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GENETIC VARIATION IN WATERLOGGING TOLERANCE OF WHEAT IN SODIC SOIL

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ABSTRACT

A field experiment was conducted to assess waterlogging tolerance of 18 wheat varieties in sodic soil. Waterlogging was imposed by flood irrigation in the field for 5d and 40d after sowing. Growth and yield was recorded in normal (non-waterlogged) and waterlogged conditions. Large variation was recorded in terms of plant height, biomass, tillering, yield and yield attributes under sodic waterlogged condition. A number of varieties showed higher biomass, grain number per plant, yield when waterlogging was imposed. Flowering & maturity was invariably delayed in most of the genotypes. Yield increase under waterlogged condition was mainly due to higher ear bearing tiller, and grain number per plant. Waterlogging probably mitigated the adverse effects of soil sodicity. Genotypes identified with a tolerance index greater than 1 to be good donors for future wheat breeding for waterlogging tolerance.

Introduction

Transient waterlogging occurs extensively in both irrigated and dry land (arid) agriculture on clay flats and on duplex soils in South Western Australia (McFarlane, 1990) and in South Eastern Australia (Victoria; Fried And Smith, 1992). In the Indo-Gangetic plains of Northern India 2.5 million ha. Of sodic soils planted with wheat are expected to experience saturated or temporary waterlogged conditions every year (Sharma and Swarup, 1988; Armstrong 1999). Waterlogging in eastern India is usually associated with lowland areas with poor drainage especially when winter rains occur just after irrigation. A sizeable wheat area along canals experiences a number of waterlogging cycles of varying intensity and duration. Waterlogging may occur at vegetative, flowering or even at maturity stage. Wheat yields anre adversely affected by waterlogging and at times a complete crop failure may occur when waterlogging is compounded with salinity or sdicity problems. Waterlogging adversely approximately 10-15 m.ha. of wheat production annually (Sayre *et al.*,1994).

The development of waterlogging tolerant wheat varieties are a sustainable strategy for improving productivity from areas prone to waterlogging. The present paper reports the relative performance of Indian and Australian wheat genotypes on waterlogged sodic soils.

Materials and Methods

Eighteen wheat genotypes were evaluated for waterlogging tolerance under moderate sodic field conditions during 2001-2002 at the main experimentation station. The soil of experimental field was silty loam (sand 22%, silt 58% and clay 20%), pH 9.0, ECe 1.6dS/m, hydraulic conductivity 1.44 mm/hr, cation exchange capacity 13.5 C mol. (p') kg^{-1} and organic carbon 0.3%. Wheat genotypes were direct seeded in 4 rows of 2.5 m length with row spacing of 23cm in augmented design with HD-2329 and PBW-343 as checks. A light irrigation was provided to non waterlogged (NWL) and waterlogged (WL) experiments at 21 days after sowing as per standard practice. Waterlogging treatment was imposed after 40days of sowing by water ponding of 10-15 cm depth for 5 days. At the end of the waterlogging treatment, the ponded water was removed from the field. A normal set was also run without waterlogging (NWL). Fifteen plants were initially tagged before waterlogging for growth (Plant height and total biomass), yield and yoeld attributes measurements. Data are presented on per plant basis since there was erratic plant population because of mortality of plants due to waterlogging. Recommended fertility level of 120:60:40(N.P.K) per ha. Was applied and standard cultural practices were adopted for both (non waterlogged and waterlogged) experiments. Growth, phenology, and yield parameters were recorded at maturity. Total biomass index and waterlogging tolerance index were calculated as the ratio of the respective parameters under waterlogged and non waterlogged conditions.

Results and Discussion

Waterlogging in the present experiment was only for a short duration of 5 days, but even after the removal of ponded water from the field, approximately 20-45% area still had small amount of surface water. This resulted in saturated soil profile for additional 5 days due to low hydraulic conductivity of the sodic soil.

A wide variation in growth and yield parameters in wheat genotypes was observed when plants were exposed to waterlogging treatment at the tillering stage. Two types of plant responses occurred during waterlogging: i) increased plant height, tillers per plant and shoot biomass, or ii) decreased plant height with no significanct change in tillering or biomass. Notable among the forest (waterlogging tolerant) type are KRL 3-4, PBW-343, NW-1014, and NW-1067 which produced significantly greater number of ear bearing tillers under waterlogging with significantly higher total biomass in relation to non waterlogged controls (Table-1). KRL3-4 was the most waterlogging tolerant variety which produced maximum biomass under waterlogging with a biomass index (ratio of WL to NWL) of 1.63; followed by HD- 2329, PBW-443, NW-1014, NW-1067, NW-1, and PBW-343 with biomass indices ranging between 1.37- 1.30(Table-1) (Fig.2).

