EFFECT OF SPRAYING FREQUENCY OF DIFFERENT CONCENTRATIONS OF SPOTLIGHT ON STEM BORER INFESTATION AND GRAIN YIELD OF PEARL MILLET (*PENNISETUM GLAUCUM* (L.) R. BR.)

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SUMMARY

Field experiments were conducted at the Leventis Foundation /Gombe State Agricultural Training School, Tumu, Gombe State of Nigeria during 2013 and 2014 cropping seasons. Five concentrations (0.0 l/ha, 0.5 l/ha, 1.0 l/ha, 1.5 l/ha and 2.0L/ ha) of spotlight were applied at three different frequencies (1, 2 and 3) on a plot size of 3.0 m x 4.0 m replicated three times. Spotlight application frequency was allocated to main plots and concentrations were allocated to subplots. Insecticide application commenced at 4 weeks after germination till harvest period. The plot size was 3.0 m by 4.0 m (12m^2) with 1.0 m space between plots and 2.0 m as alley to allow for field operations. The results obtained shows that pearl millet (SOSAT C-88) plants infestation by stem borer was significantly reduced during the study period. Spotlight sprayed three times at 1.5 l/ha had proved to be effective and appropriate for reducing stem borer feeding on pearl millet growing points (leaf sheathes), stems, peduncles and found to improve the number of grains/panicle, panicle and grain weights. It is recommended that spotlight should be applied three times at 1.5 l/ha for stem borer protection on pearl millet.

Keywords: pearl millet, spraying frequency, spotlight, stem borer, infestation, concentrations

PEARL MILLET (*Pennisetum glaucum* (L.) R. Br.) is the most widely cultivated of all millet species and the most important millet species which account for half of the global millet production in terms of cropped area and contributes to food security in regions of Africa and Asia (11; 2). In West Africa sub region, pearl millet constitutes more than 25% of

the millet produced and it is one of the most important food grains (10; 13). It is grown as a subsistence crop in Nigeria and most it is used for human consumption (5). Apart from being a source of reliable and important food, millet stalks provide building and fencing materials for farmers (13). Millet fodder and Stover are also used as livestock feed in the growing areas (18; 11).

Among the insect pests attacking pearl millet in Africa, the lepidopteran stem borer (*Coniesta ignefusalis*) is by far the most dominant and most injurious stem borer (19; 8; 16). Feeding and tunneling by stem borer larvae on plants results in crop losses as a result of destruction of the growing points, early leaf senescence, interference with translocation of metabolites and nutrients that result in malformation of the grain, stem breakage, plant stunting, lodging and direct damage to millet heads (1; 8; 9; 11).

Yield reduction due to stem borers occur as a result of leaf feeding, stem tunneling, direct damage to millet grain (14). Depending on the season and nutritional status of the plant, crop yield reduction by stem borers feeding and tunneling activities in Africa can fall between 10-100% (12). In the Sudano - sahelian zone, where pearl millet is the most important cereal crop, *C. ignefusalis* is known to cause more damage and cause serious yield reduction (19; 16; 5). Yield loss in pearl millet depends on the time of stem borer infestation, nutritional status and season (6 and 1). Millet can be protected from stem borer infestation, damage and obtain high grain yield when the right control measure is taken between 15 and 30 days after emergence (1; 11). In view of the destructive activities of stem borer, the control of stem borer becomes important in order to have a sustainable high millet yield. Most crop farmers use synthetic insecticide for controlling field and stored pests. Synthetic insecticides are the most effective means of controlling insect pests of millet stem borers due to their fast knock down action and long-lasting effects (3; 15). However, most of the farmers either overuse or underuse the chemicals thereby, causing adverse effects on human beings, environment, animals and beneficial organisms. Moreover, resource - poor farmers do not achieve the desired insect pest control goals owing to their low financial status (5; 9; 11). Therefore, this study was conducted to determine the application frequency of different concentrations of spotlight required

for reasonable control of stem borer of pearl millet.

MATERIALS AND METHODS

Experimental Site

Field experiments were conducted at the Leventis Foundation/Gombe State Agricultural Training School, Tumu, Gombe State of Nigeria during 2013 and 2014 cropping seasons. The site is located in the Sudan Savannah ecological zone of Nigeria with an annual rainfall of between 860 - 1100 mm and a temperature range of 20 - 38 ^{0}C per annum. The rainy season usually last 120 -151 days.

