BRIEF COMMUNICATION

The combined effects of acidification stress and kinetin on chlorophyll content, dry matter accumulation and transpiration coefficient in *Sorghum bicolor* plants

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Abstract

Increasing soil acidity (from pH 6.5 to pH 2.0) decreased chlorophyll (Chl) *a* and *b* contents, dry matter accumulation by plants and the transpiration coefficient. Chl stability to heat significantly increased with increased soil acidity. The Chl *a/b* ratio was increased significantly at pH 5 and 4 and decreased at pH 3 and 2. Spraying *Sorghum* shoots with kinetin solutions counteracted the above adverse effects on Chl content and dry matter accumulation. Kinetin-treated plants showed a lower transpiration coefficient than the untreated plants.

Acidification of root environment associated with the effects of acid rain is mostly evaluated as a nutrition and root growth problem (Ulrich *et al.* 1980). Nevertheless, increasing soil acidity also decreased Chl *a* and *b* contents (potato - Abdullah and Ahmad 1983, wheat - Grevby *et al.* 1987). Essentially less attention has been paid to the direct effect of acidification on phytohormones, the content of which decreases except ethylene and abscisic acid. The acidification of root environment leads to changes in the content of endogenous cytokinins (Čížková 1990); the induced Chl degradation may be improved by application of 6-benzylaminopurine (Čížková 1992).

As pointed out by Pilet and Hoffer (1966), kinetin may have two effects on Chl: (1) it increases Chl accumulation (*e.g.* Sugiura 1963, Banerji and Laloraya 1967), namely by stimulating the synthesis of protochlorophyllide (Stobart *et al.* 1972, Shlyk and Averina 1973, Bengtson *et al.* 1977) and (2) it inhibits Chl degradation (Osborne and McCalla 1961), *e.g.* by affecting chlorophyllase activity (Sabater and

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Abbreviations: Chl - chlorophyll, CSI - chlorophyll stability index, d.m. - dry mass, f.m. - fresh mass.

Rodriquez 1978). The present investigation tried to find out the combined effect of acidity and kinetin treatment on Chl and dry matter contents and transpiration coefficient.

Sorghum (*Sorghum bicolor* L. cv. Dorado) plants were grown under field conditions in plastic pots containing 1.4 kg air dry soil (sand/clay 2:1 v/v). The plants (five per pot) were twice watered with 100 cm^3 portion of full strength Hoagland solution (Hoagland and Arnon 1950). When seedlings were 6 weeks old, the soil was acidified using H_2SO_4 giving pH of soil staturation extract 2, 3, 4, 5 and 6.5 (control). For each pH level, three pots were assigned at random. The pots were irrigated periodically to keep them at their field capacity. After two weeks, plant shoots were sprayed with kinetin solutions (0, 5, 10 and 15 g m^{-3} three times at 5 d intervals). A week after the last kinetin application, plants were used for analysis.

Chl *a* and *b* content was determined according to Todd and Basler (1965). Chl stability to heat was assessed according to Murty and Majumder (1962), and the Chl stability index (CSI) was modified as follows:

$$\text{CSI} = \frac{\text{Chl content in heated sample}}{\text{Chl content in fresh sample}} \times 100$$

For dry matter determination the plants were dried in an aerated oven at 70 °C to constant mass. Transpiration coefficient (dry matter/transpiration rate) was calculated according to Chang (1968).

In absence of kinetin the increasing soil acidity highly significantly decreased the Chl *a* and *b* contents (Table 1). Kinetin treatments increased Chl content in both

Table 1. Average values of chlorophyll (Chl) content, Chl *a/b* ratio, Chl stability (CSI) to heat, dry mass content [g kg^{-1}(f.m.)], and transpiration coefficient [kg(H_2O) kg^{-1}(d.m.)] in *Sorghum* at different pH levels and kinetin concentrations.

Parameter	Kinetin [g m^{-3}]					L.S.D.	
	pH	0	5	10	15	1 %	5 %
Chl *a*	6.5	1.65	1.76	2.06	2.22	0.18	0.12
[g kg^{-1}]	5	1.19	1.48	1.56	1.59	0.33	0.23
	4	1.27	1.40	1.35	1.91	0.18	0.12
	3	0.97	1.41	1.51	1.62	0.29	0.20
	2	0.75	1.66	1.75	1.61	0.39	0.27
L.S.D.	1 %	0.24	0.22	0.21	0.38		
	5 %	0.17	0.16	0.14	0.27		
Chl *b*	6.5	1.27	1.30	1.33	1.35	0.14	0.09
[g kg^{-1}]	5	0.77	1.10	0.89	1.01	0.36	0.24
	4	0.84	0.97	1.05	1.18	0.32	0.22
	3	0.86	1.06	1.02	1.22	0.38	0.26
	2	0.59	1.14	1.09	1.13	0.24	0.16
L.S.D.	1 %	0.27	0.30	0.27	0.33		
	5 %	0.19	0.21	0.19	0.23		