Waterlogging also altered the phenology of wheat genotypesby delaying 50% flowering and increase maturity (Table-1). correlation between survival and Plant height show different variation in NML and WL condition (Fig. 1) The delay in 50% flowering and increase in maturity ranged between 2-8 days and 1-9 days respectively indifferent genotypes. Delay in maturity was non-significant in most genotypes, but it is of immense importance since it influences grain filling. Two genotypes showed early maturity under waterlogging: HD-2329 and PBW-443. Four out of eighteen genotypes did not show any change in maturity.

Yield and yield parameters also showed large genetic variation across waterlogging treatments under sodic soil. A number of genotypes produced significantly higher grain number per plant when subjected to waterlogging. Notable among them showing increase are HD-2329 (52%), NW-1012 (38%), Brooton (37%) and WH-542 (20%) (Table 2). The most intolerant variety, Spear, produced only 56% grain yield in the 5d waterlogging treatments used here, relative to non waterlogged plants.

Another important features is the variability in the ratio grain (harvest index) which, though was poor under sodic condition, showed that certain genotypes had an improved partitioning due to waterlogging (Table-2) (Fig. 2) Genotypes HD-2329, and HD-2189 showed significantly higher harvest index under WL than NWL conditions in sodic soil (Table 2), (Fig 2). Shows correlation between survival and harvest index in different variation in NWL WL conditions (Armstrong *et al.,* 2005)

Results presented in this paper showing large genetic variation in wheat genotypes are of importance in breeding wheat for waterlogging tolerance in sodic soils. Further studies and comparisons in other locations are required to validate the use of these varieties as potential donors for improving waterlogging tolerance of wheat.

Table 1: Effect of water logging on growth and phenology of wheat

Genotypes	Plant Height (cm)		Ear Bearing / Plant^{-1}		Biomass (g Plant^{-1})			50% Flowering (d)		Maturity Duration (d)	
	NWL	WL	NWL	WL	NWL	WL	Biomass Index	NWL	WL	NWL	WL
KRL-1-4	75.0	65.6	5	4	70.4	63.0	0.89	78	81	125	128
KRL-19	67.9	62.2	3	3	65.3	63.3	0.96	77	82	125	125
KRL-3-4	73.7	87.5	6	11	94.4	154.7	1.63	84	88	131	131
HD-2329	67.7	61.5	3	5	44.6	61.5	1.37	82	89	134	128
HD-2189	70.0	77.6	5	4	66.4	73.7	1.10	87	87	129	133
Brookton	72.3	59.3	2	4	36.4	85.2	0.78	88	90	125	134
Carnamah	66.1	61.0	3	4	67.7	72.5	1.07	92	100	127	136
Spear	69.2	60.0	4	4	53.2	65.1	1.22	83	87	124	131
SARC-3	72.0	71.1	3	5	34.6	42.7	1.23	82	87	124	130
WH-542	67.4	60.3	4	6	46.7	56.3	1.20	90	93	127	134
PBW-343	66.6	65.2	4	9	93.1	121.4	1.30	85	90	127	131
NW-1014	67.8	73.2	5	8	62.8	84.3	1.34	81	83	124	129
PBW-443	60.5	61.8	4	6	53.0	72.5	1.36	84	88	131	130
NW-1012	64.6	70.8	3	4	77.3	80.2	1.03	87	90	130	130
NW-1076	65.3	71.1	4	5	94.0	62.5	0.66	81	83	125	125
NW-1067	66.2	68.9	3	10	77.0	102.6	1.33	89	92	129	132
NW-1	78.2	73.9	4	5	65.8	86.4	1.31	84	89	129	135
NW-2	77.7	61.1	3	5	52.5	63.8	1.21	71	75	119	120
CD (0.05)	10.25		0.70		12.65		--	12.80		NS	

WL (water logged) and NWL, (non water logged)

Table 2: Effect of water logging on yield, yield attributes and water logging tolerance index.

