African Journal of Agronomy Vol. 2 (4), pp. 156-158, April, 2014. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Effects of fertilizer on nitrogen substance of berries of three coffee clones and berry domination by the coffee berry borer, *Hypothenemus hampei* (Ferr.) (Coleoptera:Scolytidae)

Sammie Van, Melfah Nanaba and Tadias Kwame

Department of Crop and Soil Sciences, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ashanti Region, Ghana.

Accepted 24 March, 2014

The influence of six levels of fertilizer on the nitrogen content of coffee berries and the resulting incidence of *Hypothenemus hampei* was investigated on three improved clones of Robusta coffee at the Afosu Sub-station of the Cocoa Research Institute of Ghana. The treatments were unfertilized control, basal dressing of 100 kg P_2O_5 ha^{-1} mixed with 100 kg K_2O ha^{-1}, basal dressing of 100 kg P_2O_5 ha^{-1} with 100 kg K_2O ha^{-1} and 50 kg N ha^{-1}, basal dressing of 100 kg P_2O_5 ha^{-1} with 100 kg K_2O ha^{-1} and 70 kg N ha^{-1}, basal dressing of 100 kg P_2O_5 ha^{-1} with 100 kg K_2O ha^{-1} and 90 kg N ha^{-1}, as well as basal dressing of 100 kg P_2O_5 ha^{-1} with 100 kg K_2O ha^{-1} and 150 kg N ha^{-1}. The coffee clones were E152, E139 and E138. No differences were found in the nitrogen contents of berries of the various clones. Application of higher rates of fertilizer to the soil increased the nitrogen content and *H. hampei* numbers in the berries. The correlation coefficients between fertilizer dose and *H. hampei* numbers were significant. The relation between nitrogen in the berries and *H. hampei* numbers was also significant.

Key words: Fertilizer, coffee clones, nitrogen levels, infestation, *Hypothenemus hampei*.

INTRODUCTION

The coffee berry borer, *Hypothenemus hampei* (Ferr.) (Co--leoptera: Scotylidae) causes serious berry losses in almost all the coffee producing areas of the world (Le Pelley, 1968). The larvae feed exclusively on the beans, making them unfit for human consumption and thereby causing economic losses (Hargreaves, 1926). In 1982, most farmers in Mexico resolved not to harvest their crops since it was economically not feasible, due to heavy infestation and bean damage by the borer (Baker, 1984). In Jamaica, an assessment of coffee bean losses during processing and marketing revealed that 20.9% of the beans were lost to *H. hampei* (Reid and Mansingh, 1985).

Fertilizer application to enrich soil increases not only the nitrogen content of crops but also plant consumption by insects (Tingey and Singh, 1980). Soil fertility can also change plant nutritional quality such as nitrogen and water content. Since, nitrogen contents of phytophagous insects are several times higher than those of plants, and because food is the only source of water and nitrogen for most insects, feeding on plants with good accumulation of nitrogen and water is obligatory for herbivorous insects (Scriber, 1977).

Slansky and Scriber (1985) analyzed the results of several hundreds of experiments on 25 insect species and found that the rates and efficiencies of host plants utilization in penultimate and final larval instars declined with decreases in plant nitrogen. Similarly, the feeding rate of *Papilio glaucus* larva increased with increasing nitrogen content of the leaf (Scriber and Feeny, 1979) and applying nitrogen to the soil has been reported to increase wheat panicle, leaf damage by thrips (Manolache et al., 1976) and stalk borer incidence in rice (Martins et al., 1980). On the other hand, a highly significant negative correlation between nitrogen contents of plants and high feeding rate was observed for some insect spe-

*Corresponding author. E-mail: Vansam@gmail.com

Table 1. Influence of fertilizer rates on nitrogen levels in berries of different coffee clones.

