HYDROXAMIC ACID CONTENT OF TRITICUM SPECIES

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INDEX WORDS

Triticum, hydroxamic acids, 1,4-benzoxazin-3-ones, plant resistance, wheat breeding

SUMMARY

Fifty-five accessions of Triticum species were analyzed for content of hydroxamic acids (Hx), a natural resistance factor against various organisms. Hx were found in all accessions analyzed. Extreme values were found in wild diploid species: highest in T. speltoides (16.0 mmol/kg fr. wt) and lowest in T. tauschii (0.21). Modern polyploid wheats sharing the same genome did not show substantial variations in Hx levels. The data suggest possible sources of high Hx levels for wheat breeding programs.

INTRODUCTION

Host plant resistance plays a key role in the control of pest populations in crops. Extracts of cereals such as wheat, maize and rye contain hydroxamic acids (Hx, 1)

which are claimed to be involved in resistance of wheat to stem rust, Puccinia graminis (ELNAGHY & LINKO, 1962), and to the aphids Metopolophium dirhodum (ARGANDOÑA et al., 1980, 1981), Schizaphis graminum (ARGANDOÑA et al., 1983) and Sitobion avenae (BOHIDAR et al., 1986) and to contribute to resistance of maize to fungal disease (BEMILLER & PAPPELIS, 1965; LONG et al., 1975; TOTH TOLDI, 1984), and to insect attack (KLUN et al., 1967; LONG et al., 1977; BECK et al., 1983).

In maize, breeding for high Hx levels has been suggested (KLUN et al., 1970; CABULEA et al., 1977; GAHUKAR, 1979; KOSTANDI et al., 1981), and the inheritance of Hx and sources of suitable parental material have been studied (DUNN et al., 1981; SIMCOX & WEBER, 1985).

We herein report Hx levels of several Triticum species and suggest sources of high Hx levels for wheat breeding programs.

MATERIALS AND METHODS

Plant material. Seed samples were obtained from USDA--Beltsville and from INIA-Chile. Plants were grown in a greenhouse under permanent light at ca. 26° with an 8° range, and harvested at different times according to the experiment.

Quantitation of hydroxamic acids. The method employed was essentially as described (BOHIDAR et al., 1986). Plant

tissue (0.2 to 1.5 g) was macerated with mortar and pestle in water (3 x 2 ml), filtered through cheesecloth and left 15 min at room temperature. The extract was adjusted to pH 3 with 1 M HCl and centrifuged at 10,000 g for 10 min. The supernatant was extracted with Et_2O (3 x 6 ml) and the organic phases evaporated to dryness. Ferric chloride reagent was added (3 ml) and absorbance was measured at 590 nm. Hx concentration was obtained by comparison with a standard curve made with DIMBOA. Values reported are averages of at least 3 replicate determinations which agreed within 10 per cent.

Hx levels determined by this method have been shown to closely correspond to the sum of individual hydroxamic acids determined by specific methods (WOODWARD et al., ZUÑIGA et al., 1983).

RESULTS

Table 1 shows Hx content data for the accessions analyzed. Typical determinations of Hx levels are shown in Table 2 for T. compactum.

Hx levels in wheat vary with the developmental stage of the plant (ARGANDOÑA et al., 1981). The variation of Hx levels at 2 plant ages was determined for a few of the accessions studied (Table 3). The results show that decrease of Hx levels were comparable in all the accessions studied, with the exception of T. monococcum.

For the comparisons in Tables 1 and 2, ten-day-old seedlings were analyzed, since at that age variation of Hx with age is smaller than in younger seedlings, but still reasonable amounts of tissue for analysis may be readily obtained.

DISCUSSION

Development of maize varieties with increased host plant resistance based on breeding for higher Hx levels has been suggested (KLUN *et al.*, 1970; CABULEA *et al.*, 1977; GAHUKAR, 1979; KOSTANDI *et al.*, 1981). Similar suggestions may be put forward for wheat resistance. In this case, availability of suitable germplasm must first be evaluated.

T. speltoides showed the highest Hx level among the accessions analyzed (Table 1). Interestingly, resistance towards biotype E greenbug (*S. graminum*) in wheat streak mosaic virus-resistant wheat lines was claimed to be derived from *T. speltoides* (TYLER *et al.*, 1985). Furthermore, persistance of Hx in older plants of *T. monococcum* (Table 1) may be related to the higher resistance to the aphids *M. dirhodum* and *S. avenae* reported, as compared with accessions of *T. dicoccum*, *T. spelta* and *T. aestivum* (SOTHERTON & VAN EMDEN, 1982).