Genotypes	Grain No. Plant^{-1}			Grain yield Plant^{-1}(g)			100 Seed Weight (g)		Harvest Index (%)	
	NWL	WL	%	NWL	WL	Tolerance index	NWL	WL	NWL	WL
KRL-1-4	223	170	-23.8	8.5	6.3	0.74	3.8	3.7	12.0	10.0
KRL-19	153	171	+11.8	4.7	5.6	1.19	3.1	3.3	7.1	8.8
KRL-3-4	184	222	+20.7	7.0	8.2	1.17	3.8	3.7	7.4	5.3
HD-2329	124	190	+52.0	4.1	6.8	1.65	3.3	3.6	9.1	11.0
HD-2189	186	217	+16.6	6.5	8.5	1.30	3.5	3.9	9.7	11.5
Brookton	91	125	+37.3	2.6	3.6	1.38	2.9	2.9	7.1	4.2
Carnamah	127	135	+6.4	3.0	3.5	1.16	2.4	2.6	4.4	4.8
Spear	125	77	-38.4	3.9	2.2	0.56	3.1	2.8	7.3	3.3
SARC-3	96	60	-37.5	3.6	2.2	0.61	3.7	3.6	10.4	5.1
WH-542	157	189	+20.4	4.7	5.1	1.09	3.0	2.7	10.0	9.0
PBW-343	240	222	-7.5	8.4	7.8	0.92	3.5	3.5	9.0	6.4
NW-1014	188	170	-9.6	7.1	6.6	0.93	3.8	3.9	11.3	7.8
PBW-443	140	111	-20.7	4.5	3.9	0.87	3.2	3.5	8.4	5.3
NW-1012	135	186	+37.7	4.5	6.5	1.44	3.3	3.5	5.8	8.9
NW-1076	194	170	-12.6	6.2	5.3	0.85	3.2	3.1	6.5	8.4
NW-1067	125	94	-24.8	4.3	3.2	0.74	3.4	3.4	5.5	3.1
NW-1	148	165	+11.5	5.9	5.9	1.00	4.0	3.6	8.9	6.8
NW-2	159	157	-1.3	6.4	5.7	0.89	4.0	3.6	12.1	8.9
CD (0.05)	23.3		--	0.80		--	0.50		1.16	

WL(water logged) and NWL, (non water logged)

