Fertilizer Research 16: 31-35 (1988)

Extractable iron in two soils of contrasting pH fertilized with ferrous sulfate, FeEDTA and FeEDDHA

K.L. SAHRAWAT
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru P.O., Andhra Pradesh 502 324, India

Accepted 18 January 1988

Key words: iron chelates, calcareous soil, vertisol, alfisol

Abstract. The behaviour of $FeSO_4$, FeEDTA and FeEDDHA added to a Vertisol (pH 8.3) and an Alfisol (pH 5.8) was studied by periodically monitoring DTPA extractable Fe in soil samples incubated at −33 kPa soil moisture at 30°C for 8 weeks. It was found that FeEDDHA was most effective in both Alfisol and Vertisol in maintaining high amounts of extractable Fe during 8 weeks. Both $FeSO_4$ and FeEDTA were completely ineffective in the Vertisol though they were moderately effective in the Alfisol. These results suggest that FeEDDHA is the most effective source of iron for soil application in the high pH Vertisols.

Introduction

Many agricultural crops, especially in the semi-arid tropics, suffer from iron deficiency [3]. Spraying foliage with inorganic iron salts or soil treatment with synthetic iron chelates such as FeEDTA (ethylenediaminetetra acetic acid) and FeEDDHA (ethylenediaminedi-o-hydroxyphenyl acetic acid) are the two most accepted methods of correcting iron deficiency [3, 11]. Spraying foliage of crops with inorganic salts such as ferrous sulfate ($FeSO_4$) has been shown to be useful but often results are inconsistent and several sprays are usually required for the satisfactory alleviation of iron deficiency.

At ICRISAT Center, we have observed iron chlorosis on crops such as groundnut (*Arachis hypogaea* L.) growing on calcareous soils [7]. We did not find spraying with $FeSO_4$ to be an entirely satisfactory method in itself and a combination of soil treatment with iron chelates and foliar spray with $FeSO_4$ was found to be the most effective method of correcting iron chlorosis in groundnuts [4, 7]. However, for chickpea (*Cicer arietinum* L.), Saxena and Sheldrake [9] found that two or three sprays of 0.5% $FeSO_4$ on the foliage corrected iron deficiency symptoms. We have also observed that for groundnuts growing on calcareous soils (pH > 7.5) in field and greenhouse pots, soil application of FeEDDHA was effective in correcting iron deficiency but

TROPICAL PEST MANAGEMENT, 1989, 35(2) 137–142

Insect pests of pearl millet in Sahelian West Africa I. *Acigona ignefusalis* (Pyralidae, Lepidoptera): distribution, population dynamics and assessment of crop damage†

(*Keywords* pearl millet; stemborer; *Acigona ignefusalis*; Sahel, rainfall)

KANAYO F. NWANZE

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru P O , Andhra Pradesh 502 324, India

Abstract. Pests were surveyed in farmers fields in Burkina Faso Niger and northern Nigeria from 1980 to 1983, and field trials at research stations in Burkina Faso (1980 and 1981) and at the ICRISAT Sahelian Center in Niger (1984 and 1985) *Acigona ignefusalis* is widely distributed in West Africa but its predominance as the major stem borer of millet varies with location There are two generations of the pest annually, with peaks in moth population in July and September Diapausing larval population declines during the dry season from November to May A progressive decline in borer infestation was recorded between 1983 and 1985 in Niger Damage to early-sown millet was usually low while late sowing resulted in severe stem tunnelling and unproductive tillers However under low levels of borer infestation an unprotected crop gave higher grain yield than one which was protected with insecticide

Introduction

Pearl millet, (*Pennisetum americanum* (L) K Schum) is the staple crop in the diet of several million people in the Sahelian region of West Africa West Africa grows an estimated 12.2 m ha of millet and over 93% of this area is cultivated in Burkina Faso, Mali, Niger, Nigeria and Senegal, where landraces are mostly grown with little production inputs and average yields vary from 200–600 kg/ha

Several constraints, both biotic and abiotic, limit the realization of the yield potential of both landraces and improved varieties While some of these constraints are common to other millet growing regions of Africa and India, the two major insect pests of pearl millet in West Africa, the millet stem borer, *Acigona ignefusalis* Hmps and the earhead caterpillar, *Raghuva albipunctella* De Joannis, are either not known to exist elsewhere, or if they do, are of no economic importance (ICRISAT, 1984) As a result, only limited studies have been conducted on these species (Harris, 1962; Vercambre, 1978; Ndoye, 1979; Ajayi, 1980, Guevremont, 1980, 1981, 1982, ICRISAT 1981, 1982, 1984) A review by Gahukar (1984) on the pests of pearl millet in West Africa indicated that information on their bioecologies and economic importance was incomplete.