Source of Experimental Materials

The millet variety used for the study was SOSAT C - 88 which is grown by most farmers in the study area and was purchased from Lake Chad Research Institute (LCRI), Maiduguri, while the insecticide, Spotlight (chlorpyrifos 25% EC + dimethoate 25% EC) was purchased from Jubaili Agrotech Nigeria Limited marketing shop in Gombe town.

Experimental Design and Field Layout

The trial consisted of five concentrations (0.0, 0.5, 1.0, 1.5, 2.0 L/ha) and three spraying frequencies (1 spray at seedling stage; 2 sprays at seedling and vegetative stages and 3 sprays at seedling, vegetative and booting stages) laid out in a split plot design replicated three times. Spotlight application frequency was allocated to main plots and concentrations were allocated to the subplots. Insecticide application commenced from 4 weeks after germination to harvest. The plot size was 3.0 by 4.0 m^2 with 1.0 m space between plots and 2.0 m as alley to allow for field operations.

Agronomic Practices

The experimental field was cleared of debris, harrowed, leveled manually by using hand-held hoe in order to pulverize and level the land to fine tilt. Ridges were prepared manually and spaced 75 cm. Three pearl millet seeds were sown at an intra-row spacing of 15 cm and 2.5 cm deep on 6th June, 2014 and 22nd June 2015 when the rains were established. The seedlings were thinned to 2 seedlings per stand at 3 weeks after germination (WAG). Weeding was done manually using hand-held hoe whenever weeds when necessary. A compound fertilizer, N.P.K. (15:15:15) was applied using spot application at 3 WAG.

Data Collection

The following data were collected and analyzed:

i) Number of pearl millet with perforated leaf sheathes: Ten millet plants were randomly selected, tagged and observed from each plot for the sign of leaf sheath holes (perforations) caused by stem borer larvae feeding damage during vegetative stage, and were counted and recorded.

ii) Number of pearl millet with "dead hearts": Ten randomly selected pearl millet plants from each plot with sign of dead growing points caused by stem borer larvae feeding damage were counted and recorded.

iii) Number of pearl millet stem with holes: This was obtained by taking ten pearl millet stems at random from each plot. The infested stems were peeled and those showing sign of boring holes/tunneling were counted and recorded.

iv) The abundance of stem borers: It was obtained by randomly selecting ten pearl millet stems with holes from each plot and dissected to count and record the stem borer larvae/ pupae inside the nodes, internodes and peduncles.

v) Panicle weight: Pearl millet panicles (heads) from each plot were harvested, sun dried and put in well-labeled bags and weighed using Jenway top loading balance (2000 model) scale.

vi) Number of grains per panicle: Ten randomly selected pearl millet panicles (heads) from each plot were threshed, winnowed and the grains were counted and recorded.

vii) Grain weight: The grains obtained from panicles (heads) in each plot were weighed using Jenway top loading balance (2000 model).

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using a statistical package (17) version and where there were significant differences among the treatments, the means were separated at 5 % level of significance using Duncan New Multiple Range Test (DNMRT).

RESULTS

Number of pearl millet with perforated leaf sheathes

Results presented in Table 1 showed that plots treated with spotlight at 1.5 L/ha had significantly lower (0.86) pearl millet leaf sheathes with holes followed by 2.0 L/ha while untreated

plots had the highest (1.24) leaf sheathes with holes. Results further indicated that plots sprayed three times had lower (0.57) leaf sheathes with holes than plots sprayed only once (2.46).

Table 1 also showed that spotlight application at 1.5 L/ha had the least (0.18) number of pearl millet plants with "dead hearts" dead growing points) while control (0.0L/ha) plots had the highest (2.11) dead hearts. The plots that were sprayed only once had the highest (2.14) plants with dead hearts followed by two applications (1.67) while three insecticide applications had the lowest (0.44) plants with dead hearts.

