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Original Article

Evaluation of Neem Dust Formulations for the Control of *Sorghum* Stemborers in the Semi-Arid Zone of Nigeria

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ABSTRACT

Sorghum stemborer species remains key yield limiting factor for sorghum production in the Nigerian semi-arid region. When they can afford, farmers rely almost solely on synthetic insecticides for control. Owing to the misuse and environmental and health challenges attributed to the use of synthetic insecticides, a two-year field study was carried out at the University of Maiduguri Research Farm to evaluate the efficacy of various neem dust formulations for the control of *Sorghum* stemborers. The experimental design was Randomized Complete Block Design and various neem dust formulations were compared with carbaryl dust and the control (untreated). All the insecticidal treatments significantly (p<0.05) reduced stalk and peduncle damage caused by stemborers with a resultant increase in grain yield when compared with the control. Neem Kernel Powder (NKP)+Finesand proved more superior in efficacy than all the other insecticidal treatments in checking stemborer damage.

Key words: Carbaryl dust, Formulation, Integrated pest management, Neem based treatments, Neem kernel powder.

Introduction

Sorghum (*Sorghum bicolor* [L.] Moench) is the most important food crop in the savanna areas of West Africa. It's stalk is used for mulching, animal feed, roof, shade, kiosks, bedding and fence building (Adegbola *et al*., 2013; MAFAP, 2013). The most important and most widespread field insect pest of *sorghum* are the lepidopterous stemborers (Malgwi and Adamu, 2013). They constrain production of *Sorghum* wherever it is grown (Mathieu *et al.,* 2006). Report on grain losses in sorghum due to stemborer reveals that crop loss could range from 10-100% (Kfir *et al*., 2002; Ajala *et al*., 2010; Malgwi and Adamu, 2013; Okweche *et al*., 2013).

While the characteristic external symptoms of stemborer infestation include leaf injury and presence of holes on stems [Stalks and peduncles] (Mathieu *et al.,* 2006; Van den Berg, 2009), important internal symptoms of infestation is the extensive tunneling due to their feeding activities. Farmers largely rely on synthetic insecticides which are in most cases expensive especially for the resource poor farmers. Aside economic factors, chemical control has been reported to have some health and environmental drawbacks in addition to pesticide resistance and pest resurgence (Oswald, 2005). Owing to the nocturnal habits of the adult stemborer species and cryptic lifestyle of the larvae, control is generally challenging. Whorl application of Carbaryl 85WP, granular Endosulfan 5G and granular Trichlorphon 5G have been recommended for their management (Malgwi and Adamu, 2013). However, due to their persistence and high health and environmental risks, some of these synthetic insecticides are now banned.

Of the several plant species screened as sources of biopesticides, neem (*Azadirachta indica* A. Juss) is perhaps the most promising because it possesses nearly all the characteristics of an ideal biopesticidal agent as listed by (Ahmed and Grainge 1986). Since good results against lepidopterous stemborers have been obtained by applying neem products into the whorls of cereals (Seshu Reddy, 1988; Wahedi *et al*., 2016), an attempt was made in these trials to protect *sorghum* from stemborers using various neem dust formulations.

Materials and methods

A two-year field experiment was conducted at the University of Maiduguri Teaching and Research Farm. Seeds of *sorghum* (var. KSV_4) used for the trials were obtained from Borno State Agricultural Development Programme (BOSADP).

Land preparation and management

The land was ploughed and harrowed after which a 121×21 m area was demarcated into four blocks (replicates). The blocks were separated by 1 m alleys which served as a passage between the blocks. Each block had 6 plots each measuring, 10×10 m (100 m^2) and the plots were separated by 30 cm bounds.

Following land preparation, 200 $kgha^{-1}$ of compound fertilizer, NKP (15:15:15) was applied by broadcasting at the time of sowing and 75 $kgha^{-1}$ of Urea was applied by side placement at 6 weeks after sowing. The crop was left to natural infestation of pest. Meanwhile, in order to ensure good stemborers (pest) population build-up, the crop was sown a few weeks after rain establishment. Seedlings were thinned to 2 plants per stand after 2 weeks of emergence. Seeds were sown at 75×40cm inter- and intra-row spacing, respectively.

Experimental design and treatments

The experimental design used was the Randomised Complete Block Design (RCBD). The treatments evaluated were;

Equal parts by weight (50/50, w/w) of:

Neem Kernel Powder (NKP) + Fine sand,

NKP + Kaolin dust,

NKP + Sawdust,

Carbaryl dust (a recommended synthetic insecticides for stemborers) and,

Control (untreated).

