Sci. Annals, Fac. Phys. & Mathem., Univ. Thessaloniki, 20a, 9 (1980)

PRESERVATION AND HEREDITY OF TOLERANCE AGAINST HEAVY METALS IN *AGROSTIS TENUIS* Sibth. PLANTS:

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(Received 15.5.1980)

Abstract : *The character of tolerance that plants collected from toxic soil show against other toxic metals is placed under study. It was seen that these plants maintain their tolerance only against the eorrespondingly eollected metals and may keep this property unchangeable for more than 20 years. Crosses between tolerant and non-tolerant genotypes against Cu have demonstrated that the seleeted character of tolerance can be inherited. It is finally shown that the manifestation of tolerance against a metal does not neeessarily mean tolerance against metals which were not collected and used in our experiment.*

INTRODUCTION

At mine waste and the immediate environment of industries where heavy metals are being manufactured, heavy metals such as Cu, Zn, Pb, Ni, etc. are to be almost always found in small or larger amounts. These are toxic to most plant species. The result of this toxicity is a limited floral variety. However, there are certain species which develop satisfactorily under unfavourable edaphic conditions as tolerant ecotypes against heavy metals (Turesson 1922, Gregor 1944, Bradshaw 1952).

The ability of these ecotypes to settle in toxic areas is probably attributed to their property of developing various mechanisms of tolerance against the particular ecological factors (in our case the presence of high concentrations of heavy toxic metals) which are responsible for this suspension in growing (Antonovics et al. 1971, Snaydon 1970, Wu et al. 1975a, b, Mathys 1975, 1977, Karataglis 1980 c, d).

It has been ascertained that in such adjusted to heavy metals tolerant plant ecotypes a variation degree fluctuating on several levels has manifested itself among populations or even among indivi-

duals of one and the same population (Karataglis 1978a, b, 1980b). The seeds forming from these individuals or these populations continue to maintain similar or almost the same tolerance to the one the progeny showed. (Gregory and Bradshaw 1965). Such a fact is a clear evidence that tolerance against toxic metals happens to be a hereditary property. Since the experiments were carried out by employing tolerant plants which had been cultivated on normal soil for a relatively limited period of time, the question of whether and how long they were going to preserve this tolerance after a prolonged cultivation on normal soil, soon arose.

We have endeavoured to pilot our work toward this direction by using *Agrostis tenuis* plants selected from two different mines.

MATERIALS AND METHODS

Agrostis tenuis plants collected from two different mines, from Parys Mountain (ecotypes tolerant only to Cu) and from Goginan mine (ecotypes tolerant to Zn/Pb) in N.Wales, were submitted to the Welsh Plant Breeding Station, Aberystwyth, after their tolerance had been tested. These plants had been cultivated for 20 perpetual years on non-toxic soil. Seeds coming from these plants were used for our experiments. Material recently selected from the two corresponding mines made a comparison with the ones deriving from the seeds feasible, while materials from non-toxic areas were used as pasture.

All plant samples were grown on soils differing in origin:

1-. Normal soil (John Innes No 1).

2-. Soil coming from Parys Mountain mine, with a 480 ppm in Cu concentration and

3-. Soil selected from Goginan mine of 590 ppm in Zn and Pd concentrations.

Each of these three series of experiments were repeated 3 times over and the given values made the average of our measurements.

The checking of tolerance was performed by means of a rooting test which is described in detail in other papers (McNeilly and Bradshaw 1968, Karataglis 1976, 1978a, b, c, 1980a, b).

An analysis of the rizosphere soil in recent samplings has given us the right to know the concentration of the toxic metals found in their immediate environment. The soil analysis was carried out by me-

ans of a Unicam SP 90 atomic absorption spectrophotometer. The detailed process is being described in another paper (Karataglis 1978b).

Finally, crosses between tolerant and non-tolerant genotypes enabled a further verification of the fact that tolerance against Cu can be inherited. The index of tolerance of the non-tolerant genotype against Cu was 6,8% while the one of the tolerant was 38,6%. The springs of progeny F_1 and F_2 were checked by employing the rooting test method employied and the variability of their tolerance was evaluated.

RESULTS

An examination of the results (Tables I, II, III) has shown that none of the pasture populations developed on non-toxic soil presented any tolerance against Cu, Zn or Pb, as it had been expected (Table I).

TABLE I

Results from plants grown on normal soil (J. Innes).

	Pasture populations		
	Cu	Zn	Pb
$S/J.I_7$	7,49	7,27	5,79
$S/J.I_{57}$	6,99	6,39	5,02
$T/J.I_{27}$	6,88	5,24	4,42
$T/J.I_{52}$	4,16	7,55	5,78
	Plants tolerant to Cu		
$P/J.I_3$	38,25	5,88	6,09
$P/J.I_{28}$	43,77	5,78	7,81
$PW/J.I_{15}$	42,88	6,62	5,61
$PW/J.I_{49}$	49,64	6,42	5,72
	Plants tolerant to Zn/Pb		
$G/I.J_2$	8,24	41,89	16,19
$G/J.I_{58}$	6,96	47,07	17,14
$GW/J.I_{11}$	8,30	43,38	18,76
$GW/J.I_{29}$	7,10	48,60	20,40

S/J.I and T/J.I Pasture populations growing on normal soil (J. Innes).

