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THE EFFECTS OF WEATHER AND SOIL FACTORS ON THE INCIDENCE OF RED MITE IN THE GOMOA DISTRICT OF THE CENTRAL REGION OF GHANA

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Abstract

The study was done to investigate the effect of weather and soil factors on the incidence of the red mite (*Oligonychus gossypii*). The field extensive survey method was used in the study that was conducted on nine (9) cassava farms in the Gomoa District of the Central Region of Ghana. Additionally, soil samples were taken from the selected fields and analyzed to ascertain the soil factors while data on the weather parameters was collected from the Regional Meteorological Station at Cape Coast. Data collected on red mite population or density, weather as well as soil physical and chemical properties indicated that the incidence and population of the red mite were at their highest in the early dry season (December to January) and during the short dry spell (October) in the wet (rainy) season. The lowest density was recorded following periods of fresh foliage when the rains had set in. The principal mortality factors of the red mite were rainfall and drought which were severe enough to cause complete defoliation and, thereby, destroying the food available to the mites. However, temperature and relative humidity levels did not adversely affect the incidence and development of the mite. It was further noted that, among the soil factors investigated, available phosphorus and organic matter hindered the development of red mites and its attack.

Résumé

OPOKU-ASIAMA, Y., ABOLE, E. A. & YANINEK, J. S.: *Effects des facteurs de temps et de sol sur la fréquence de tétranyque rouge dans le district de Gomoa de la région centrale du Ghana.* L'étude était faite pour enquêter sur l'effet de facteurs de temps et de sol sur la fréquence de tétranyque rouge (*Oligonychus gossypii*). La méthode d'enquête extensive sur le terrain (Hammond, 1992) était utilisé pour l'étude qui se déroulait sur neuf champs de manioc dans le district de Gomoa de la région centrale du Ghana. En plus les échantillons de sol étaient prélevés des champs sélectionnés et analysés pour vérifier les facteurs de sol alors que les données des paramètres du temps étaient recueillies de la station régionale méteorologique de Cape Coast. Les données recueillies de la densité ou la population de tétranyque rouge le temps ainsi que les propriétés physiques et chimiques, indiquaient que la fréquence et la population de tétranyque rougé étaient aux niveaux les plus élevés au début de la saison sèche (decembre au janvier) et pendant une courte période sèche (qui a lieu en octobre) dans la saison pluvieuse mineure. La moindre densité était enregistrée suivant les périodes de feuillage frais lorsque la pluie a l'air bien installée. Les principaux facteurs de mortalité de tétranyque rouge étaient la pluie et la sècheresse, qui étaient assez sèvères de provoquer une défoliation complète et détruisant par ce moyen la nourriture disponible aux mites. Toutefois, les niveaux de températures et d'humidité relative, n'ont pas influencé défavorablement la fréquence et le développment de mite. Il était constaté en plus que parmi les facteurs enquêtés, le phosphore disponible et la matière organique empêchaient le développement rouges et ses attaques.

Introduction

Cassava (*Manihot esculenta,* Grantz) is considered a major root crop being the main staple in many tropical countries especially those of sub-Saharan Africa. Its importance has been assured by its comparatively high biological efficiency of food-energy production (Cock, 1989).

It has been found that approximately 80 million hectares of land in 34 African countries is under cassava cultivation (FAO, 1986), and more than 200 million people below the poverty line in Africa depend on cassava for their food and carbohydrate needs (Herren & Bennet, 1984).

The adaptability of the crop to a wide range of conditions such as poor soils, protracted periods of drought and pest attacks (Cock, 1978, 1985) makes it a very popular crop in Ghana. As much as 19 per cent of the Ghanaian Agricultural Gross Product (AGDP) is accounted for by cassava outstripping the contribution of cocoa, the main traditional export crop of Ghana. The nation produces three million metric tonnes annually (PPMED, 1991) with an average yield of 7.8 Mt/ha, which is far below the potential yield of 28 Mt/ha. The considerably low yield may be attributed to poor management practices, diseases and pests, among other factors.

