THE ROLE OF SEED SIZE IN THE NON-GENETIC VARIATION EXHIBITED IN SALT TOLERANCE STUDIES INVOLVING THE BREAD WHEAT CV. CHINESE SPRING

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ABSTRACT

The intention of this study was to confirm the role of seed size in the non-genetic variation exhibited during salinity tolerance experiments involving the bread wheat cv. Chinese Spring. The nutrient film/rockwool hydroponics technique was utilised. This study concluded that seed size does not play a significant role in the non-genetic variation generated during a study of salinity tolerance of the bread wheat cv. Chinese Spring.

KEY WORDS: Seed size, non-genetic variation, nutrient film technique, bread wheat cv. Chinese Spring.

INTRODUCTION

Physiological and genetical experiments investigating the salt tolerance of plants are often prone to variation. This variation can lead to difficulties in the interpretation of the results obtained from such experiments. Frequently, for example, within a salt treatment some plants of a genotype survive, while others die. To overcome this, Forster et al. (1990) attempted to preselect only seedlings of good vigour for testing, but this presents problems of how to quantify seedling vigour. Seed size in contrast, is a simple trait to measure. Carver (1977) working with wheat, found that seed size was closely correlated with final grain yield, as later confirmed by other studies (Rao 1980, Jha et al. 1985).

The aim of the present study was to confirm whether the interaction between seed size and biomass production at plant maturity when wheat is grown under saline conditions, reported by Grieve and Francois (1992), was evident when plants were grown under the hydroponics system described by Martin et al. (1994).

MATERIALS AND METHODS

The bread wheat *Triticum aestivum* cv. Chinese Spring was grown using the NFT (nutrient film technique) system described by Martin et al. (1994). Two plants were grown per 25x25x10cm rockwool block. The experiments were conducted in a lit greenhouse which was maintained at approximately 20°C. Illumination was provided by Osram HQI lighting. The two salt treatments consisted of 100mM NaCl/5mM

CaCl₂ and 200 mM NaCl/10 mM CaCl₂ plus optimized nutrient base, provided by 1g/l Sangral and 0.25g/l Fe-chelate. Due to the body of evidence available in the literature showing seed size to be positively correlated to biomass production and yield, it was not felt necessary to repeat this work by growing the plants under non-saline conditions. Seed weights were determined prior to germination. Initially, the seeds were classed into small (S) up to 25 mg, medium (M) 26-35 mg and large (L) 35-50 mg, as described by Main and Nafziger (1994). Each category was replicated sixteen times and arranged randomly for each treatment. At plant maturity, shoot dry weight and tiller number were recorded.

The results were analysed statistically with Genstat 5.

RESULTS

The effects of the salt treatments on shoot dry weight and tiller number are shown in Table 1. All seeds that germinated survived to plant maturity. At 100 mM NaCl/5 mM CaCl₂ there were no significant differences in either trait between the medium and small seed sizes. However, the large seed size category appeared to produce plants with greater shoot dry weight and tiller number. At 200 mM NaCl/10mM CaCl₂, there were no significant differences for either shoot dry weight or tiller number between any of the three seed size categories.

The effect of individual seed size upon the shoot dry weight and tiller number at maturity of plants grown at 100 mM NaCl/5 mM CaCl₂ and 200 mM NaCl/10 mM CaCl₂ is shown in Figures 1 and 2, respectively. The scattering of the data in both salt treatments reveal that the arbitrary division of seed

TABLE 1. The effect of seed size upon the mean shoot dry weight (DWT) and tiller number (TNO) of plants grown to maturity in saline media. The treatments consisted of 100mM NaCl/5 mM CaCl₂ or 200 mM NaCl/10 mM CaCl₂ plus optimized nutrient solution. S.E. – Standard Error.

	100 mM NaCl/5 mM CaCl ₂		200 mM NaCl/10 mM CaCl ₂	
Seed size	DWT (g)	TNO	DWT (g)	TNO
Small	9.9	3.8	1.8	1.1
Medium	9.6	4.1	1.4	1.0
Large	12.4	6.8	1.5	1.2
S.E.	2.70	1.36	0.50	0.22

Fig. 1. Scatter plot of shoot dry weight (g) and tiller number plotted against seed size for Chinese Spring plants grown until plant maturity at 100mM NaCl/5 mM CaCl₂ plus optimized nutrient solution. Shoot dry weights are shown by open icons and tiller number by closed icons.

Fig. 2. Scatter plot of shoot dry weight (g) and tiller number plotted against seed size for Chinese Spring plants grown until plant maturity at 200 mM NaCl/10 mM CaCl₂ plus optimized nutrient solution. Shoot dry weights are shown by open icons and tiller number by closed icons.

size into three categories gives a false picture of the relationship between seed size and biomass traits. A linear regression of seed size against shoot dry weight and tiller number shows that there is no significant correlation between seed size and either of these characters (see Figures 1, 2 and Tables 2, 3).