Table 1: Number of pearl millet with leaf sheath holes and dead hearts

Treatment	No. of plants with leaf sheath holes	No. of plants with dead hearts
Spotlight Concentrations L/ha (SC)		
0.0	2.41[a]	2.11[a]
0.5	2.13[a]	1.86[a]
1.0	1.54[ab]	1.33[ab]
1.5	0.86[b]	0.18[b]
2.0	1.24[ab]	1.14[ab]
SE±	0.43	0.46
Spraying Frequency (SF)		
1	2.46[a]	2.14[a]
2	1.61[ab]	1.67[ab]
3	0.57[b]	0.44[b]
SE±	0.61	0.58
Interaction (SC x SF)	NS	NS

Number of pearl millet stem with stems and peduncle holes

Table 2 showed that there were significant differences among the

treatments. Pearl millet plants treated with spotlight at 1.5 L/ha had the least (0.91) number of plants with stem holes while untreated plots had the highest (1.79) number of plants with stem holes. When the spraying frequency was compared, three insecticide sprays had the least (1.12) number of plants with stem holes followed by two sprays (1.51) while one spray had the highest (2.18) stems with stem holes. The results also showed that there were higher (1.46) number of millet peduncles with holes in control plots while plots treated with spotlight at 1.5L/ha had the least (0.48) peduncles with holes. Plots sprayed three times with the insecticide had the least (0.33) peduncles with holes while plots sprayed only once had the highest (1.75) peduncles with holes.

Table 2: Number of pearl millet with stem and peduncle borer holes

Treatment	No. of plants with leaf sheath holes	No. of plants with dead hearts
Spotlight Concentrations L/ha. (SC)		
0.0	1.79^{a}	1.46^{a}
0.5	1.54^{a}	1.34^{a}
1.0	1.23^{ab}	0.87^{ab}
1.5	0.91^{b}	0.46^{b}
2.0	1.08^{b}	0.63^{b}
SE±	0.12	0.09
Spraying Frequency (SF)		
1	2.18^{a}	1.75^{a}
2	1.51^{a}	0.87^{ab}
3	1.12^{b}	0.33^{b}
SE±	0.62	0.06
Interaction (SC x SF)	NS	NS

Effects of insecticide concentrations and frequency on the abundance of pearl millet stem borers

Results in table 3 showed that spotlight concentrations and spraying frequency reduced the abundance of stem borer on millet plants. Spotlight applied at 1.5 L/ha reduced the number of stem borer larvae feeding in the nodes, internodes and peduncle. Spotlight insecticide applied at 1.5 L/ha had the least (0.12, 1.44 and 0.28) number of larvae/pupae in the nodes, internodes and peduncle respectively. Untreated plots of pearl millet had the highest (0.6, 2.21 and 0.88) number of larvae/pupae in the nodes, internodes and peduncle in that order.

Spraying frequency also showed that the application of the insecticide three times produced the lowest (0.11, 0.31 and 0.08) larvae/pupae in the nodes, internodes and peduncle while one application produced the highest (0.72, 2.11 and 0.67) larvae/pupae in the nodes, internodes and peduncle. The result further indicated that the pearl millet stem borer preferred to attack and feed in the internodes more than the nodes and peduncles.

Table 3: Effect of spotlight concentrations and spraying frequency on the abundance of millet stem borers

	Number of larvae/pupae per plant		
Treatment	Node	Internode	Peduncle
Spotlight Concentrations L/ha. (SC)			
0.0	0.61^{a}	2.21^{a}	0.88^{a}
0.5	0.57^{a}	2.03^{a}	0.62^{a}
1.0	0.33^{ab}	1.67^{a}	0.40^{ab}
1.5	0.12^{b}	1.44^{ab}	0.28^{a}
2.0	0.28^{b}	1.59^{ab}	0.36^{b}
SE±	0.49	0.79	0.59
Spraying Frequency (SF)			

1	0.72[a]	2.11[a]	0.67[a]
2	0.41[ab]	0.53[ab]	0.41[ab]
3	0.11[b]	0.31[b]	0.08[b]
SE±	0.61	1.80	0.60
Interaction (SC x SF)	NS	*	NS

NS =Not significant. * = Significant

Effects of spotlight concentrations and spraying frequency on panicle number, panicle and grain weight

Panicle number, panicle and grain weights were lowest (196.90, 611.70 kg and 514.13 kg) in untreated plots and highest (2298.41, 1236.31 kg and 1016.51 kg) as presented in Table 4. The results on spraying frequency indicate that plots sprayed three times produced more panicles (2318.33), panicle weight (1241.11 kg) and grain weight (1108.21 kg) than plots sprayed two times (2014.92, 714.33 kg and 608.13 kg) and one application with only 1899.64 number of panicles, 608.45 kg of panicle weight and 510.25 kg of grain weight. In all the interaction analysis, there were no significant differences between the insecticide concentrations and spraying frequency.

