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Effects of White Leaf Disease on Mineral Nutrient Accumulation in Sugarcane Leaf

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ABSTRACT

White leaf disease caused by mycoplasma like organism has a marked effect on the mineral content in leaves of sugarcane clones Isd 16 and Isd 20. Leaves of the infected sugarcane plants were found to contain less amounts of nitrogen, calcium, magnesium and manganese compared to healthy leaves. On the other hand phosphorous, potassium, sodium, iron, zinc and boron contents were found to increase in the diseased plants compared to their healthy ones. The ratios of P/Fe, K/Ca and Mn/Fe in the white leaf disease infected leaves changed drastically from their healthy check.

Key words: Sugarcane, white leaf disease (WLD), and mineral nutrients.

INTRODUCTION

In Bangladesh about thirty eight-sugarcane diseases have been reported (Rahman *et al.* 1993). Out of these, white leaf disease (WLD) (Photograph 1) is one of the most serious diseases. The disease was first observed in three widely cultivated varieties such as Isd.2/54, Co.1158 and Isd 16 (Rahman *et al.*, 1980). Later the disease was found to increase in the subsequent years and covered most of the commercial varieties of sugarcane (Anon., 1988). The most popular varieties of the country, Isd 16 and Isd 20 are susceptible to this disease. In both cases the incidence of disease is very high.

White leaf disease alters the morphology of sugarcane plants. Infected sugarcane plants exhibit reduced vegetative growth, albino in colour, premature drying and drying of leaves, thinning of canes and shortening of inter node which finally affect cane yield and cane quality adversely. It is reported that Mg^{++} and Mn^{++} act as co-factor in sucrose synthesis and sucrose synthesis is accelerated with increased Mg^{++} and Mn^{++} content in the metabolic environment (Patil and Joshi, 1972). Impaired sucrose metabolism, less chlorophyll content, shortened length and thinner stalks of the grassy shoot diseased sugarcane plants may be due to lower concentration of Mg (Dhumal and Nimbalkar, 1982).

Disturbed mineral nutrition is one of the most common effects of plant disease (Huber 1978). This may reflect an imposed mineral deficiency somewhere in the plant, impaired utilization or toxicity from abnormal accumulation around the site of infection. Hence the present studies have been carried out to elucidate the effects of WLD infection on mineral nutrient content in leaves of sugarcane varieties Isd 16 and Isd 20.

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Photograph 1. White leaf disease infected sugarcane plant

MATERIALS AND METHODS

Healthy and white leaf disease (WLD) infected canes of varieties Isd 16 and Isd 20 were obtained from Bangladesh Sugarcane Research Institute farm and were planted in the micro plots (5x6 m) having 6 rows of sugarcane. Attempts were made to maintain identical condition for all the treatments throughout the experimental period. Third leaves from the top of the plants were cut randomly from healthy and diseased plants of 7-8 months old from each plot. Samples were taken three times at 15 days intervals and leaves from each plot for each sampling were analyzed as composite samples. The leaf samples dried at 70°C in an oven for 48 hours and were powdered in a Wiley mill and passed through a sieve of 50 mesh. Powdered samples were used for analysis of different inorganic constituents. Amount of total nitrogen in the sample was determined by the modified Micro Kjeldahl method (Jackson, 1973 and Yamakawa, 1993) following Sulfuric acid digestion using a mixture of $CuSO_4$ and K_2SO_4 (1:9) as catalyst. For determining the contents of P, K, Na, Ca, Mg, Fe, Mn, Zn, and Boron, extraction from leaf sample was done by Perchloric acid digestion method. Contents of Ca, Mg, Fe, Mn, Zn, Na and K were estimated by Atomic Absorption Spectrophotometer (Yamakawa, 1993). Contents of P and B were determined colorimetrically using the methods developed by Sekine (1965) and Hatcher and Wilicox (1950), respectively.

RESULTS AND DISCUSSION

The concentration of different mineral elements like N, P, K, Ca, Mg, Na, Fe, Mn, Zn and B in leaf tissues of WLD infected sugarcane plants of both the varieties showed a serious imbalance compared to the healthy plants (Table 1). In both cultivars, infected leaves contained greater amount of P, K, Na, Fe, Zn and B than healthy leaves. Amount of N, Ca, Mg and Mn was less than that of the control. Diseased cane leaves of Isd 16 contained greater concentration of P and Fe and less of Na when compared with Isd 20 (Table 1)

The effects of white leaf disease on N, P, K, Na, Ca & Mg

Infected leaves of both the cultivars of sugarcane were found to contain less nitrogen content compared to their respective healthy ones (Table 1). The results agreed with the observation of Dhumal and Nimbalkar (1982), Rao (1984) and Gupta *et al.* (1988). They reported that grassy shoot diseased leaves of sugarcane contained significantly reduced quantity of N. Decrease in N content in the diseased leaves were also reported by many other workers (Ghorpade and Joshi, 1981; Hedge and Mungal, 1971; Singh and Verma, 1973). This reduction may be due to utilization of nitrogen by the pathogen (Hedge and Mungal, 1971). The reduction in N may be due to blockage of protein synthesis (Goodman *et al.*, 1967) or due to proteolysis caused by the pathogen (Subramanyam *et al.*, 1976). Hence decrease in N content in WLD infected plant may be attributed to the decreased quantity of protein found by Shukla *et al.* (1988).