The major cassava pests include phytophagous arthropods such as cassava mealybug (*Phenacoccus manihoti* Mati-Ferr), cassava green mite (*Mononychellus tanajoa,* Bondar) and whiteflies (*Bemisia tabaci,* Genn). Plant pathogens like the cassava mosaic virus, anthracnose (*Colletotrichum glosporiodes* f. sp. *manihotis* (Arthaud, Berthet) and root rot pathogens like *Sclerotium* and *Fusarium* also contribute to the reduction of cassava yield. Weeds like *Imperata cylindrica* (Anderss), C.E. Hubbard also considerably influence the growth and yield of cassava.

Available literature on the red mite (*Oligonychus gossypii*) is scanty. The red mite is a polyphagous mite considered indigenous and associated with cassava in a number of countries including the Congos, Nigeria, Benin and Ghana (Gutierrez & Bonato, 1994. Yaninek *et al.,* 1991). It is also reported in Brazil, where it is associated with cultivated rubber trees (*Hevea pauciflora*) (Fazolin & Periera, 1989).

Oligonychus gossypii shows higher preference for the middle and lower leaves (mature) of the cassava plant in an intraplant distribution analysis (Bonato *et al.*, 1995). A study of the influence of relative humidity on the life-history parameters of *O. gossypii* indicated that 96 per cent of the immature stages of the mite died at a relative humidity (RH) of 90 per cent (Bonato *et al.,* 1995). It further indicated that low (30% RH) air humidity had negative effects on the life history traits (such as fecundity, development and oviposition). It was, however, observed that medium air humidity (60% RH) favoured these traits of the mite. Bonato *et al.* (1995) concluded that relative humidity is an important abiotic factor influencing the population dynamics of the mite and may explain part of the decrease in populations observed in the middle to the end of the dry season, and the virtually absence of mites during the wet season.

In a separate laboratory study, Bonato *et al.* (1995) observed that temperature has tremendous effect on *Oligonychus gossypii.* The study which was on biological parameters noted that the lower thermal threshold of the mite was 11 °C but developed in the temperature range of 22-36 °C. The shortest development time was 8.2 days at 31 °C. Additionally, maximum fecundity was recorded at 26 °C with 36.3 eggs.

Extensive work has, however, been carried out on cassava pests such as cassava green mite (*Mononychellus tanajoa*), an exotic pest, and the cassava mealybug, but not at the same extent as work done on the red mite. Although *Oligonychus gossypii* pest status with the associated economic damage has been established in studies by Bonato *et al.* (1994) in

Central Africa, much is yet to be done on the pest in West African, especially in Ghana. Further to this, they noted that *Mononychellus progressivus* and O. *gossypii* impact negatively on cassava growth and yield. They also reported that mite densities fewer than 50 mobile forms per leaf (maximum number of mites) were not sufficient to cause significant loss of leaf, stem and root dry matter. The red mite has been reported to cause extensive damage to the cassava plant in close association with the cassava green mite (Yaninek *et al.*, 1989).

Even though some studies have been carried out on the capability of *Oligonychus gossypii* to cause damage to cassava not much is known about environmental factors influencing cassava red mite in Ghana in particular.

The objective of this study was, therefore, to investigate the influence of weather and soil factors on the incidence of red mite in the Gomoa District of the Central Region of Ghana.

Experimental

Location

The investigation was carried out on selected cassava plots in the Gomoa District of the Central Region of Ghana between June 1994 and June 1995. A major rationale for the choice of the location is that the study area is a major cassava-growing belt that feed markets like those in Kasoa, Accra, Tema and Mankessim. Also, accessibility is easy since it lies along a major trunk road. The study area stretched about 10 km along the main Accra-Cape Coast road. The plots were selected cassava farms spaced at about 1 km from each other.