Preparation of treatments

Ripe fruits from neem trees (*A. indica*) in Maiduguri, Borno State of Nigeria were collected, washed and air-dried under shade. The fruits were cracked to obtain the kernel which were further air dried. The NKP was prepared by pulverizing the neem kernel with the aid of a Molinex brand electric blender (MX–795N). The powder obtained was further passed through a Suplex Standard Test Sieve (500 µm) to improve the smoothness of the particles. Kaolin dust was equally prepared by grinding pellets of kaolin in an electric grinder and further sieving the material through the sieve to make it fine. Finesand (from riverbank) was prepared by sieving sand particles through the sieve while sawdust (derived from Iroko wood) was obtained from Maiduguri wood market. The various mixtures (treatments) were formulated by thoroughly mixing equal parts by weight of NKP and the respective diluents in a wide container. The individual mixture was further homogenized in the electric blender.

Application of treatments

At 20 days after sowing (DAS), the treatments were applied (between 6:30 am and 7:30 am) by introducing approximately 5 g of each pesticide formulation into the whorl of sorghum plants. This was repeated at 10 days intervals until 50% booting was achieved.

Data collection and analysis

The data were collected from the 4 middle rows which covers a net plot size of 10×5.25 m (52.5 m^2/plot). The data collected were proportion of stalks and peduncle tunneled their tunneling length and grain yield (kg/plot). The collected were subjected to one way variance analysis after appropriate arc-sine transformation and significant differences among treatment means were based on estimates of least significant differences (LSD) at 5% level of probability.

Results

Table 1 reveals that the insecticide treatments significantly ($p<0.01$) suppressed stalk damage caused by stemborers as the proportion of stalk tunneled were significantly ($p<0.01$) higher in the control plots. Mean separation indicates that the proportion of stalks tunneled in plots treated with the neem based treatments were comparable and each significantly ($p<0.001$) more effective than carbaryl dust. Similarly, tunnel length was significantly higher in the untreated plants. NKP+Fine sand however proved to be the most effective treatment for checking stalk tunneling. Table 1 also shows that percentage of peduncles tunneled were significantly ($p<0.01$) higher in the untreated plants. Mean separation also revealed that, the neem based treatments were significantly ($p<0.01$) more effective than carbaryl dust in this respect. Peducle tunnel length was also significantly ($p<0.01$) lower in treated with NKP+Fine sand being the most suppressive of the damage. Results for stalk and peduncle tunneling in year 2 presented in Table 2 also follow a somewhat similar trend with that of year 1. Table 3 shows that the insecticide treatments resulted in significantly ($p<0.01$) higher grain yield than the control. However, aside NKP+Fine sand, which was significantly the most effective, the other neem based treatments were statistically comparable with carbaryl dust across the years.

Table 1. Effect of treatments on stalk damage caused by stemborers, year 1

Treatment	Stalks tunneled at harvest (%)[1]	Stalk tunneling length (%)[1]	Peduncles tunneled at harvest (%)[1]	Peduncle tunneling length (%)[1]
Control	34.38 (35.93)	21.21 (27.40)	37.00 (37.50)	33.81 (35.63)
Carbaryl dust	9.37 (17.73)	10.12 (18.50)	13.50 (21.55)	12.04 (20.33)
NKP	6.25 (14.40)	7.98 (16.37)	8.00 (16.35)	9.68 (18.15)
NKP + Fine sand	4.38 (11.95)	4.71 (12.50)	9.00 (17.40)	11.07 (19.43)
NKP + Kaolin dust	5.61 (13.65)	6.09 (14.17)	9.50 (17.88)	10.79 (19.18)
NKP + Sawdust	6.25 (14.40)	7.92 (16.35)	10.00 (18.38)	11.43 (19.75)
Mean	18.01	17.55	21.51	22.08
SED	1.32	1.31	1.04	0.65
LSD	2.81 **	2.79 **	2.21 **	1.39 **

[1]Mean of 4 replications; Figures in parentheses are arc-sine values to which mean, SED and LSD are applicable; ** Significant at 1% level of probability ($p<0.01$)

Table 2. Effect of treatments on stalk damage caused by stemborers, year 2

Treatment	Stalks tunneled at harvest (%)[1]	Stalk tunneling length (%)[1]	Peduncles tunneled at harvest (%)[1]	Peduncle tunneling length (%)[1]
Control	30.63 (33.60)	18.53 (25.00)	33.50 (35.40)	24.93 (29.95)
Carbaryl dust	10.63 (18.93)	9.01 (17.53)	10.00 (18.38)	11.99 (20.23)
NKP	5.00 (12.70)	7.41 (15.78)	7.00 (15.30)	9.28 (17.75)
NKP + Fine sand	5.00 (12.70)	4.39 (12.10)	7.00 (15.30)	9.63 (18.07)
NKP + Kaolin dust	5.00 (12.70)	7.78 (13.85)	8.00 (16.35)	10.25 (18.70)
NKP + Sawdust	6.25 (14.40)	7.28 (15.63)	9.00 (17.40)	10.27 (18.70)
Mean	17.54	16.73	19.66	20.56
SED	1.53	0.77	1.33	0.65
LSD	3.26 **	1.64 **	2.84 **	1.40 **