Modern wheats are amphipolyploids containing different combinations of genomes G, A, B, and D, as

shown in Fig. 1 (SCHMIDT, 1974; BRIGGLE, 1980). It may be suggested from Fig. 1 that the unknown wild diploid species contributing genome B may contain high Hx levels. It would be desirable to test this prediction on T. searsii, recently claimed as the B genome donor (THOMPSON & NATH, 1986). Additionally, the present results indicate that substantial increases in Hx levels are unlikely to be attained by hybridization within a set of wheats sharing the same genomes. Furthermore, they show that largest differences in Hx levels occur upon changes of ploidy. It would seem desirable to produce amphipolyploidy utilizing the wild species possessing the G and B genomes (Fig. 1).

Wild relatives of wheat have been extensively used as genetic sources for resistance towards various organisms through wide hybridization (SHARMA & GILL, 1983). Hence, it would be desirable to search for sources of high Hx levels in species of the subtribe Triticinae, in which intergeneric hybridization with wheat is readily achieved (DEWEY, 1984). This approach has already shown promise: a screening of several wild Gramineae showed that Elymus gayanus contains relatively high Hx levels (ZUÑIGA et al., 1983).

Hydroxamic acids are involved in the detoxification of atrazine-derived herbicides (HAMILTON, 1964). Hence, in addition to increasing host plant resistance to fungal

and insect attack, an increase in Hx levels could bring increased differential tolerance to these herbicides.

Finally, it should be pointed out that an increase in the level of toxic hydroxamic acids in wheat pose no threat to human consumption, since Hx are not present in the grain (ARGANDOÑA et al., 1981).

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Table 1. Hydroxamic acid content of *Triticum* species[a]

Species	n[b]	Range of Hx (mmol/kg fr. wt)	Mean Hx
T. aestivum	4	0.69 - 2.0	1.4
T. araraticum	2	2.1 - 3.5	2.8
T. boeoticum	1	0.52	0.52
T. carthlicum	3	3.5 - 4.5	3.8
T. compactum	5	1.2 - 2.8	1.9
T. dicoccum	4	4.1 - 6.1	5.1
T. durum	2	3.6 - 4.9	4.2
T. macha	2	1.6 - 2.5	2.0
T. monococcum	4	0.26 - 1.7	0.62
T. polonicum	3	3.8 - 6.2	5.3
T. spelta	5	1.6 - 3.4	2.5
T. speltoides	5	12.4 - 16.0	14.3
T. sphaerococcum	4	2.6 - 3.4	2.9
T. tauschii	3	0.21 - 0.46	0.37
T. timopheevi	4	1.3 - 2.9	2.5
T. turgidum	4	2.6 - 6.4	4.7
T. zhukovskyi	1	1.8	1.8

[a] Ten-day old seedlings were analyzed.

[b] Number of accessions studied.

Table 2. Hx levels in 10-day-old seedlings of 5 accessions of *T. compactum*

PI Number	n[a]	Hydroxamic acids[b] (mmol/kg fr. wt)
341432	4	1.72 ± 0.13
352288	4	2.77 ± 0.13
352314	3	1.21 ± 0.12
352319	3	2.17 ± 0.11
372151	4	1.44 ± 0.08

[a] Number of replicates.

[b] Mean ± standard deviation.

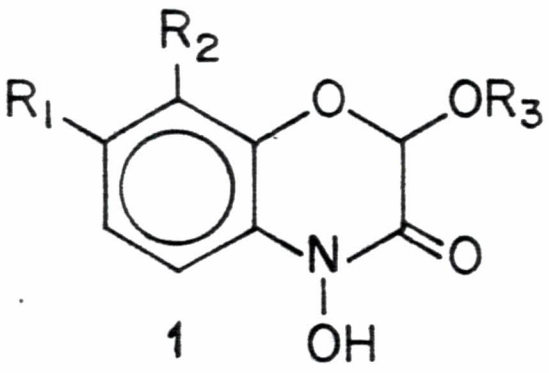
Table 3. Variation of Hx content with plant age in *Triticum* species

Species	PI number	Hydroxamic acids (mmol/kg fr. wt)		Decrease in Hx (%)
		Plant age		
		6-day	10-day	
T. carthlicum	94754	6.50	3.24	50
T. compactum	352288	5.77	2.23	61
T. macha	428179	5.54	1.95	65
T. monococcum	168804	0.72[a]	0.58[a]	19
T. polonicum	290512	7.87	4.80	39
T. spelta	348474	6.74	3.77	44
T. sphaerococcum	4531-0	4.74	2.26	52
T. turgidum	91673	5.36	2.35	56

[a]Numbers do not differ significantly (P= 0.05).

Legend to Figure

Fig. 1. Mean hydroxamic acid levels along the evolutionary development of wheat. Hexagons= hexaploid wheats; rectangles= tetraploid; truncated circles= diploid..