Climate

The areas fall within the coastal scrub and grassland zone with a bimodal rainfall averaging between 74 and 89 cm (Dickson & Benneh, 1970). The major wet season begins in the middle of March, peaks in June and ends in July. The two wet seasons are separated by a short dry spell between July and August. The minor wet season, which starts in September and ends in November, is followed by a dry season from December to February that is characterized by hot days, cool nights and low relative humidity. Temperatures are uniformly high throughout the year with the highest mean monthly temperature of about 30°C occurring in August. Mean monthly relative humidity ranges between 60 and 75 per cent.

Design

The field extensive survey method (Hammond, 1992) was used. In March when farmers were clearing plots for the planting of maize and cassava, plots for the study were selected. Farmers of the identified plots were first met either on the site working or at their homes. Neighbours who were working on their fields assisted the researcher to trace those at home for the initial discussions and negotiations. Farmer participatory approach was adopted and, in order to get their full cooperation, a kind of agreement was reached with them. They were rewarded in cash for their labour and farm produce to serve as motivation; a condition critically required for the success of the study. With some financial support in a collaborative work from the International Institute of Tropical Agriculture (IITA), Benin, Cotonou, each farmer was paid three times the cost of the plot of cassava at a matured stage. The payment was staggered in three installments over the period of the research. The periods were:

a. When the planted cassava was 2 month old in June;

b. At 10 months old in March 1995;

c. In July 1995 after the last data was collected.

Agronomic practices

The cooperating farmers carried out the initial clearing of the land, planting and subsequent weeding and maintenance of the plots within the period of the study. Each farmer was requested to plant the local cultivar 'Amadua' or 'Abadua'. The cultivar is an early maturing type, which accounts for its preference by the local farmers. Planting was carried out between 15th April and 15th May 1994 at spacings consistent with the cropping arrangement of the farmers but ensuring a minimum planting density of 500 cassava stands per plot size of 750 m^2.

Field survey of the incidence of the red mite and laboratory analysis of the soil samples in the selected fields were carried out beginning from July 1994. Stratified sampling procedure was adopted to assess the population of the red mite on the field. Each plot was divided into three strata and from each stratum10 cassava plants were randomly selected for the incidence of the mites. On each selected cassava plant, a young (top) leaf and a mature (bottom) leaf were picked for laboratory assessment. With the aid of the microscope the red mites were counted and the numbers recorded. This process was repeated every month for the period of the study.

Meteorological and soil data

Mean monthly temperatures, relative humidity and rainfall during the study were obtained from the Regional Meteorological Station, Cape Coast.

The soil factors studied were soil moisture, nitrogen, available phosphorus, *p*H, soil texture and organic matter. Soil moisture content was

