http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 1 (3): 159-162, 1998 *Research Article*

Heterotic Effects in Spring Wheat (*Triticum aestivum* L.) Under Saline Conditions

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Abstract
Heterotic effects in spring wheat was investigated using the six basic generations (P_1, P_2, F_1, F_2 and back crosses, BC_1 and BC_2) of cross between Alexandria (salt sensitive) and KRL1-4 (salt tolerant) varieties. Heterotic effects were greatly pronounced as F_1, means fall outside the parental range for all physiological and most of the agronomic traits except number of spikes per plant and average grain weight. The significantly different estimates of the dominance components in F_2 for Na^+, K^+, K^+/Na^+ ratio, number grains per spikes and grain weight per spike than that obtained from F_1 indicate spurious overdominance exhibited by the F_1 generation for these traits. Gene dispersion or non-allelic interaction or involvement of modifier are suggested from the transgressive segregation in the F_2 population. It is also suggested from the F_2 population frequency distributions for all traits that they were quantitatively inherited.

Key words: Wheat, Salinity, Ion content, Heterosis

Introduction
Salinity problems are especially prevalent and serious in irrigated lands in many parts of the world. It has been estimated that nearly 40 percent of world 's land surface can be categorized as having potential salinity problems. Pakistan has extensive areas of saline soils and the area of saline arable land is growing at the rate of 250 acres per day (Rozema, 1991). Biotic approaches to overcoming salinity problems have recently received considerable attention from many worker throughout the world. For successful increases in plant salt tolerance, breeding and selection techniques can be used (Epstein *et al*., 1980). This can be achieved if the traits associated with salt tolerance are genetically controlled and potentially heritable (Shannon, 1984). In addition patterns of inheritance (qualitative and or quantitative), the number of genes contributing to salt tolerance and the nature of gene action should be known.
Salt tolerance in wheat is associated with accumulation of inorganic ions (Begum *et al*., 1992; Gorham and Jones, 1990; Joshi *et al*., 1980; Sastry and Prakash, 1993) and in rice (Gregorio and Senadhira, 1993). However in this paper we report the genetic information, obtained by estimating the F_2 population frequency distribution and heterotic estimates of sorne, physiological and ergonomic traits.

Materials and Methods
A salt sensitive wheat variety, Alexandria (maintainer Twyford Seeds, Oxen, UK) and salt tolerant variety KRL1-4 (a selection with increased salt tolerance from the salt tolerant Indian Landrade Kharchia, supplied by Dr. S. Quarrie, Cambridge Laboratory, Norwich, UK), together with F_1, F_2 and backcrosses generated from their cross. Alexandria was the female parent in each case. These were tested at 100 mol m^3 NaCl in a glass-house on 22-01-1995. The seeds were pregerminated by using capillary matting in growth-room set at 20°C. Seedling were transplanted at the two leaf stage into hydroponic culture with plant-plant and row-row distances 3.5 and 6.0 cm respectively. The size of the pot was 52 x 35 x 16 cm. The total number of plants were 60 for each of the parents, 52 for F_1, 270 for F_2, 30 for BC_1 and 42 for BC_2. A Randomized Complete Block Nested Design with three replications was used. Salt stress was introduced in three increments over a five day period starting seven days after transplanting the seedlings. The salinized nutrient solution was renewed every two weeks and the water level in pots was maintained as required to replace losses by transpiration. A modified Long Ashton Solution (Hewitt, 1966) was used in combination with phostrogen (0.5 g L^{-1}, Phostrogen Ltd., Corwen, Clwyd, UK) to supply nutrients (Gorham *et al.*, 1984). Temperature was not controlled and natural day light was supplemented by mercury vapour bulbs to give a photoperiod of 16 h. Average temperature during the course of the experiment was 16.70°C. A youngest fully expanded fourth leaves were sampled 25 days after transplanting from 15 randomly selected plants per parent, 14 from F_1, 89 from F_2, 11 from BC_1 and 16 from BC_2. The leaves rinsed quickly in distilled water and blotted dry with tissue paper. The samples were placed in Eppendorf tubes and stored at -10°C. Cell sap was extracted following the method of Gorham *et al*. (1984). The cell sap was diluted with distilled water for the estimation of cations using an atomic absorption spectrophotometer. Chlorides were measured with an ion selective electrode (Microprocessor lonalyzer/901). All plants were harvested at maturity and main tiller height (cm) and number of spikes per plant were recorded. Total number of plants harvested were 40 from P_1, 46 from P_2, 27 from F_1, 230 from F_2, 23 from BC_1 and 36 from BC_2. The ears were detached and straw weight per plant (g), number

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of infertile spikelets per spike and number of fertile spikeiets per spike were recorded. Threshing was done by hand. Grain weight per spike (mg), number of grains per spike, grain weight per plant (mg), number of grains per plant and average grain weight (mg) were determined.
The coefficients for the additive and dominance $[h_1]$ and $[h_2]$ effects for the weighted least squares analysis of generation means are presented in Table 1. Weighted least square analysis (Mather and Jinks, 1982) was computed on the generation means, while other effects such as additive x additive, additive x dominance and dominance x dominance were ignored. The $[h_1]$ and $[h_2]$ were compared applying t test at 5 percent level of significance.