Phosphorus concentration (P_2O_5) was found to increase significantly in the diseased leaves over their respective healthy ones of both the tasted varieties. The varieties Isd 16 and Isd 20 showed significantly higher quantity of phosphorus in their diseased leaves compared to their respective healthy checks (Table 1). Greater concentration of P in the diseased leaves ware also reported by other workers (Dhumal and Nimbalker, 1982; Singh and Verma, 1973; Singh and Mall, 1974). A pathogen induced an increase in respiration may be responsible for this accumulation (Akazawa and Uritani, 1955). This higher rate of respiration in WLD and GSD affected plants reported respectively, by Chen and Kong (1976) and Shukla *et al.* (1988) may be attributed to the increased quantity of P in the diseased leaves.

Potassium content was found to increase significantly in the diseased leaf tissues over their respective healthy check (Table 1). The results supported the findings of Dhumal and Nimbalkar (1982). They observed that the leaves of GSD infected sugarcane plants contained 29.36 to 30.23% higher K compared to healthy checks. Greater concentration of K in the diseased leaves has been observed in sorghum and sugarcane infected by downy mildew, sugarcane moasic virus (SCMV) and smut (Ghorpade and Joshi, 1981; Balasubramanian, 1975; Padmanaban *et al.*, 1988). Potassium plays an important role in plant metabolism and is found in higher concentration wherever high energy transformations take place (Humbert, 1963). In general it bestows resistance to disease, as it is associated with maintenance of permeability which is important to disease resistance (Dastur and Bhatt, 1964). The higher concentration of K in leaves of infected plants may reduce the severity of diseases and increase disease resistance (Balasubramanian, 1975; Ghorpade and Joshi, 1981; Kulkarni and Kulkarni, 1978). Accumulation of K in leaves of infected canes of both the cultivars may serve as a defense mechanism.

Sodium was considered to be nonessential elements in glycophytes. Now it has been shown that C_4 needs Na in micro quantities (Brownwell and Crossland, 1972). Conflicting reports are available regarding the effects of disease on Na content. In the present study Na was found to increase in WLD infected plants compared to healthy checks (Table 1). Similar observations were made by many workers (Balasubramanian, 1973; Dhumal and Nimbalkar, 1982; Ghorpade and Joshi, 1981; Gupta, 1975; Sankpal and Nimbalkar, 1980) which indicate infection causes a marginal increase in Na content. An increase in Na content may cause an increase in moisture content of diseased cane leaves which was observed by Dhumal and Nimbalkar (1982) in GSD infected cane leaves. With regards to physiological aspects of higher Na content in the plant, the metabolic disturbance induced by entry of Na into the cytoplasm is the most important factor for primary reaction of plants cells (Katsuhara and Tazawa, 1986). The abnormal morphological structures of white leaf disease infected plant are probably due to disturbance of some of metabolic activities in plant cells. However at present it is difficult to ascertain an exact cause of greater Na content in WLD infected sugarcane leaves. Possibly it participates in the maintenance of ionic balance (Dhumal and Nimbalkar, 1982).

Calcium content was found to decrease in WLD infected leaves compared to healthy ones but the decrease was not significant (Table 1). Dhumal and Nimbalkar (1982) reported both increase and decrease concentration of Ca in the GSD infected leaves compared to healthy ones. Decrease in Ca content was also reported in coriander leaves and fruits infected with stem gall (Gupta, 1975) and hollyhock leaves infected with hollyhock yellow mosaic virus (Singh and Verma, 1973). Polyvalent cat ion such as Ca increases disease resistance (Bilgrami and Dube, 1976) by governing the membrane permeability that regulates the nutrient supply available to invading pathogen. The lower concentration of Ca in the diseased leaves of both the cultivars may attribute to susceptibility.

The diseased cane leaves of both the cultivars contained less Mg than normal ones (Table 1). The decrease in Mg content may be due to greater concentration of K as it inhibits the uptake of Mg (Huber, 1980). The results support the reports of Padmanaban *et al.* (1988).