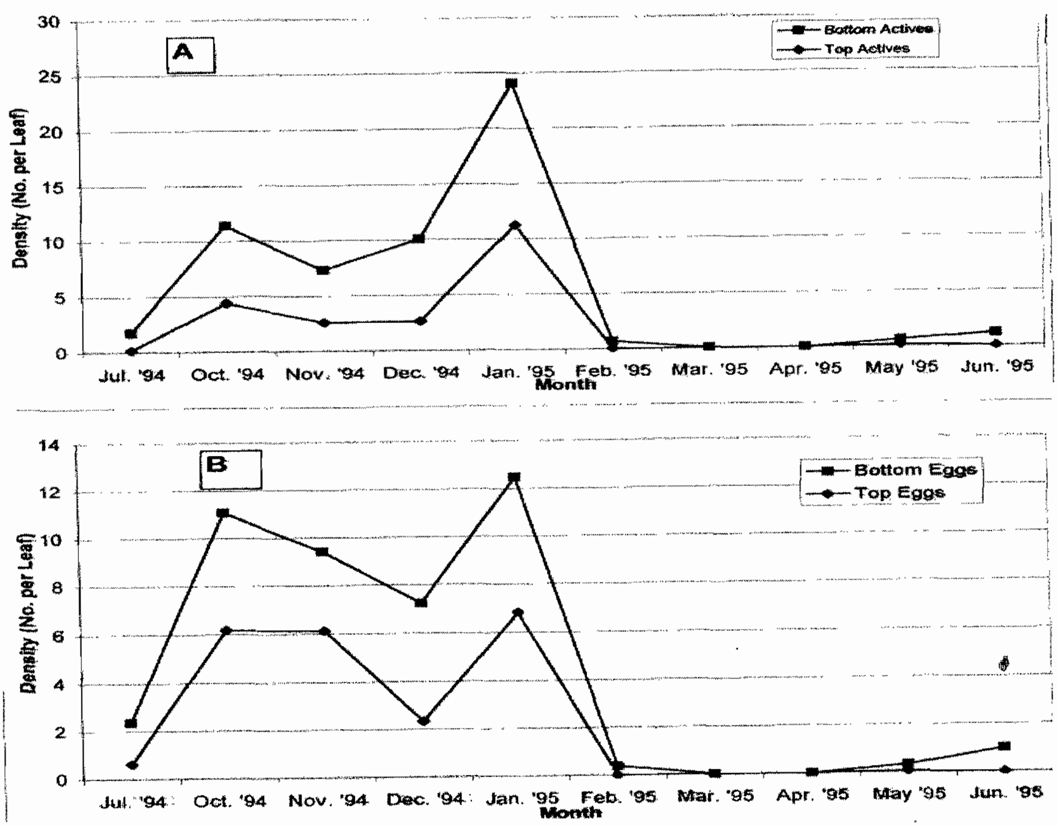

Fig. 1. The population dynamics of red mites (actives and eggs) on the young (top) and mature (bottom) leaves of cassava