Table 1: Coefficients for the additive and dominance effects for the weighted least squares analysis of generation means

Generations	Parameters			
	M	[d]	$[h_1]$	$[h_2]$
P_1	1	1	0	0
P_2	1	-1	0	0
F_1	1	0	1	0
F_2	1	0	0	0.5
BC_1	1	0.5	0	0
BC_2	1	-0.5	0	0

m = means, [d] = additive, $[h_1]$ = dominance due to F_1 and $[h_2]$ = dominance due to F_2

Results and Discussion

The frequency distribution for Na^+, K^+, Cl, K^+/Na^+ ratio, yield and its components show near normal distributions in F_2 which also exhibited transgressive segregation. The F_1 means fall out side the parental range for all traits except number of spikes per plant and average grain weight (Fig. 1 to 4). Thus heterosis in F_1, was greatly pronounced. Which can arise any one of the following individually or in combination: overdonance, unidirectional dominance with gene dispersion, non-allelic interactions, maternal effects and seasonal effects or seed production environmental effects. Overdonance, unidirectional dominance with gene dispersion, non-allelic interactions were examined by model fitting on generation means and variances (Ahsan, 1996). There is no way to verify maternal effects in the present material as reciprocal crosses were not available for the analysis. Seasonal effects or seed production environmental, effects are verified by estimating the magnitude of dominance component from F_1, generation $[h_1]$ and comparing it with that estimated from F_1, generation $[h_2]$. The $[h_1]$ and $[h_2]$ will be homogeneous if the F_1 seeds did not differ in manifesting greater initial capital because the environment is specific to F_1, generation only. If $[h_1]$ $[h_2]$, the estimates of $[h_1]$ using the F_1, generation should be viewed very carefully. Thus, the heterotic effects need further investigation. $[h_1]$ was found to be significantly