The effects of white leaf disease on Fe, Mn, Zn & Boron

Diseased leaves found to contain significantly higher amount of Fe compared to the healthy ones (Table 1). The results are in conformity with the observation of Srivastava *et al.* (1987) and Dhumal and Nimbalkar (1982). They observed that the leaves of grassy shoot disease infected sugarcane plant contained 13 to 139% higher quantity of Fe compared to healthy ones. More or less similar results were also reported by some other workers (Kulkarni and Kulkarni, 1978, Hedge and Mungal, 1971). It was reported that increased Fe content facilitates the disease development and respiration (Hedge and Mungal, 1971). The observation made by Shukla *et al.* (1988) supported the result of Chen and Kong (1976) who reported that the rate of respiration was much higher in the WLD infected sugarcane plants compared to healthy ones. The leaves of WLD infected plants though appear chlorotic but contained higher quantity of Fe. In these leaves iron may exist in physiologically inactive state. Increased P content in diseased cane leaves may cause inactivation of Fe and results in its accumulation (Brown, 1976).

Diseased leaves contained significantly lower quantity of Mn. The results are in concurrence with the observations made by Rao (1984) and Dhumal and Nimbalker (1982) who reported about the lower concentration of Mn in the GSD infected plants. Infection has an adverse effect on Mn content in leaves, which was observed by a group of workers (Ghorpade and Joshi, 1981, Sankpal and Nimbalker, 1980). Manganese participates in chlorophyll synthesis and sucrose metabolism. Under Mn deficient condition, correlation exists between Mn content and the degree of albinism (Singh *et al.*; 1967). So, it appears that in WLD infected leaves, the lower concentration of Mn may impair chlorophyll synthesis, which result albinism of leaves. In the present investigation an inverse correlation between Mn and Fe were also observed in the diseased leaves (Table 2).

Zinc was found to increase significantly in the diseased leaf tissue compared to healthy checks (Table 1). Zinc plays an important role in auxin synthesis (Huber, 1978). Virus infection increases Zn content (Bamberg, 1976). The accumulation of Zn in WLD infected cane leaves may result in hyper auxinity that may cause excessive tillers and premature lateral bud proliferation, the diagnostic characters of this diseases as described by Dhumal and Nimbalker (1982).

Boron was found to increase in the diseased leaves compared to healthy check. Humbert (1963) reported that the optimum values of B in leaves of sugarcane are 7 ppm. It was also reported that B limits the uptake of Ca (Huber, 1980). In the present study, results regarding increase of B and decrease of Ca content in the diseased plant support this view. Disturbed B/Ca balance may be one of the causes for disturbed carbohydrate metabolism in diseased sugarcane plant.

The effect of white leaf disease on P/Fe, K/Ca and Mn/Fe ratio

In the present investigation it was found that the ratios of P/Fe, K/Ca and Mn/ Fe in the white leaf disease infected leaves of sugarcane changed drastically from their healthy check. (Table 2) Ratios of P/Fe in the healthy leaves of Isd 16 and Isd 20 were respectively 10.94 and 15.18, which changed to 5.27 and 7.76, respectively in their diseased leaf tissues. Ratios of K/Ca increased in the diseased leaves of both the cultivars. Disease infected leaves showed much less ratios of Mn/Fe compared to their healthy check in both the cultivars (Table 2). Disturbed mineral nutrition observed in the white leaf disease infected sugarcane leaves corresponds with the observation made by Huber (1978) who reported disturbed mineral nutrition is one of the most common effects of plant disease.

Table 1: Effects of white leaf disease on different nutrient element accumulation in the Leaves of sugarcane varieties Isd 16 and Isd 20.

	Comparison between healthy and diseased plants		Comparison between healthy and diseased plants	
Nutrient elements1	Isd 16		Isd 20	
	Healthy	**Diseased**	**Healthy**	**Diseased**
Nitrogen (Ammonium %)	1.635	1.475**	1.667	1.605*
Phosphorous (P_2O_5 %)	0.197	0.353**	0.248	0.339*
Sodium (ppm)	570	650*	400	960**
Potassium (%)	1.213	1.583**	1.20	1.553**
Calcium (%)	0.393	0.35	0.43	0.397
Magnesium (%)	0.25	0.197*	0.29	0.26
Iron (Fe)(ppm)	180	670**	163.33	436.67**
Manganese (ppm)	49.833	32.5**	53.5	3.833**
Zinc (ppm)	55.667	63.333*	49.00	59.00*
Boron (ppm)	9.00	12.00**	9.63	10.85

* Significantly different from healthy (control) at 5% level of probability.
** Significantly different from healthy (control) at 1% level of probability.
1 Mean of three replicates.

Table 2: Ratios of Phosphorus / Iron, Potassium / Calcium and Manganese/ Iron in healthy and white leaf disease infected sugarcane leaf.

Varieties	Material	Ratios		
		P/Fe	K/Ca	Mn/Fe
Isd 16	Healthy	10.94	3.08	0.28
	Diseased	5.27	4.52	0.048
Isd 20	Healthy	15.18	2.79	0.33
	Diseased	7.76	3.91	0.077

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