P/J.I Plants deriving from seeds from the Welsh Plant Breeding Station tolerant to Cu and collected from Parys Mountain. These were grown on J. Innes normal soil.

PW/J.I Plants collected during the experiment from Parys Mountain mine and grown on normal soil.

G/J.I Plants coming from seeds from the Welsh Plant Breeding Station, tolerant to Zn/Pb and collected from Goginan mine. These were grown on J. Innes normal soil.

GW/J.I Plants collected during the experiment from Goginan mine and grown on normal soil (J. Innes).

TABLE II

Results from plants grown on Parys Mountain mine soil.

	Cu	Zn	Pb
	Pasture populations		
S/P_6	12,9	8,12	5,93
S/P_{50}	14,11	5,37	7,25
T/P_{18}	12,78	6,78	6,61
T/P_{47}	18,84	9,66	7,33
	Plants tolerant to Cu		
P/P_{12}	48,7	4,15	6,95
P/P_{55}	42,1	6,67	8,03
PW/P_1	52,4	6,0	5,49
PW/P_{26}	48,6	5,2	4,77
	Plants tolerant to Zn and Pb		
G/P_{44}	12,95	39,45	18,47
G/P_{46}	13,65	36,87	17,25
GW/P_{31}	12,80	42,28	19,55
GW/P_{41}	11,35	40,99	17,95

TABLE III

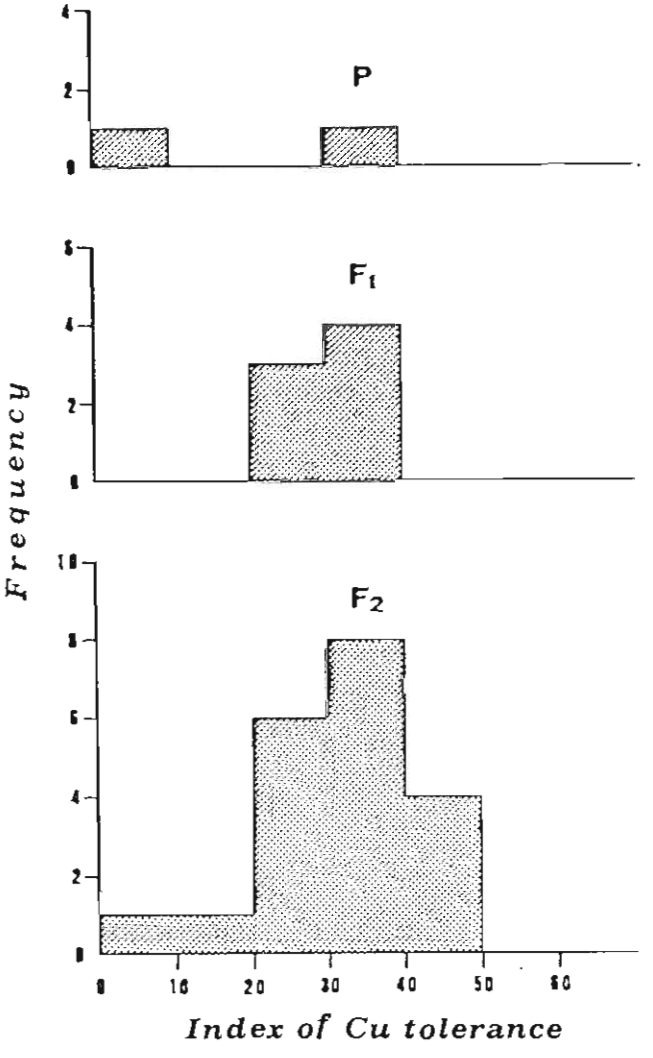
Results from plants grown on soil of Goginan mine.

	Cu	Zn	Pb
	Pasture populations		
S/G_{34}	5,82	13,9	9,12
S/G_{57}	5,49	15,2	10,66
T/G_{54}	6,83	17,23	12,55
T/G_{60}	4,22	15,26	11,68
	Plants tolerant to Cu		
P/G_{16}	39,88	13,71	10,81
P/G_{13}	38,17	13,74	10,04
PW/G_{20}	38,87	13,69	10,25
PW/G_{56}	48,63	17,96	9,70
	Plants tolerant to Zn and Pb		
G/G_{17}	8,95	44,68	16,49
G/G_{48}	9,61	42,90	15,82
GW/G_4	7,96	47,68	22,97
GW/G_{19}	6,99	48,96	18,96

When grown on soil collected from a Cu mine (Parys Mountain), however, they showed a relatively increased index of tolerance only against copper. (Table II). When again grown on mine soil with an

increased concentration in Zn and Pb (Goginan) they correspondingly demostrated a rather increased index of tolerance against Zn and Pb (Table III).