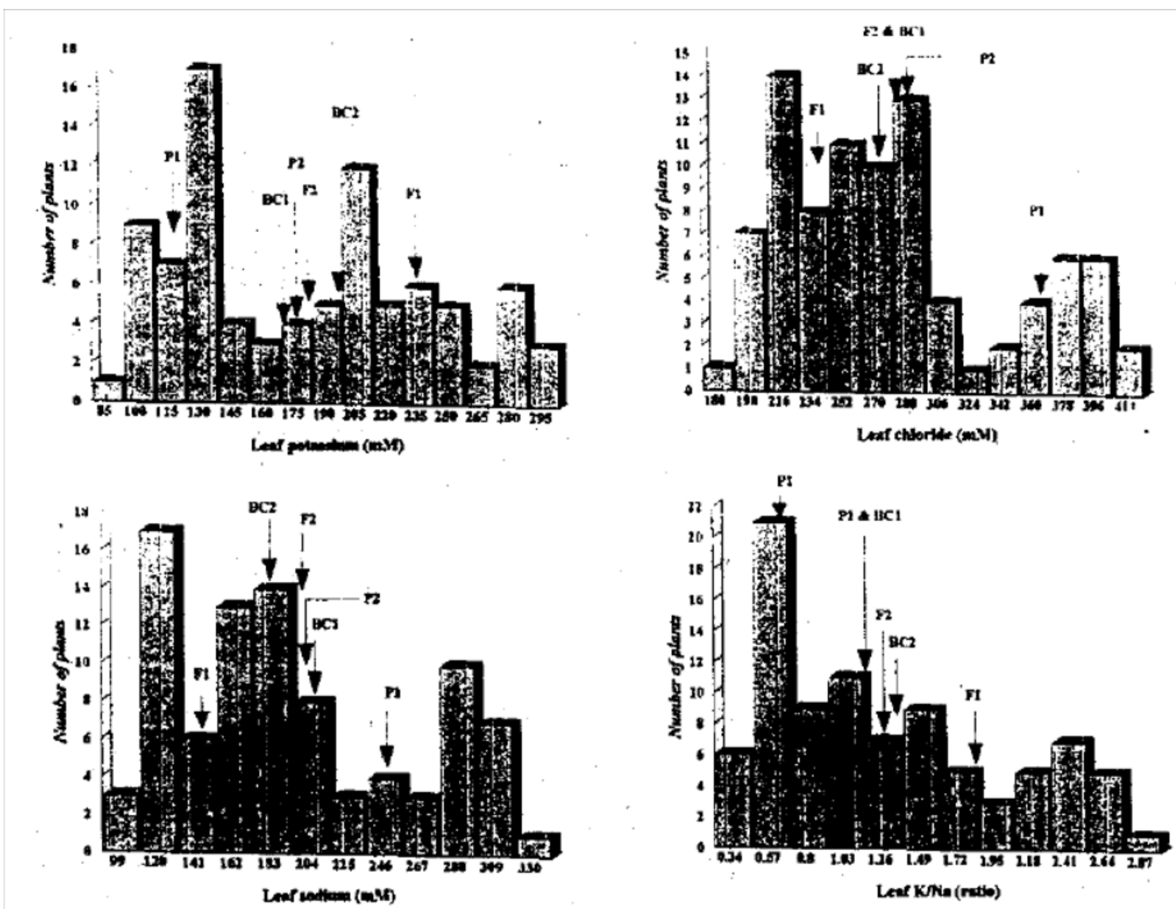

Fig. 1: Frequency distribution for content of potassium, sodium, chloride and K/Na ratio in sap of fully expended leaves of the F2 population. Arrows indicate generation means

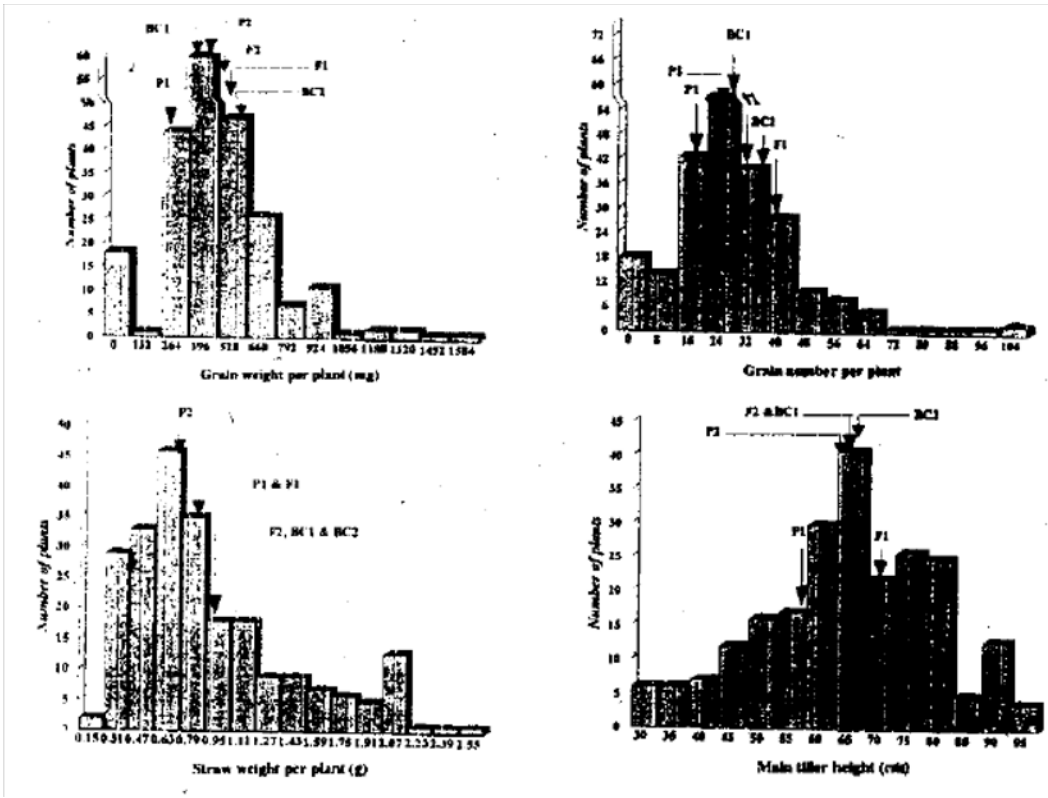

Fig. 2: Frequency distribution for gain weight per plant, grain number per plant, straw per plant and main title height of the F2 population. Arrows indicate generation means