Rates of fertilizer application	Nitrogen levels in berries (Kg ha^{-1})			Mean	LSD(P=0.05)
	E152	E139	E138		
150 kgN ha^{-1} and basal dressing of 100 kg P_2O_5/ha and 100 kg K_2O ha^{-1} (T_6)	17.30	15.75	15.75	16.3b	
90 kgN ha^{-1} and basal dressing of 100 kg P_2O_5/ha and 100 kg K_2O ha^{-1} (T_5)	16.08	18.97	17.73	17.6a	
70 kgN ha^{-1} and basal dressing of 100 kg P_2O_5/ha and 100 kg K_2O ha^{-1} (T_4)	17.91	19.09	18.73	18.5a	
50 kgN ha^{-1} and basal dressing of 100 kg P_2O_5/ha and 100 kg K_2O ha^{-1} (T_3)	15.50	14.95	16.42	15.4b	0.94
Basal dressing of 100 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} (T_2)	14.91	14.20	13.35	14.4c	
Unfertilized control (T_1)	9.88	10.21	9.09	9.7d	
Mean	15.2^{ns}	15.4^{ns}	15.1^{ns}		

Values in a column followed by different letters are significantly different.

cies (Chand et al., 1979; Verma et al., 1981). Therefore, the existing knowledge on the relationship between host plant nitrogen and food utilization in herbivorous insects is not conclusive. Moreover, the effect of fertilizer on the incidence of *H. hampei* has not been reported in Ghana.

The present study therefore examines the influence of different fertilizer rates in three coffee varieties on the incidence of *H. hampei*.

MATERIALS AND METHODS

The study, which was conducted from 1999 to 2001, was superimposed on an on-going coffee clonal trial started in 1991 at a sub-station of the Cocoa Research Institute of Ghana (CRIG) at Afosu (longitude 1^{o} NE, latitude $6^{o}20'$ N) in Eastern Region of Ghana. Three improved Robusta coffee clones, E152, E139 and E138, developed by CRIG, were planted in 1991. The first application of fertilizer was done in March 1998 and repeated annually for four years. Prior to the fertilizer application, the following parameters were measured; soil texture, percent organic carbon, percent nitrogen, available phosphorus (P) and potash (K).

The soil was sandy loam with pH of 4.5, 1.75% organic carbon, 0.30% nitrogen, 11.5 kg ha^{-1} available P_2O_5 and 93 kg ha^{-1} K_2O. The experimental design was a split plot. It was replicated three times, the main plot treatments being the coffee clones E152, E139 and E138. The following six fertilizer levels served as the sub-treatments; an unfertilized control (T_1), basal dressing of 100 kg P_2O_5 ha^{-1} mixed with 100 kg K_2O ha^{-1} only (T_2), basal dressing of 100 kg P_2O_5 ha^{-1} mixed with 100 kg K_2O/ha and 50 kg N/ha (T_3), basal dressing of 100 kg P_2O_5/ha mixed with 100 kg K_2O ha^{-1} and 70 kg N ha^{-1} (T_4), basal dressing of 100 kg P_2O_5 ha^{-1} mixed with 100 kg K_2O ha^{-1} and 90 kgN ha^{-1} (T_5), and basal dressing of 100 kg P_2O_5 ha^{-1} 100 kg ha^{-1} K_2O ha^{-1} and 150 kgN ha^{-1} (T_6). The nitrogen was applied in the form of Ammonium Sulphate ($(NH_4)_2SO_4$). The control of insects was achieved by bi-monthly spraying of 120 ml ha^{-1} of 2.5% EC Lambda-Cyhalothrin. Spraying was stopped two months after fruit set. Each fertilizer level appeared in nine sub-plots.

To determine the effect of the fertilizer, and the resulting fruit nitrogen content on the numbers of *H. hampei* in the berries, 400 ripe berries were harvested randomly when about 70% of all berries had ripened.