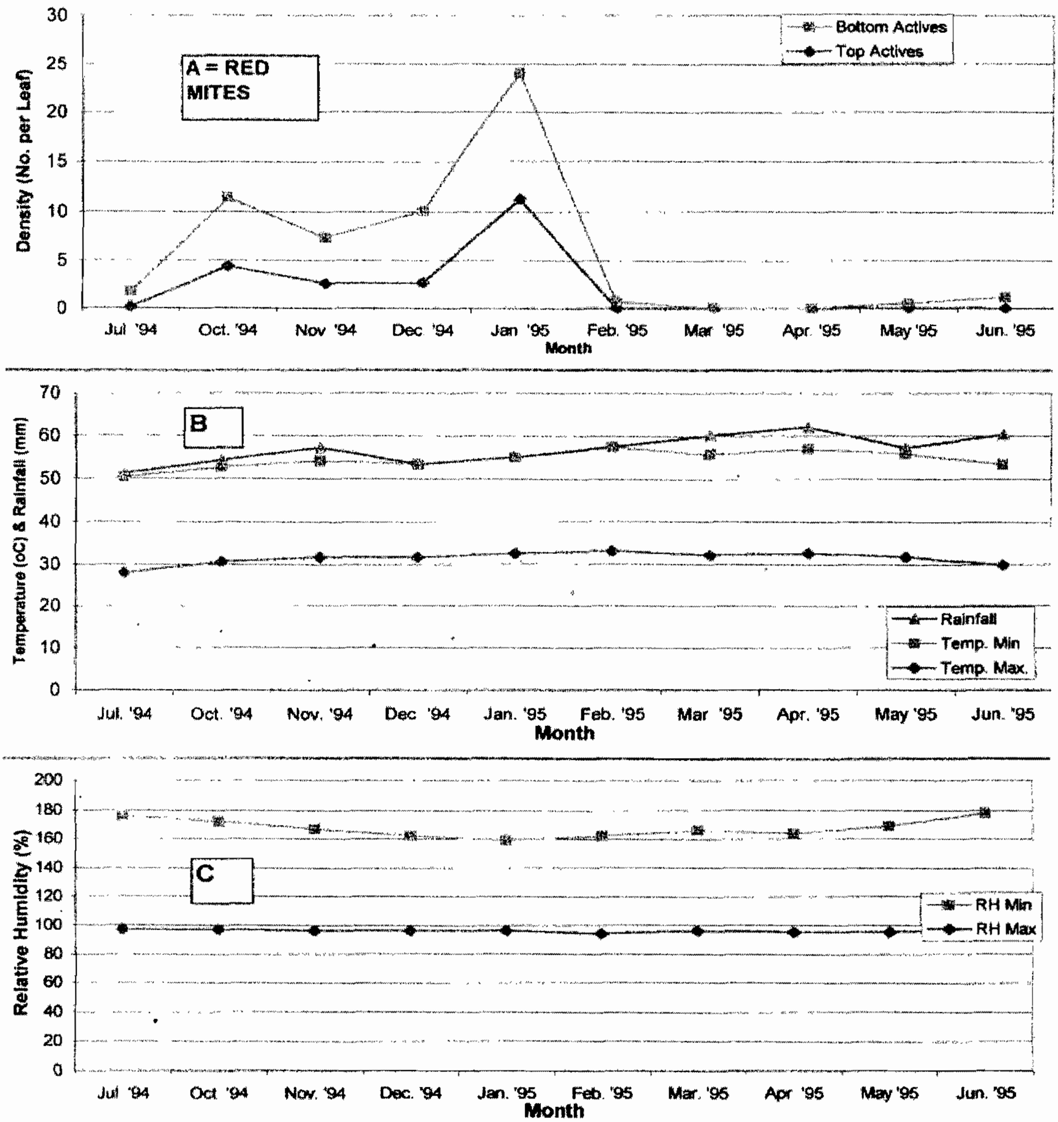

Fig. 2. The actives of red mites on the young (top) and mature (bottom) leaves of cassava and weather factors

determined by weighing soil samples collected randomly from each of the sub-plots. The samples were weighed and then oven-dried at temperature of 105 °C until a constant weight was obtained. The soil moisture content was determined by subtracting the oven-dried weight from the fresh weight and expressing the difference as a percentage of the fresh weight. This process was repeated every month beginning from the onset of the dry season. Soil nitrogen was determined by the use of Regular Macro-Kjeldahl Method, available phosphorus by Olsen's Test for Soil "Available" P and *p*H by

TABLE 1

Correlation co-efficient, R-sq (%) and R-sq (adj) (%) of red mite and weather factors

Weather factors	*Red mite actives*					
	Correlation co-efficient		*R-sq (%)*		*R-sq (adj) (%)*	
	BACTS	*TACTS*	*BACTS*	*TACTS*	*BACTS*	*TACTS*
Rainfall	-0.503	-0.435	25.3	18.9	16	8.8
RH. (max)	0.31	0.204	9	4.2	0	0
RH (min)	-0.498	-0.532	24.8	28.3	15.4	19.3
Temperature (max)	-0.089	0.186	0.8	3.5	0	0
Temperature (min)	-0.728	-0.522	53*	27.3*	47.2*	18.2

* Indicates significance at $P = 0.05$

BACTS = Actives of bottom (mature) leaf

TACTS = Actives of top (young) leaf

Bates' Electrometric *p*H Determinations Method (IITA, 1985).

Soil organic matter was determined using the Walker-Black Method (IITA, 1985). The method developed by Anderson & Ingram (1989) was used to determine the textures of soil samples collected.

Analysis of variance (ANOVA)used to test for significance while correlation and regression analysis was used to establish relationships between the variables.

Results

Red mite actives

The density of the red mites on young leaves was very low in July 1994 but rose in October 1994 with a gradual decrease up to December 1994. It shot up in numbers till it reached its peak in January 1995 (Fig. 1a). After this, it fell to zero where it remained until June 1995. On the mature leaves, the pattern was not different (Fig. 1a). The density of the red mite was equally low in July 1994 but rose sharply in October 1994 with some decrease in November 1994. It, however, rose again in December 1994 and got to its peak in January 1995, after which it fell sharply to almost zero in February 1995. It was zero in March and April 1995 but picked up again in May 1995 with an appreciable increase in June 1995. In all cases, densities were higher on the mature leaves than on the young leaves.