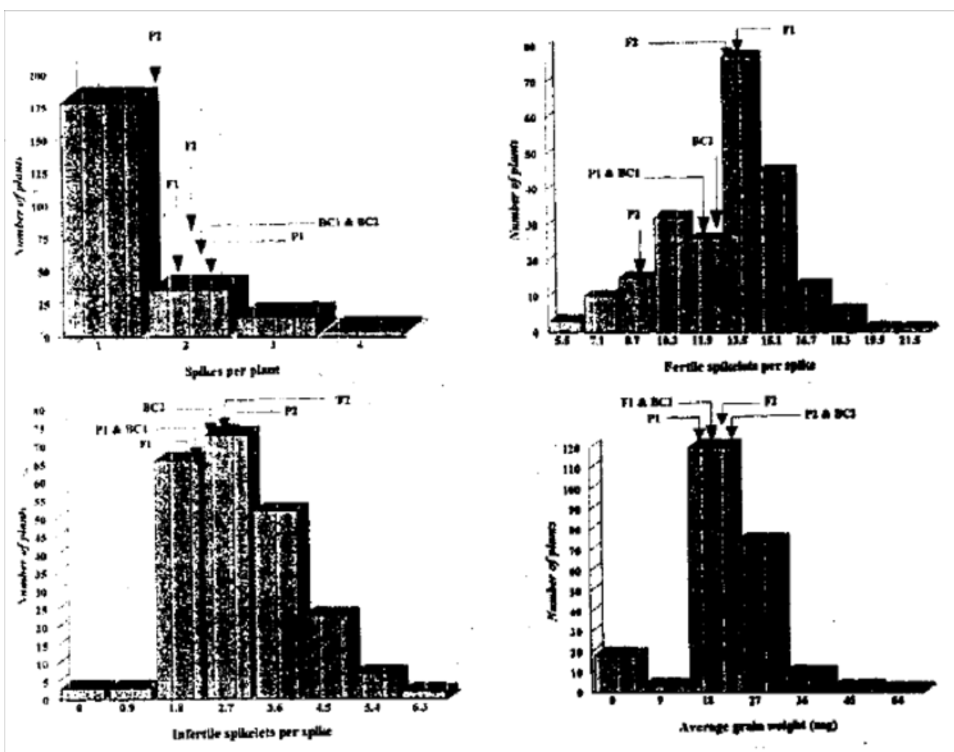

Fig. 3: Frequency distribution for gain weight per plant, grain number per plant, straw per plant and main title height of the F2 population. Arrows indicate generation means

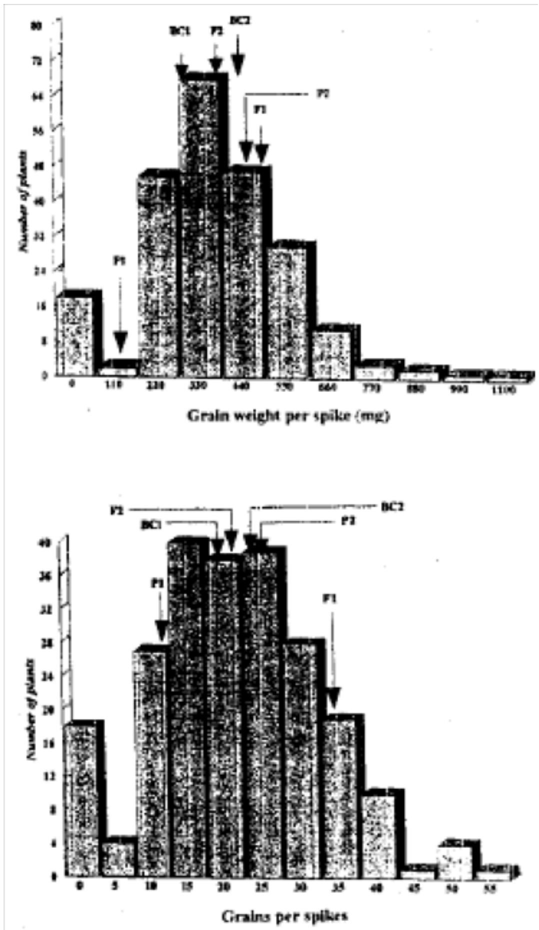

Fig. 4: Frequency distributions for grain weight per spike and grains per spike of the F2 population. Arrows indicate generation means

higher than [h_2] for Na^+ K^+, K^+/Na ratio, number of grains per spike and grain weight per spike. However [h_1] was significantly less than [h_2] for straw weight per plant, number of infertile spikelets per spike, number of fertile spikelets per spike and average grain weight. In general, the magnitude of [h_2] was smaller than the [h_1] even when the coefficient of dominance is smaller in the F_2 generation which usually results in larger estimates of dominance components having larger standard errors. This means that [h_2] is closer to the real dominance effects.

It was clear from an examination of the F_2 population frequency distribution for all traits that they were under the control of many genes and gene dispersion or non-allelic interaction or involvement of modifies are also suggested from the transgressive segregation. The significant differences between [h_1] and [h_2] for Na^+, K^+, K^+/Na^+ ratio. number of grains per spike and grain weight per spike indicate spurious overdominance for these traits.

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