The tolerant to Cu genotypes of the Plant Breeding Station maintained the index of tolerance against Cu on considerably high levels, whereas the tolerance against Zn or Pb was found on the levels of the non-tolerant populations (Table I). But when tolerant to Cu genotypes are grown on Zn/Pb soil, they present relatively increased tole-



rance against Zn and Pb (compare Tab. I, II, III). Plants collected during the experiment from Parys Mountain mine (PW) showed a high index of tolerance only against Cu since they were grown on non-toxic soil (John Innes) or on a Cu mine soil. Yet, when grown on Zn/Pb mine soil these genotypes yielded a relatively increased index of tolerance against these metals (see Tab. III).

A correspondingly similar behaviour was demonstrated by several genotypes coming from Goginan mine (Zn/Pb).

Observations made upon crosses between a non-tolerant individual with an index of tolerance of about 6,8% and a tolerant to Cu one having an index of tolerance of about 38,6% have shown us the following: The seeds of the forst generation (F_1) gave individuals with an index of tolerance fluctuating between 20-40% (see Fig. 1) and with variability limits of about 40,2% for the highest value and 21,1% for the lowest. The second generation (F_2), however, presented a variability in the index of tolerance against Cu even higher, fluctuating between 8,9-48,6% (see Fig. 1).

DISCUSSION

It is clearly seen from the experimental facts (Tables I, II, III) that adjustment of selected plants preserves its tolerance against heavy metals even after a period of 20 years has elapsed. Due to the results from crosses between tolerant and non-tolerant genotypes we have concluded that tolerance against Cu is an inheritable trend.

Ecological factors, and in our case the soil toxicity, are likely to change the behaviour of the individuals (Barber 1964) by adjusting them to the environmental factors (ecotypes). Consequently populations developed in Cu mines were selected only against Cu while populations of Zn/Pb mines only against Zn and Pb. The development of tolerance of plauts in one or more toxic metals does not necessarily mean tolerance in other metals too which may either be completely absent from the soil or may be found in it in very low concentrations (Karataglis 1978a). When tolerant and non-tolerant genotypes are grown on soil toxic to another metal which never existed in their soil before, it is then possible for these genotypes to manifest a rather increased tolerance against that metal in a short period of time (see Bradshaw 1975 and Karataglis 1980d). It is thus obvious that the selection of the tolerance character is a relatively rapid process. The evolution of a well-adjusted population takes some generations before it can be fruitful in practice, though.

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ΠΕΡΙΛΗΨΗ

ΔΙΑΤΗΡΗΣΗ ΚΑΙ ΚΛΗΡΟΝΟΜΗΣΗ ΤΗΣ ΑΝΘΕΚΤΙΚΟΤΗΤΑΣ ΕΝΑΝΤΙ ΤΩΝ ΒΑΡΕΩΝ ΜΕΤΑΛΛΩΝ ΦΥΤΩΝ *AGROSTIS TENUIS* Sibth.

Ὑπὸ

Σ. ΚΑΡΑΤΑΓΛΗ

Ἐργαστήριο Βοτανικῆς Πανεπιστημίου Θεσσαλονίκης

Ἐρευνᾶται ὁ χαρακτήρας τῆς ἀνθεκτικότητας ἔναντι διαφόρων τοξικῶν μετάλλων γιὰ φυτὰ ποὺ ἐπιλέχθηκαν ἀπὸ τοξικὰ ἐδάφη (Cu ἢ Zn/Pb). Διαπιστώθηκε ὅτι τὰ φυτὰ αὐτὰ διατηροῦν τὴν ἀνθεκτικότητά τους μόνο στὰ ἀντίστοιχα μέταλλα ποὺ ἐπιλέχθηκαν χωρὶς ἡ ἰδιότητα αὐτὴ νὰ μεταβληθεῖ μέσα σὲ χρονικὸ διάστημα μεγαλύτερο ἀπὸ 20 χρόνια. Παράλληλα ἡ διασταύρωση μεταξὺ ἀνθεκτικῶν καὶ μὴ ἀνθεκτικῶν γενοτύπων ἔναντι του Cu, ἔδειξε ὅτι ὁ ἐπιλεγὴς χαρακτήρας τῆς ἀνθεκτικότητας κληρονομεῖται. Τέλος δείχνεται ὅτι ἡ ἐκδήλωση τῆς ἀνθεκτικότητας σὲ ἕνα μέταλλο δὲν συνεπάγεται ἀνθεκτικότητα καὶ σὲ ἄλλο ἢ ἄλλα γιὰ τὰ ὁποῖα δὲν ἐπιλέχθηκαν.