1

R_1 = H or CH_3O

R_2 = H or CH_3O

R_3 = H or Glucosyl

DIMBOA : $R_1 = CH_3O, R_2 = R_3 = H$

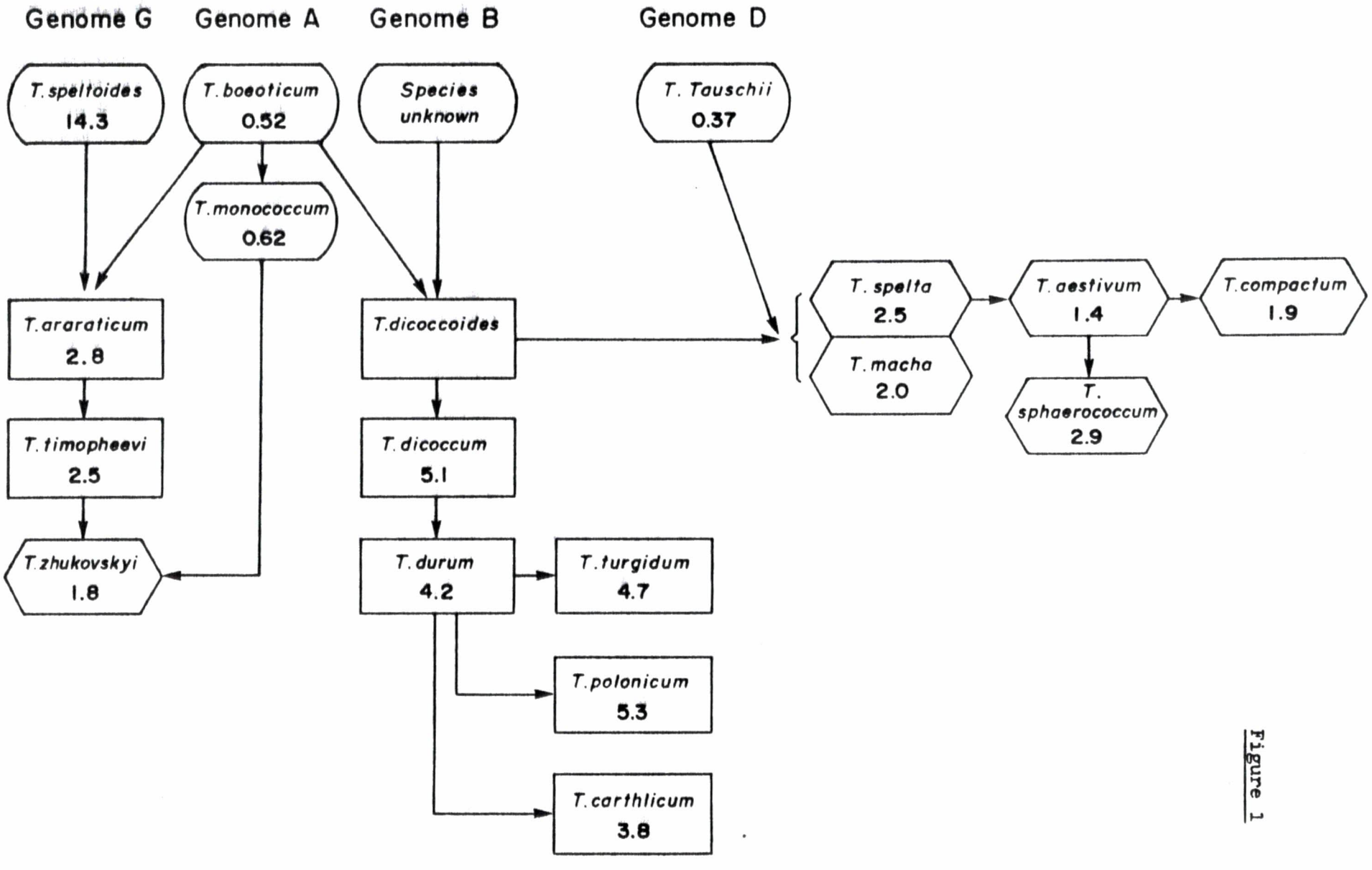

Genome G
Genome A
Genome B
Genome D
T. speltoides
14.3
T. boeoticum
0.52
Species unknown
T. Tauschii
0.37
T. monococcum
0.62
T. araraticum
2.8
T. dicoccoides
T. spelta
2.5
T. aestivum
1.4
T. compactum
1.9
T. macha
2.0
T. sphaerococcum
2.9
T. timopheevi
2.5
T. dicoccum
5.1
T. zhukovskyi
1.8
T. durum
4.2
T. turgidum
4.7
T. polonicum
5.3
T. carthlicum
3.8

Figure 1