DISCUSSION

The simple ANOVA suggests that, when the plants are grown at 100mM NaCl/5 mM CaCl₂, larger seeds tended to produce greater shoot dry weight and significantly more tillers, in agreement with Grieve and Francois (1992). This however is not the case at 200 mM NaCl/10 mM CaCl₂. Seed size will inevitably vary within each category, and further stu-

TABLE 2. Linear regression analysis for tiller number and shoot dry weight (g) ($r^2 = 0.19$ ns and 0.03 ns respectively) for Chinese Spring plants grown at 100mM NaCl/5 mM CaCl₂, plus optimized nutrient solution until plant maturity. ** $p < 0.01$, ns Not significant. * indicates that degrees of freedom are lower than in Table 3 due to 4 seeds failing to germinate.

Variate: Tiller number Fitted terms: Seed size				
Source of Variation	d.f.*	s.s.	m.s.	v.r.
Regression	1	43.4	43.43	10.20**
Residual	42	178.8	4.26	
Total	43	222.3	5.17	
Variate: Shoot dry weight Fitted terms: Seed size				
Source of Variation	d.f.*	s.s.	m.s.	v.r.
Regression	1	18.8	18.79	1.23 ns
Residual	42	643.8	15.33	
Total	43	662.6	15.41	

TABLE 3. Linear regression analysis for tiller number and shoot dry weight (g) ($r^2 = 0.005$ ns and 0.03 ns respectively) for Chinese Spring plants grown at 200 mM NaCl/10 mM CaCl₂ plus optimized nutrient solution until plant maturity. ns Not significant.

Variate: Tiller number Fitted terms: Seed size				
Source of Variation	d.f.	s.s.	m.s.	v.r.
Regression	1	0.03	0.030	0.31 ns
Residual	46	4.45	0.098	
Total	47	4.48	0.095	
Variate: Shoot dry weight Fitted terms: Seed size				
Source of Variation	d.f.	s.s.	m.s.	v.r.
Regression	1	0.78	0.782	1.58 ns
Residual	46	22.78	0.495	
Total	47	23.56	0.501	

dy of the data indeed shows that the arbitrary categorization of seed size employed is misleading, since there is no correlation between absolute seed size and biomass at either salinity level. If the non-genetic variation is in part at least the result of variation in seedling vigour, then other factors influencing seedling vigour, apart from seed size, need to be considered. Among these are the physiological state of the seed, and the size of the embryo and/or the endosperm.

If seed size is not responsible for the observed variation in salt tolerance and the seeds employed for this experiment were in good condition (physiologically), then what is the cause of the observed non-genetic variation? Mozafar and Oertli (1993) showed that high root temperatures lead to poor plant growth under saline conditions, whilst plant growth was considerably better at lower root temperatures. It would be of interest to correlate block temperature within a treatment with the observed results. This will determine the role of within

treatment temperature gradients in the variation exhibited by the observed results.

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LITERATURE CITED

- CARVER M.F.F., 1977. The influence of seed size on the performance of cereals in variety trials. *Journal of Agricultural Science*. 61: 247-249.
- GRIEVE C.M., FRANCOIS L.E., 1992. The importance of initial seed size in wheat plant response to salinity. *Plant and Soil*. 147: 197-205.
- FORSTER B.P., PHILIPS M.S., MILLER T.E., BAIRD E., POWELL W., 1990. Chromosome location of genes controlling tolerance to salt (NaCl) and vigour in *Hordeum vulgare* and *H. chilense*. *Hereditas*. 65: 99-107.
- JHA B.N., SINHA S.K., SINGH J.N., 1985. Effect of seed size on yield of wheat (*Triticum aestivum*). *Seed Research*. 13: 24-27.
- MAIN M.A.R., NAFZIGER E.D., 1994. Seed size and water potential effects on germination and seedling growth of winter wheat. *Crop Science*. 34: 169-171.
- MARTIN P.K., HUMBLE J., KOEBNER R.M.D., 1994. The use of the nutrient film technique as a method for the assessment of plant response to salt stress in the cereals. *Acta Societatis Botanicorum Poloniae*. 63: 159-165, 1994.
- MOZAFAR A., OERTI J.J., 1993. Root temperature and salinity: interacting effects on tillering, growth, and sodium content of barley. *Tasks. Veg. Sci.* 28: 129-133.
- RAO S.K., 1981. Influence of seed size on field germination, seedling vigour, yield and quality of self-pollinated crops: A review. *Agricultural Review*. 2: 95-101.

WIELKOŚĆ ZIARNIAKÓW W NIEGENETYCZNEJ ZMIENNOŚCI PSZENICY CV. CHINESE SPRING TOLERANCYJNEJ NA ZASOLENIE

STRESZCZENIE

Celem badania było potwierdzenie roli wielkości ziarniaków w niegenetycznej zmienności, wykazanej w toku doświadczeń nad tolerancją na zasolenie pszenicy cv. Chinese Spring. Zastosowano hydroponiczną metodę cienkowieńcowej pożywki w połączeniu z węglą mineralną. Stwierdzono, że wielkość ziarniaków nie odgrywa istotnej roli w niegenetycznej zmienności spowodowanej tolerancją na zasolenie pszenicy cv. Chinese Spring.

SŁOWA KLUCZOWE: wielkość ziarniaków, zmienność niegenetyczna, metoda cienkowieńcowej pożywki, pszenica cv. Chinese Spring.