They were transported to CRIG laboratory at Tafo where berries from each treatment plot were weighed, washed in water, rinsed in a weak solution (5%) of sodium hypochlorite to rid them of exogenous pathogens, allowed to air dry for 24 h, transferred into separate glass chimneys, covered with perforated lids and left undisturbed until the emergence of the F1 generation of *H. hampei*. The insects were sieved out and counted at 24 hourly intervals until all adults had emerged. The experiment was repeated for three years from 1999 to 2001 and the design was a split plot.

Thirty berries were randomly sampled from each treatment for the determination of the concentration of nitrogen (N) in them. For this purpose, the berries were sun dried for 72 h, oven-dried at 80ºC for 12 h and ground with a mill grinder to facilitate their pass-ing through a 0.75 mm screen. The concentration of total N was determined using the Kjeldahl distillation method as described by Bremner (1965).

All data from the three years were pooled together because no significant differences existed among the years and analyzed using the least-squares approach of analysis of variance (Steel and Torrie, 1980) and regression techniques. Data on the borer numbers were square root transformed to stabilize error variance (Harcourt, 1963). Fisher's least significant difference test was used to separate regression parameter estimates (Neter and Wasserman, 1974).

RESULTS

Data on the nitrogen levels and *H. hampei* infestation in the berries are presented in Tables 1 and 2. Application of fertilizer to the soil increased the nitrogen content in the berries and the incidence of *H. hampei*. The correlation coefficients between fertilizer dose and berry nitrogen (0.647) and *H. hampei* numbers (0.921) were statistically significant (P = 0.05) . Similarly, the correlation coefficient for nitrogen in the berries and *H. hampei* numbers (0.581) was statistically significant (P = 0.05). The following regression equations explain the relation between insect numbers and fertilizer dose, insect number

Table 2. Influence of fertilizer rates on numbers of *H. hampei* in berries of different coffee clones.

Rates of fertilizer application	*H. hampei* numbers in			Mean	LSD(P=0.05)
	E152	E139	E138		
150 kgN ha^{-1} and basal dressing of 100 kg P_2O_5/ha and 100 kg K_2O ha^{-1} (T_6)	6240	7288	6947	6825.0a	0.33
90 kgN ha^{-1} and basal dressing of 100 kg P_2O_5/ha and 100 kg K_2O ha^{-1} (T_5)	6153	7233	5853	6413.0b	
70 kgN ha^{-1} and basal dressing of 100 kg P_2O_5/ha and 100 kg K_2O ha^{-1} (T_4)	4150	4652	4945	4582.3c	
50 kgN ha^{-1} and basal dressing of 100 kg P_2O_5/ha and 100 kg K_2O ha^{-1} (T_3)	3398	3649	3966	3671.0d	
Basal dressing of 100 kg P_2O_5 ha^{-1} and 00 kg K_2O ha^{-1} (T_2)	3340	3021	3547	3302.6e	
Unfertilized control (T_1)	2862	3070	3162	3020.3f	
Mean	4357c	4813a	4736b		
LSD (P = 0.05)	0.70				

Values in a column and row followed by different letters are significantly different.

umbers and nitrogen levels in the berries and nitrogen levels in the berries and fertilizer dose, respectively:

H. hampei =3039+26.6X fertilizer dose ($kgha^{-1}$) r = 0.921;
Nitrogen in coffee berries = 13.1 + 0.0371X fertilizer dose (kg ha^{-1}) r = 0.647;
H. hampei numbers = 27 + 301X nitrogen in coffee berries (kg ha^{-1}) r = 0.581.

Nitrogen content of the berries differed significantly (P = 0.05) between fertilizer dosages except for treatment T_4 (70 kgN ha^{-1}) and T_5 (90 kgN ha^{-1}) and for treatment T_3 (70 kgN ha^{-1}) and T_6 (150 kgN ha^{-1}), (Table 1). Insect numbers in the berries also differed significantly between the fertilizer dosages, with treatment T_6 (150 kgN ha^{-1}) re-cording the largest *H*. *hampei* numbers and the control treatment T_1 recording the smallest numbers (Table 2).