[1]Mean of 4 replications; Figures in parentheses are arc-sine values to which mean, SED and LSD are applicable; ** Significant at 1% level of probability ($p<0.01$)

Table 3. Effect of treatments on grain yield

Treatment	Grain yield (kg/plot)		Grain yield over control (%)	
	Year 1	Year 2	Year 1	Year 2
Control	3.15	3.40	-	-
Carbaryl dust	4.50	4.79	42.86	40.88
NKP	4.86	5.31	54.29	56.18
NKP + Fine sand	5.35	5.57	69.84	63.82
NKP + Kaolin dust	4.95	5.40	57.14	58.82
NKP + Sawdust	4.86	5.28	54.29	55.29
Mean	4.61	4.96		
SED	0.17	0.23		
LSD	0.49	0.67		
	**	**		

[1]Mean of 4 replications; Figures in parentheses are arc-sine values to which mean, SED and LSD are applicable; ** Significant at 1% level of probability ($p<0.01$).

Discussion

The significant suppression of stalk and peduncle tunneling by the neem based treatments suggests that neem has antifeedant and repellent characters as reported by (Aldhous 1992; Satti *et al.*, 2013; Okrikata *et al*., 2016). The comparable and sometimes superior efficacy of the neem based treatments when compared with carbaryl dust in checking stemborer damage agrees with the findings of (Adane and Asmare, 2006), who reported that, neem powder provided better control than carbaryl when used to control stemborers on sorghum.

The comparatively better efficacy of NKP+Fine sand could likely be due to the hardness and density of the fine sand component. These factors have been reported to be important in the choice of carriers used in formulating dry pesticides (Hassall, 1990). The comparatively higher hardness of fine sand vis-à-vis those of the other carriers used might have enhanced its (NKP+Fine sand) efficacy by making it (the formulation) more abrasive to the stemborer larvae leading to dehydration and death. The higher density of fine sand relative to the other carriers used will complement the effect of rain which helps to push the NKP from the tunnel where it was placed down the stalk to where the stemborer penetrated the plant, hence having it effect on the stemborer at that point. This phenomenon is very important against stemborer species that do not directly bore into the stalk through the funnel but, leave the funnel to the stembase and bore in through the stembase into the stalk to cause deadheart or tunneling as characterized by *Sesamia* spp.

Peduncle damage occurs during the advanced stage of the crop. Since application of treatments into the funnel of sorghum stops at the booting stage, it is obvious that the ability of the neem based treatments to suppress peduncle damage could be due to some level of persistence and systemic action (van den Berg and van Rensburg, 1991; Okrikata and Anaso, 2008).

(Adane and Asmare, 2006; Chunshan et al., 2011) reported the very high efficacy of neem products in controlling stemborer infestations. Their findings also reveal that, neem products check stemborer menace to the same magnitude, and sometimes more than synthetic insecticides. A related information has been reported by (Anaso, 1999), who reported the efficacy of different dosages of aqueous neem seed extract than carbaryl in checking leaf feeding damage by flea beetles on okro.

All the insecticide treatments gave higher grain yield than the control with NKP+Fine sand being the most effective. This observation is not unconnected with the efficacy of the neem based treatments in checking stalk and peduncle damage as discussed above and also buttressed the finding of (Asawalam 2007; Ogah *et al.,* 2011; Wahedi *et al.*, 2016) who reported the grain yield of neem treated plots being comparable to that obtained with furadan (a systemic insecticide against stemborers) and 1.5 times higher than control.

Conclusion

Stemborers were prevalent and significantly reduce yield of *sorghum* in the semi-arid zone of Nigeria and the neem dust formulations were more effective than carbaryl dust in protecting the crop. NKP+Fine sand was generally more effective than the other neem based treatments and the ability of the neem based treatments to check peduncle damage suggests some sort of persistence and systemic action. That the neem based formulations and particularly, NKP+Fine sand were more effective than carbaryl in suppressing borers damage with a resultant increase in yield, coupled with ease of preparation, use, safety in handling and environmental friendliness of the neem dust formulations, indicates that the neem based treatments could be useful components of the integrated pest management strategy for *sorghum* stemborers.

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