Red mite eggs

From a very low density in the wet season, the concentration of the eggs of red mite on young leaves increased appreciably from the onset of the dry season (Fig. 1b). The density of eggs on these leaves then declined gradually to zero from which it slowly increased. On the other hand, the density of eggs on the mature leaves in July 1994 was higher than on the young leaves. This concentration increased and peaked in the middle of the dry season. From Fig. 1b, general reduction to very low numbers was observed in the later part of the dry season and fell to zero in the early part of the next wet season. There was a slow rise in egg density as the wet season advanced in June 1995. The difference in the density of eggs between young and mature leaves was found to be statistically non-significant.

Weather influence on red mite

Low densities of the red mites were recorded during the wet season (Fig. 2). A substantial increase in density was noted at the end of the wet season and remained without much variation till the beginning of the dry season. The density remained relatively stable till the middle of the dry season in January 1995 when it rose sharply.

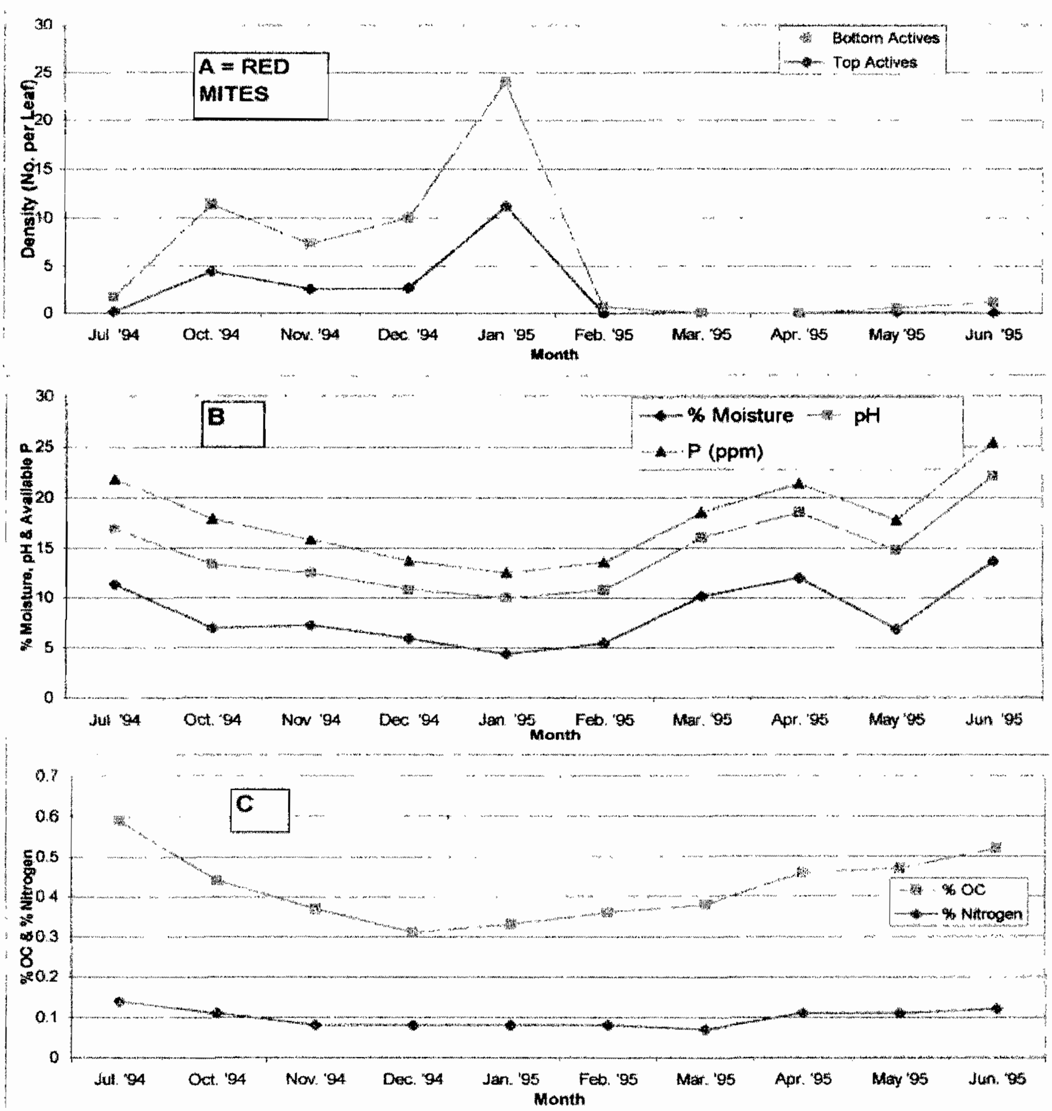

Fig. 3. The actives of red mites on the young (top) and mature (bottom) leaves of cassava and soil factors

At the latter part of the dry season and during the early and mid wet season of the study period, the red mite population remained low and, in some cases, was not found at all.

Rainfall was observed to be negatively but moderately correlated with the densities of the red mites (Table 1). The correlation was, however, not significant. It was further observed that the R-sq and R-sq (adj) values were quite high but not significant.

Maximum temperatures were noted to be positively but poorly and non-significantly correlated with the densities of the red mites. On the other hand, minimum temperatures were

TABLE 2

Correlation co-efficient, R-sq (%) and R-sq (adj) (%) of red mite and Soil Factors

Weather factors	*red mite*					
	Correlation co-efficient		*R-sq (%)*		*R-sq (adj) (%)*	
	BACTS	*TACTS*	*BACTS*	*TACTS*	*BACTS*	*TACTS*
Soil moisture	-0.634*	-0.603	40.2*	36.4	32.7*	28.4
Soil *p*H	0.393	0.3	15.5	9	4.9	0
% soil N	-0.313	-0.319	9.8	10.5	0	0
Available P	-0.004	0.094	0	0.9	0	0
% Organic C	-0.58	-0.524	33.6	27.5	25.5	18.4

* Indicates significance at $P = 0.05$