The influence of nitrogen levels in the various coffee clones and the occurrence of *H. hampei* in fruit are also shown in Tables 1 and 2. The differences in the nitrogen contents of the berries were not statistically significant, but the differences in *H. hampei* numbers for the clones were significant (P = 0.05), with the trend E139 > E138 > E152 (Table 2).

Although *H. hampei* numbers were smaller where only a basal dressing of 100 kg P_2O_5 ha^{-1} mixed with 100 kg K_2O ha^{-1} was applied (T_2), significantly (P = 0.05) higher numbers of the pest were encountered in this treatment than in the unfertilized control (T_1). Similarly, nitrogen levels in berries from T_2 were greater (P = 0.05) than those in T_1. *H. hampei* numbers and nitrogen levels in berries also differed, when the fertilizer and coffee clone interactions were considered. The interaction between fertilizer and coffee clone, did not significantly affect the nitrogen levels in the berries. However, the interaction between fertilizer and coffee clone did significantly affect the borer infestation.

DISCUSSION

Vanden Driessche and Webber (1977) reported a nineteen-fold increase in the soluble nitrogen content of Douglas- fir trees from increased application of nitrogen fertilizer. The build-up in free amino acid levels of the tomato plant and fruits as a result of nitrogen fertilizer application have been reported by Hoff et al. (1974). In the present study, nitrogen content of coffee berries increased with application of Ammonium sulphate fertilizer thus confirming the finding by Vanden Driessche and Webber (1977). Irrespective of the coffee clones, the improved nutritional status of the berries resulted in significant increases in *H. hampei* numbers.

Southwood (1972) revealed that reproductive success of insects depend to a large extent on their ability to ingest, digest and convert plant nitrogen efficiently and rapidly. Fertilization with high doses of urea, a source of nitrogen, has also been reported to increase the feeding and growth as well as development of insects (Slansky and Scriber, 1985). It is, therefore, possible that as a result of $(NH_4)_2SO_4$ applications, the nutritional qualities of the berries improved, thus enhancing feeding and development of *H. hampei* and subsequent development of more *H. hampei* into adulthood.

Srinivasaperumal et al. (1992) have pointed out a direct linear relationship between nitrogen content of host plants and the intrinsic rate of population increase in the bug *Megacopta cribrarira*. The seed-eating lygaeid bug, *Oxycarenus laetus*, built up its population faster when it fed on protein- rich seeds (Raman, 1987). The regression analysis in the present study also showed that increasing fertilizer dosage raised nitrogen levels in the berries with a resultant development of high numbers of *H. hampei* from berries. Therefore, results from the present study confirm a similar trend in *H. hampei* populations with increase nitrogen fertilization. Scriber (1984) has also point out that, in about 115 studies, crop damage by pests increased with increasing nitrogen content of the host plant.

Conclusion

The study reveals that fertilizer application to the soil planted with coffee increased the nitrogen content in the coffee berries produced and also the numbers of *H. hampei* infesting the berries. Although, the differences in the nitrogen contents of the berries were not significant, the differences in *H. hampei* numbers for the clones were significant.

ACKNOWLEDGEMENT

The authors wish to thank staff of the Entomology and Agronomy/Soil Science Divisions of CRIG, particularly Rev. Agyenim Boateng, Messrs Albert Afari and Emmanuel Owusu. This paper is published with the permission of the Executive Director of Cocoa Research Institute of Ghana.

REFERENCES

Baker PS (1984). Some aspects of the behaviour of the coffee berry borer in relation to its control in southern Mexico. Folia-Entomologica-Mexicana 61: 9-24.

Bremner JM (1965). Total nitrogen. In: Methods of soil analysis. C.A. Black (ed.), American Society of Agronomy, Madison, part 2: 1149-1178

Chand P, Sinha MP, Kumar P (1979). Nitrogen fertilizer reduces shoot fly incidence in sorghum. Sci. and Culture 45 (2): 61-62.

