦100/MD	1000	1000	1000	1000	1000	1000
Fertilizer, 200Kg NPK + 75Kg urea	8475	8475	8475	8475	8475	8475
Fertilizer application, 5md at ₦100/MD	1000	1000	1000	1000	1000	1000
Three weeding operations at ₦1000/weeding	3000	3000	3000	3000	3000	3000
Insecticide + application	6950	4613	6125	5850	8875	–
Sorghum seeds, 10kg at ₦/kg*	350	350	350	350	350	350
Harvesting and processing; 12MD at ₦100/MD	1200	1200	1200	1200	1200	1200
Miscellaneous expenses	400	400	400	400	400	400
Total Production cost	23875	21535	23050	22755	25800	16925
Income/Profit						
Grain yield (kg/ha)-mean of 2002 and 2003	1935	2080	1970	1931	1768	1248
Selling price (₦)	116220	124800	118200	115866	106000	74880
Profit (₦)	92345	103262	95180	93085	80200	57955
Cost-benefit ratio**	1: 3.86	1: 4.79	1: 4.12	1: 4.09	1: 3.10	1: 3.42

* – based on state subsidized cost of improved seed

** – cost-benefit ratio is based on ₦60/kg, the cost of sorghum grain in Maiduguri Metropolitan Market.

[I] 1US$ = ₦125 in 2003

Formulation of NKP into commercial pesticide in Nigeria is a new technology and potential investors would be interested in its cost and benefits. These values are almost always measured in monetary terms and this planning tool, which according to Upton (1997), is most relevant to investment made for commercial gain. Table 4 shows the cost-benefit of protecting sorghum against *S. calamistis* with NKP mixed with three diluents. Based on the production cost of sorghum, mean grain yield for the two years 2002 and 2003, and the cost of the commodity at Maiduguri Metropolitan Grain Market, it was most beneficial to control *S. calamistis* with NKP + fine sand. With the monetary profit of ₦ 103,262.00 per ha (₦ 125 = 1US $) by using NKP + fine- sand compared with profits of ₦ 95,180.00, ₦ 93, 085.00, ₦ 92,345.00, ₦ 80,200.00, and ₦ 57, 955.00 by using NKP + kaolin-dust, NKP + saw-dust, sole NKP, carbaryl and untreated check respectively, the advantage is obvious. The cost-benefit ratio which is the relationship between the production cost and monetary profit has also followed the same trend.

From this study some important conclusions may be drawn. Firstly, NKP diluted with inert materials or used sole was effective in reducing the symptoms and impact of *S. calamistis* on grain yield. In this regard NKP + fine-sand was most effective. Secondly, phytotoxicity of NKP on sorghum was highly reduced by using inert diluents or completely absent when saw-dust was used. This shortcoming may be further reduced if the ratio of fine-sand and kaolin-dust to NKP is increased. Thirdly, the results from cost-benefits analysis shows that it was clearly beneficial to dilute NKP with inert diluents and in this regard, the monetary profit of using NKP + fine-sand was too significant to ignore.

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POLISH SUMMARY

WPŁYW NIEKTÓRYCH OBOJĘTNYCH ROZCIEŃCZALNIKÓW DO SPROSZKOWANYCH NASION *AZADIRACHTA INDICA* A. JUSS NA OCHRONĘ SORGO PRZECIWKO ŚMIETCE *SESAMIA CALAMISTIS* LEDERER W NIGERYJSKIEJ SAWANNIE SUDAŃSKIEJ

W doświadczeniach polowych prowadzonych w latach 2002 i 2003 młode rośliny sorgo traktowano, po 20, 30, 40 i 50 dniach od siewu nasion, proszkiem z nasion *Azadirachta indica* zmieszanym w stosunku wagowym 1 : 1 z niektórymi obojętnymi rozcieńczalnikami (drobny piasek, pył kaolinowy, trociny) w celu ochrony roślin przed śmietką *Sesamia calamistis,* szkodnikiem drążącym łodygi. W kombinacji kontrolnej uwzględniono rośliny nietraktowane oraz rośliny traktowane karbarylem (Sevin 85). Uzyskane wyniki wykazały, że rozcieńczony proszek z nasion *A. indica* oraz karbaryl zmniejszały istotnie ($p \leq 0,001$) ilość nakłuć na liściach sorgo, zamieranie liści sercowych, oraz liczbę drążonych łodyg i szypułek, w porównaniu do kontroli. Chociaż nierozcieńczony proszek z nasion *A. indica* wywoływał poparzenie liści (fitotoksyczność), to nie obserwowano tego zjawiska stosując proszek rozcieńczony lub karbaryl. Średni wzrost plonu sorgo w latach 2002 i 2003 wynosił 40,0% w przypadku użycia jako rozcieńczalnika drobnego piasku, 36,4% przy użyciu pyłu kaolinowego, 35,3% przy użyciu trocin, 35,5% gdy stosowano nierozcieńczony proszek z nasion *A. indica* i 29,4% gdy stosowano karbaryl. Przeprowadzona analiza ekonomiczna wykazała, że najlepszą skuteczność zwalczania *S. calamistis* oraz najwyższą opłacalność zabiegów uzyskano przy użyciu drobnego piasku jako rozcieńczalnika do sproszkowanych nasion *A. indica.*