(continued)

Table 1. (continued)

Chl *a/b*	6.5	1.31	1.36	1.554	1.57	0.17	0.12
	5	1.61	1.36	1.76	1.59	0.38	0.27
	4	1.55	1.45	1.20	1.62	0.33	0.24
	3	1.20	1.33	1.49	1.34	0.34	0.23
	2	1.27	1.37	1.61	1.43	0.41	0.28
L.S.D.	1 %	0.32	0.17	0.34	0.32		
	5 %	0.22	0.12	0.24	0.22		
CSI for Chl *a* [%]	6.5	75.10	71.01	67.83	65.64	8.80	6.05
	5	72.10	93.39	91.44	84.40	11.16	7.67
	4	87.52	90.02	97.05	86.31	8.09	5.38
	3	81.47	97.12	73.83	84.41	9.00	5.98
	2	95.27	69.13	75.00	76.30	10.28	7.07
L.S.D.	1 %	8.11	9.81	10.13	7.72		
	5 %	5.70	6.89	7.12	5.43		
CSI for Chl *b* [%]	6.5	71.66	54.34	67.56	66.05	10.79	7.41
	5	81.37	86.49	84.74	81.27	7.11	4.89
	4	84.28	94.35	75.87	84.03	8.95	6.15
	3	55.98	76.28	68.42	73.19	7.98	5.48
	2	84.96	53.88	70.31	71.07	6.77	4.65
L.S.D.	1 %	10.99	8.49	5.73	7.55		
	5 %	7.73	5.97	4.02	5.31		
Dry mass content [g kg^{-1}(f.m.)]	6.5	3.12	3.37	3.81	3.97	0.79	0.55
	5	2.69	3.74	3.96	4.21	0.83	0.57
	4	2.52	3.03	3.60	4.25	0.62	0.43
	3	2.36	3.16	3.56	3.52	0.80	0.56
	2	2.22	3.12	3.71	3.65	0.59	0.41
L.S.D.	1 %	0.73	0.71	0.86	0.81		
	5 %	0.51	0.50	0.60	0.57		
Transpiration coefficient [kg(H_2O) kg^{-1}(d.m.)]	6.5	8.77	8.20	7.56	7.29	0.68	0.47
	5	8.26	7.66	7.35	7.05	0.65	0.45
	4	8.02	7.89	7.03	7.42	0.73	0.50
	3	8.73	7.41	6.54	5.51	0.95	0.65
	2	7.42	7.74	7.26	6.65	0.93	0.64
L.S.D.	1 %	0.84	0.75	0.88	0.90		
	5 %	0.59	0.53	0.62	0.63		

unstressed (pH 6.5) and stressed plants (statistically insignificant were only the differences at pH 4 and 6.5 at the lower kinetin applications). Chl *b* content was enhanced significantly by the 5 g m^{-3} kinetin treatment over the pH range 6.5 to 2. In the absence of kinetin, the Chl *a/b* ratio increased significantly at pH 5 and 4, but it decreased at pH 3 and 2. The effect of kinetin on this ratio was variable; most effective was the concentration 10 g m^{-3} (except at pH 4). In the absence of kinetin, there was an increasing trend in Chl *a* and *b* stability to heat with increasing soil acidity except at pH 2 (Chl *a*) and pH 3 (Chl *b*). No definite pattern was observed in the CSI response to kinetin (see Table 1).

Dry matter accumulation by the plants decreased progressively with decreased pH; the decrease was significant at pH 4 and highly significant at pH 3 and 2. Kinetin treatment induced an increase in dry matter accumulation; the increase was significant at all acidities except at pH 6.5 with 5 g(kinetin) m^{-3}. The highest used kinetin concentration was generally the most effective one.

Kinetin treatment and/or increased soil acidity decreased the transpiration coefficient except at pH 2 with the lowest kinetin concentration.

The found decrease in Chl *a* and *b* contents in response to acidification is in agreement with the findings of Abdullah and Ahmad (1983) and Grevby *et al.* (1987). The enhanced Chl content induced by kinetin treatment is in agreement with findings of Gadallah (1986 and 1990). This enhancement was higher in highly stressed plants (pH 2) than in the control plants (pH 6.5), which may be an outcome of the combined effects of kinetin and acidification on both Chl synthesis or degradation and chloroplast development (Stetler and Laetsch 1965), replication (Rosalinda *et al.* 1971) or senescence (Woolhouse 1967).

Kinetin-treated plants generally produced more biomass than the untreated plants; the kinetin effect may be either direct *e.g.* on protein synthesis (Parthier and Wollgiehn 1961, Osborne 1962) or mediated by enhanced photosynthesis (as shown in Chl contents).

Transpiration coefficient may be the sole parameter estimated in this investigation which reflects the combined effects of kinetin, namely, increasing transpiration and preserving Chl integrity. Kinetin treatment decreased the transpiration coefficient in both the unstressed and stressed plants.

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