The development of pest management programmes requires knowledge of the distribution of the pests, their bioecologies, their seasonality of occurrence, and the damage they cause. This paper covers the results of detailed studies on the stem borer, *A. ignefusalis*, referred to hereafter as *Acigona*. It reports results from extensive surveys in Burkina Faso, Niger and parts of northern Nigeria and from field studies on population dynamics and the evaluation of crop damage at research stations in Burkina Faso and at the ICRISAT Sahelian Center (ISC), at Sadore, Niger

Materials and methods

1 *Pest surveys*

The distribution of *Acigona* was determined by sampling pearl millet crops in farmers fields In 1980 and 1981, extensive field surveys were conducted on 64 farms in Burkina Faso, 78 in Niger, and 34 in Northern Nigeria. In 1982 and 1983 additional surveys were conducted on 203 farms in Niger Fields were selected at random at intervals of 10–40 km depending on their distribution, road accessibility and zone to be sampled during each survey

The incidence of *Acigona* was assessed by splitting millet stems and examining them for borer damage. When a survey involved crops at the flowering stage, depending on farmer cooperation, usually 5–10 stems were randomly selected. At harvest, up to 25 stems/farm were sampled. The following observations were recorded percentage infested stems, percentage internodes tunnelled, number of borer larvae per stem, and species identification

2 *Population studies*

The annual fluctuation of borer population was monitored in 1980 and 1981 at two research stations in Burkina Faso, (Kamboinsé near Ouagadougou and at Farako-Bâ, near Bobo Dioulasso), and in Niger in 1983, 1984 and 1985 at Sadoré. At each location counts of *Acigona* larvae (using the stem-splitting method) were made during the crop season in millet fields that were sown at monthly intervals with the local cultivar and an improved variety, Nigerian Composite. The trials were laid out in four replications in a randomized split plot design with sowing dates as main plots and cultivars as subplots (5 × 5 m). Irrigation was supplied during the dry season from October to May.

At weekly intervals, 25 stems per sub-plot were randomly selected, split and examined for borer damage. During the

. Effect of date of sowing on the extent of damage caused by infestations of Acigona ignefusalis on pearl millet at Sadoré, Niger (mean of 1984 and 1985)

	Variety	% Infested stems (50 d.a.s.)	% Infested stems (at harvest)	% Bored internodes	No. larvae/ 10 stems	% Non-productive stems
wing	HKBtif	9·4	36·7	1·9	1·2	11·9
	CIVT	7·5	30·0	1·7	1·5	4·1
	Local	7·2	13·0	1·0	1·3	2·3
	Mean	8·0	26·5	1·5	1·3	6·1
	S.E. ±	0·7	7·0	0·27	0·1	2·9
l sowing	HBKtif	15·9	69·4	29·2	5·3	14·3
	CIVT	6·5	49·1	25·4	2·7	17·8
5	Local	4·3	32·2	12·2	3·5	8·5
	Mean	8·9	50·2	22·2	3·8	13·5
	S.E. ±	3·5	10·7	5·1	0·7	2·7
owing	HKBtif	20·3	88·3	39·2	6·0	30·9
4	CIVT	14·2	93·3	45·4	9·8	33·1
	Local	7·9	72·5	37·8	5·1	26·2
	Mean	16·1	84·7	40·8	6·9	30·0
	S.E. ±	3·5	6·2	2·3	1·4	2·0

Table 4. Assessment of crop loss caused by infestation of Acigona ignefusalis *in two millet cultivars, Sadoré, Niger 1985*

	Cultivar/treatment				
	Nigeria composite		Sadoré local		
eters measured	Protected check	Unprotected	Protected check	Unprotected	Mean ± S.E.
vae/stem d.a.s.)†	1·55	3·0	0·0	0·2	1·2 ± 0·73
ested stems d.a.s.)	8·3	10·0	1·7	3·3	5·8 ± 2·10
ernodes tunnelled d.a.s.)	1·4	2·6	0·3	0·6	1·2 ± 0·60
rvae/stem harvest)	11·5	11·2	6·3	7·5	9·1 ± 1·49
ested stems harvest)	28·0	37·3	17·3	23·0	26·4 ± 2·87
ernodes tunnelled harvest)	4·9	8·5	2·6	3·4	4·8 ± 0·52
yield /ha)	1856	2076	1414	1432	1720 ± 377
loss (%)	11·9‡		1·3‡		

s.: Days after sowing.
cates yield advantage of unprotected over protected checks.

ults and discussion

urrence and distribution

igona is widely distributed in West Africa and its ominance as the major stem borer species of millet s with location (Table 1). In the drier northern Sahelian s it was the only borer species recovered from millet. her south, in Nigeria and Burkina Faso, two other borer cies, the sorghum pink borer, *Sesamia calamistis* Hmps., the sorghum maize borer, *Eldana saccharina* Walker, e occasionally encountered. *Sesamia calamistis* and *E. charina* were less abundant in northern Nigeria than in ina Faso and were seldom of any importance as pests of . *Acigona* also attacks sorghum and in the northern [illegible] stem borer, *Busseola fusca* Fuller, which otherwise is the predominant borer of sorghum (Nwanze, 1981).