BACTS = Actives of bottom (mature) leaf

TACTS = Actives of top (young) leaf

negatively correlated with the densities of the mites on the mature leaves showing significance at $P = 0.05$. The densities on the young leaves was negatively but moderately and non-significantly correlated. From Table 1, R-sq and R-sq (adj) values were quite high and, in the case of the densities on the mature leaves, statistically significant.

While the maximum relative humidity was positively correlated with the red mites, the minimum relative humidity was found to be negative. For the former, it was lowly and non-significantly correlated but the latter was moderate though non-significant. R-sq and R-sq (adj) values from Table 1 were moderately low.

Red mite and soil factors

The population of red mites varied inversely with soil moisture, *p*H, N and organic carbon (Fig. 3). Also from the figure, an inverse relationship was observed between red mites and available P in the first half of the study period while the second half of the study showed no definite trend. All the soil factors investigated in this study were found to be negatively correlated with the density of the red mite except available phosphorus which was observed to be positively but very poorly correlated with the densities of red mites on the mature leaves (Table 2). On the whole, the computed R-sq and R-sq (adj) values for soil moisture and organic carbon were markedly high with that of the soil moisture and the desities of red mites on the mature leaves showing significance at $P = 0.05$. Of the rest, soil *p*H was observed to have substantial R-sq (adj) values with the red mites on the mature leaves while that of nitrogen was very low (Table 2).

Discussion

The red mite *(Olygonychus gossypii)* was found to be an important foliar pest of cassava in the Gomoa District of the Central Region of Ghana. They were observed throughout the year, except during severe drought when most cassava plants had lost their foliage. Their persistence during the dry season when they peak in high numbers, and the subsequent very low numbers following periods of fresh foliage suggest that the red mite thrives well on mature leaves and are more drought resistant. Other pests found in low numbers on the foliage were the white flies (*Bemisia tabaci*), the cassava mealybugs (*Phenacoccus manihoti*) and the variegated grasshopper (*Zonocerus variegatus*).