Table 4: Effect of spotlight concentration and spraying frequency on Number of panicle grains, panicle and grain weight

Treatment	Number of grains/panicle	Panicle weight (Kg)	Grain weight (g)
Spotlight Concentrations L/ha. (SC)			
0.0	196.90[c]	611.70[c]	514.13[a]
0.5	1037.16[b]	669.41[a]	561.33[b]
1.0	2089.72[ab]	1022.49[ab]	862.12[ab]
1.5	2298.41[a]	1236.31[a]	1016.51[a]
2.0	1997.12[ab]	1016.33[ab]	891.67[ab]
	2101.51	624.61	502.40

SE±			
Spraying Frequency (SF)			
1	1899.64[c]	608.45[c]	510.25[c]
2	2014.92[b]	714.33[b]	608.13[b]
3	2318'33[a]	1241.11[a]	1108.21[a]
SE±	418.70	632'66	597.96
Interaction (SC x SF)	NS	*	NS

NS=Not significant. * = Significant

DISCUSSION

Among the spotlight concentrations used during the study, 1.5 L/ha was found to be effective in reducing the number of pearl millet plants with perforated leaf sheathes, dead hearts, stem and peduncle tunneling, the number of stem borer larvae/pupae per plant and had improved the number of pearl millet grains/panicle, panicle and grain weights. This indicates that spotlight insecticide applied at 1.5L/ha was the appropriate and effective concentration for the control of pearl millet stem borer. Plots treated with spotlight at 0.5L/ha and 1.0L/ha were found not to be effective and appropriate in controlling pearl millet stem borer infestation and damage during the study period. This implies that only when spotlight is applied at the appropriate and effective concentration that will give the required control of pearl millet stem borer while application of wrong concentration will not be effective against the pest and may cause pest resistance and probably resurgence (7, 1, 16) reported that for adequate control of cereal stem borers, the appropriate chemical and concentration should be applied using the appropriate equipment. For optimum grain production in cereal growing areas, the appropriate concentration and spray regime must be adapted (12; 4). Feeding and tunneling by stem borer larvae on plants results in crop losses as a result of destruction of the growing points, early leaf senescence, interference with translocation of metabolites and nutrients that result in malformation of the grain, stem breakage, plant stunting, lodging and direct damage to millet heads (1, 8, 9, 11).Yield reduction due to stem borers occur as a result of leaf feeding, stem tunneling, direct damage to millet grain (14).

Spraying frequency also was found to have significant differences. Crops sprayed three times with the correct concentration of spotlight was found to be very effective in reducing the number of millet plants with holes, dead hearts, stem and peduncle holes, number of larvae/pupae /plants, higher panicle and grain weights during the study period. Millet plants sprayed two times and once were found not to be effective in reducing the stem borer infestation and damage. This implies that for effective millet stem borer control, three chemical sprays are recommended for maximum pearl millet production (13, 10). The more frequent the spray of this systemic, contact, stomach poison and repellant organophosphate insecticide, the more effective it is in controlling the pest because they will not allow the pest in their feeding areas to be comfortable and enjoy feeding in the plants (1, 19).

It has been reported that pearl millet growth and yield reduction result due to stem borer feeding on the growing point, early leaf senescence, interference with translocation of metabolites, malformation of the grain, stem breakage, plant stunting and lodging. Maximum pearl millet growth and yield will be obtained when millet is protected with the right insecticide sprayed at the appropriate concentration and frequency (7, 6, 10). This is because growth and yield loss in pearl millet depends on the time and duration of the infestation which needs to be targeted correctly (1).

CONCLUSION

Pearl millet protection was better when sprayed three times with spotlight insecticide at 1.5L/ha. This concentration and spraying frequency had proved to be more effective and appropriate for reducing stem borer feeding in the plants growing points (leaf sheath), stems, peduncles, interfering with nutrient and metabolites translocation, panicle and grain yield. The appropriate concentration of the insecticide sprayed at the appropriate frequency to target the stem borer time and duration of infestation is very important in obtaining maximum pearl millet growth and yield in the study area.

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