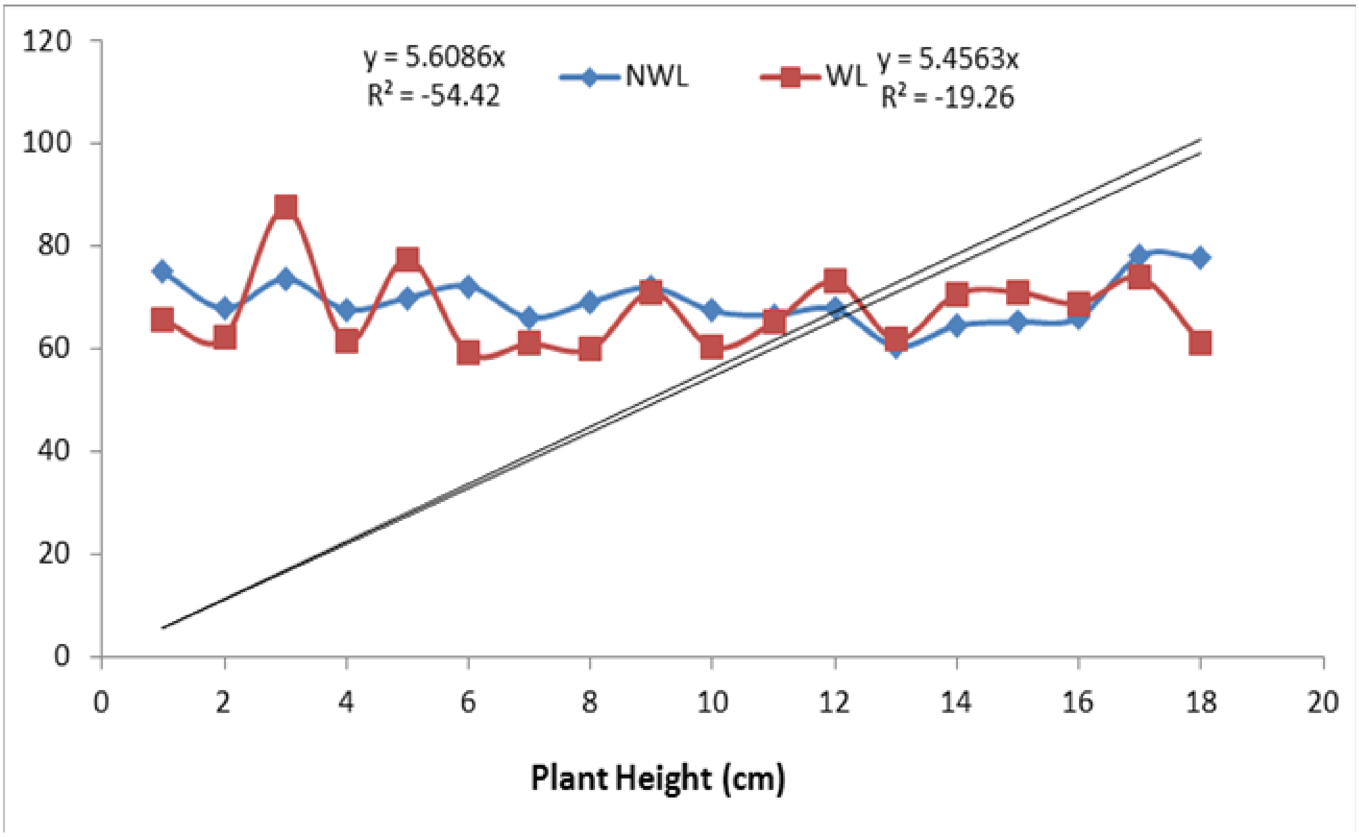

Fig. 1: Correlation Between survival and Plant Height in different Genotypes in NWL and WL conditions

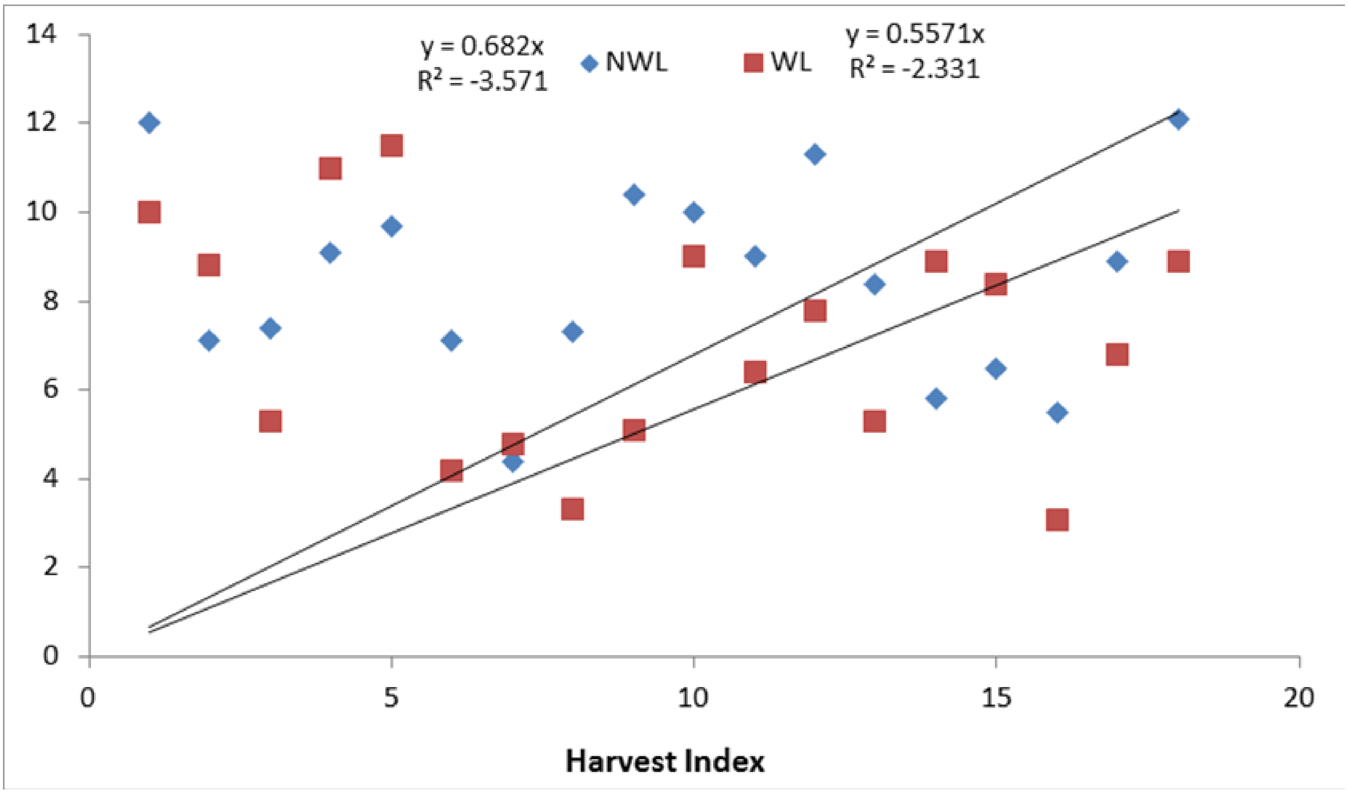

Fig. 2: Correlation Between surviv al and Harvest Index in different Genotypes in NWL and WL conditions.

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