In farmers' fields in the Zaria area, the southern limit of the region surveyed in northern Nigeria (Figure 1), *Acigona* accounted for only 40% of the borers in millet although at the Samaru research station it was as high as 93% (Table 1). However northwards at Funtua (65 km north-west of Zaria) it was the only borer species recorded right up to the northern border town of Jibiya. All fields of the 34 farms surveyed in northern Nigeria were infested. Stem damage ranged from 36–100% ($n = 416$) and was most severe between Funtua and Zaria and in the northwest around Sokoto (Figure 1).

Stem borer infestation in Niger was less severe than in Nigeria in 1981 and although all fields sampled had borer infestation, stem damage ranged from 8–49%, with a mean of 19% ($n = 330$). The highest infestation was recorded at Tamaske (District of Tahoua). In 1982 and 1983, borer

Table 3. DTPA extractable iron (mg kg^{-1} soil) in soils treated with three iron sources.

Soil	Iron source	Weeks of incubation			
		0	2	5	8
Alfisol	$FeSO_4$	18	15	13	9
	FeEDTA	19	16	15	15
	FeEDDHA	25	25	20	20
	SE ±	0.2	0.4	0.2	0.1
Vertisol	$FeSO_4$	7	3	2	2
	FeEDTA	8	2	2	2
	FeEDDHA	19	19	17	14
	SE ±	0.2	0.3	0.1	0.4

in the Vertisol. For example, only 14% of the added iron as FeEDDHA was extracted by DTPA after 8 weeks of incubation. The corresponding extractable iron values for $FeSO_4$ and FeEDTA treatments after 8 weeks were only 2%. The ineffectiveness of the iron sources might have been due to reactions with carbonates, adsorption by clay minerals, and decomposition of the iron chelates by soil micro-organisms [3].

The amounts of extractable iron in the Alfisol treated with $FeSO_4$, FeEDTA and FeEDDHA after 8 weeks of incubation were 9, 15 and 20%, respectively, of the amounts of iron added initially.

The results are consistent with the knowledge that FeEDTA is not stable in nutrient solutions above pH 6 and that it is quite effective in correcting iron deficiency in plants growing on acid soils [3]. On the other hand FeEDDHA has been found to be the most effective iron chelate for correcting lime-induced iron deficiency in soils with varying pHs because it exists as a soluble anion at all soil pHs [3].

These results are also in agreement with those recently reported by Ryan et al. [8], who found that FeEDDHA was the most effective form and that $FeSO_4$ was found to be completely ineffective in the two Lebanese calcareous soils. These authors, however, did not evaluate the efficacy of FeEDTA.

In summary, our results suggest that while FeEDDHA was effective in maintaining a higher pool of DTPA extractable iron in both Alfisol and Vertisol, $FeSO_4$ and FeEDTA were moderately effective in the Alfisol only.

Acknowledgement

Approved for publication as ICRISAT **Journal Article No. 701.**

References

1. Allison LE and Moodie CD (1965) Carbonate. In: CA Black (ed.) Methods of Soil Analysis, part 2. Agronomy 9: 1379–1400. Am Soc of Agron, Madison, Wisconsin, USA
2. Bremner JM (1965) Total nitrogen. In: CA Black (ed.) Methods of Soil Analysis, Agronomy 9: 1149–1178. Am Soc of Agron Madison, Wisconsin, USA
3. Chen Y and Barak P (1982) Iron nutrition of plants in calcareous soils. Adv Agron 35:217–240
4. ICRISAT (1983) International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Annual Report 1982. Patancheru, A.P. India, pp 273–276
5. Lindsay WL and Cox FR (1985) Micronutrient soil testing for the tropics. In: PLG Vlek (ed.), Micronutrients in Tropical Foods, pp 169–200. Dordrecht: Martinus Nijhoff Publishers
6. Lindsay WL and Norvell WA (1978) Development of DTPA soil test for zinc, iron, manganese and copper. Soil Sci Soc Am J 42:421–428
7. Rao JK, Sahrawat KL and Burford JR (1987) Diagnosis of iron deficiency in groundnut, *Arachis hypogaea* L. Plant Soil 97:353–359
8. Ryan J, Hamze M, Shwayri R and Hariq SN (1985) Behavior of iron-supplying materials in incubated calcareous soils. J Plant Nutr 8:425–436
9. Saxena NP and Sheldrake AR (1980) Iron chlorosis in chickpea (*Cicer arietinum* L.) grown on high pH calcareous Vertisol. Field Crops Res 3:211–214
10. Walkley A and Black IA (1934) An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chromic acid titration method. Soil Sci 37:29–38.
11. Wallace A, Wallace GA and Abou-Zamzam AM (1984) Experiments on correcting iron deficiency in plants. J Plant Nutr 7:211–222