However, Yaninek *et al.* (1989) have noted that except for patchy outbreaks of the grasshopper, the only other major foliar pest of cassava in Africa, besides CGM (cassava green mite) is the exotic cassava mealybug. This observation is likely to be at variance with the finding of this study, which revealed that, with the densities recorded for red mite, it was possibly the next major foliar pest after CGM. The absence of the mealybug on cassava farms might have been brought about by the success of the classical biological control programme of the exotic mealybug, in which the parasitic wasps *(Epidinocarsis lopezi)* was used as the control agent (Herren *et al.,* 1987).

The study showed that the eggs of the red mites were more abundant on the mature leaves than on the young ones. The red mites apparently prefer to feed on leaves that are not too rich in nitrogen; hence, their abundance on such leaves. It is also probable that the red mites prefer areas of low light intensity for carrying out their biological activities.

It was also observed that the red mite seemed able to withstand dry weather conditions. They are, therefore, very hardy. The positive correlation values between the red mite and maximum relative humidity and maximum temperature are probable indications that they thrive well in hotter conditions.

The excellent adaptation of the red the mite to its environment is shown by the correlation co-efficient values between the red mite and the minimum relative humidity and minimum temperature which were negative and moderately high. The red mite's dependence on minimum temperature was, however, significant. This additionally supports the observation that the red mite thrives well in hot and dry conditions. Furthermore, the negative correlation value between rainfall and the red mite as well as the R-sq (adj) value point to the fact that the red mite is very adversely influenced by rainfall. It is possible that rainfall might be an important mortality factor where the impact of the raindrops washed the mites off the leaves and in some cases, killed them. Similarly, Yaninek *et al.* (1987) have reported that heavy rains wash mites off their hosts, but most mites move to sheltered places during rains while natural pubescence on some plants serve as point of attachment for other mites during storms.

The observed negative significant correlation between soil moisture and the red mites indicates the considerable influence soil moisture has on the red mite. This assertion is supported by R-sq and R-sq (adj) values. The high numbers of red mites in January 1995 when moisture content was lowest strongly suggests that the prevalence of low moisture content very much favours red mite multiplication. It is possible that moisture stress in the cassava plant lowers its resistance to the red mite if nutrients required for plant development were unavailable in the soil solution. Thus, the metabolic and physiological processes tend to be affected.

Also, the negative correlation between red mite and the soil factors such as soil nitrogen and organic carbon suggests the adverse influence these factors might have had on the development of the red mite. It might be that the organic matter which provides essential nutrients to the plant helps improve the resistance of the cassava plant to the red mite attack. The very weak correlation coefficient value as well as the zero R-sq and R-sq (adj) values of available phosphorus further suggest that unlike factors such as humidity, temperature, and soil moisture, phosphorus does not have much influence on the pest.

The low density of the red mites in the dry season could, most probably, be attributed to non-availability of food since there was complete defoliation of the cassava plants in almost all the fields. The absence of the red mites for about three consecutive months, despite the flushing of fresh foliage during the early part of the wet season, suggests that they might have had to diapause. It is probable that the scarcity of food could have induced the diapause. This could be inferred from the absence of the red mites from the fresh cassava foliage and their reappearance when the leaves started maturing; a state of the cassava leaf most preferred by the red mite.

Conclusion

The red mite was found to be an important pest of cassava in the Gomoa District of the Central Region of Ghana. Its incidence and population on the cassava plant were at their highest in the early dry season and at their lowest following periods of rain when there were flashes of fresh foliage. However the red mite was scarce during severe drought when the plants were completely defoliated.

Although rainfall and severe drought appeared to be important mortality factors, on the whole, the red mite's development was not affected by weather factors like temperature and relative humidity. It was also evident that available soil phosphorus, nitrogen and organic carbon hindered the red mite's development and attack. Low soil moisture content was found to favour the mite's multiplication and increase the damage done to the cassava plants.

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