Harcourt DG (1963). Population dynamics of *Leptinotarsa decemlineata* (Say) in eastern Ontario. I. Spatial pattern and transformation of field counts. Canadian entomologist. 95: 813-820.

Hargreaves H (1926). Notes on the coffee berry borer' Bulletin of Entomol. Res. 16: 347-354, London.

Hoff JE, Wilcox GE, Jones CM (1974). The effect of nitrate and ammonium nitrogen on the free amino acid composition of tomato plants and tomato fruits. J. American Society of Horticultural Sci. 99: 27-30.

Le Pelley RH (1968). The coffee berry borer, *Hypoithenemus hampei* (Ferari).. In: D. Rhind (ed.), Pests of coffee. Longmans, London. pp. 114-138

Manolache C, Pasol P, Nicolaresur N, Naum A, Schmidt E (1976). Role of some cultural measures in the control of pests of wheat crops in reddish brown forest soil. Problene de Protectia Planteler 2(4): 363-379.

Martins JP, Pinoceiro B, Love JA (1980). Nitrogen and infestation by the stalk borer in irrigated rice. Pesquisa Agropecuaria Brasilliera 13(3),:23-25.

Neter J, Wasserman W (1974). Applied linear statistics models. Richard D. Irwin, Homewood, III.

Raman A (1987). Nutritional value of malvaceous seeds and related life table analysis in terms of feeding and reproductive indices in the dusky cotton bug, *Oxycarenus laetus* Kirby (Hemiptera: Lygaeidae). Proceedings: Indian academy of Sci.96: 195-206.

Reid JC, Mansingh A (1985) Economic losses due to *Hypothenemus hampei* Ferr. During processing of coffee berries in Jamaica. Trop. Pest Manage. 31 (1): 55-59.

Scriber JM (1977). Limiting effects of low leaf water content on nitrogen utilization, energy budget, and larval growth of *Hyalopora cecropia* (Lepidoptera: Saturniidae). Oecologia 28: 269-287.

Scriber JM, Feeny PP (1979). The growth of herbivorous caterpillars in relation to degree of feeding specialization and growth form of food plant. Ecol. 60: 829-850.

Scriber JM (1984). Nitrogen nutrition in plants and insect invasion. 175-228.In R.D. Hauck (ed.), Nitrogen in crop production. American Society of Agronomy, Madison, WI.

Slansky F Jr, Scriber JM (1985). Food consumption and utilization. 87-164. In: G.A. Kerkuit & L.I. Gilbert (eds.), Comprehensive insect physiology, biochemistry and pharmacology. Pergamon, Oxford.

Southwood TRE (1972). The insect/plant relationship – an evolutionary perspective. In: Insect/Plant Relationship (Van Emden, H.F., ed.). Symposium. Review of Entomological Society, London. 6, 3-30.

Srinivasaperumal S, Samuthiravelu P, Muthukrishnan J (1992). Host plant preference and life table of *Megacopta cribraria.* Proceedings*:* Indian national academy of Sci. 42: 123-128.

Steel RGD, Torrie JH (1980). Principles and procedures of statistics. McGraw-Hill, New York.

TingeyWM, Singh SR (1980). Envir. factors influencing the magnitude and expression of resistance,. *In* F.G. Maxwell and P.R. Jennings (Eds.) Breeding plants resistant to insects. J Wiley, New York. pp. 89-113

Vanden Driessche R, Webber JE (1977). Variation in total and soluble nitrogen concentrations in response to fertilization of Douglas-fir. Forest Sci. 23: 134-142.

Verma AN, Khurana AD, Malik BS (1981). Effects of different levels of irrigations and fertilizers on termite damage and yield of wheat. In: Progress in Soil Biology and Ecology in India (ed G.K. Veeresh) Bangalore: University of Agricultural Science Technical Series No.37. pp. 291-294.