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WHEAT BREEDING IN WATER STRESSED ENVIRONMENT
VI. INTER-RELATIONSHIPS OF MORPHO-PHYSIOLOGICAL TRAITS WITH GRAIN YIELD

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Abstract

Inter-relationships of morpho-pysiological traits with grain yield of seven bread wheat genotypes were examined in the field trials through the study of correlation and regression analyses. Under terminal stress, highly significant positive correlations of grain yield with all the traits except vegetative tillers and top root ratio at maturity, were observed. Top root ratio at maturity showed negative nonsignificant relationship with grain yield under both pre and post anthesis stress. Stepwise multiple regression analyses showed that harvest index accounted for 97% and 88% variation in grain yield under terminal and post anthesis tress. It concluded that harvest index is more important in regulating stress yield.

Introducation

Drought resistance tolerance in native plant species is often defined as survival, but in crop species in productivity terms (Passioura 1983). Although high grain yield under stress is the target of plant breeding, yet selection for stress yield is inefficient (Blum 1983). The greater efficiency of direct selection under stress has been emphasized by Hurd (1971), Johnson (1980), and Clarke *et al.*, (1984, 1992).

Grain yield is a complex polygenic trait (Walton 1972) and is greatly influenced by environmental factors (Kheradnam & Niknejad 1974). An adequate understanding of mlutal relations of some morpho-physiological traits with plant productivity is valuable in search for more effective way of yield improvement. The present study attempts to determine inter-relationships of these traits with grain yield and to find out their contribution towards stress yield through stepwise multiple regression analysis.

Material and Methods

Seven bread wheat genotypes identified to vary in yield potential

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and drought tolerance identified to vary in yield potential and drought tolerance (Sadiq *et al.*, 1994), were grown under irrigated (T_3; 300 mm irrigation excluding soaking dose of 75 mm.) and nonirrigated conditions simulated through withholding irrigation at different stages of plant development viz; T_0, no irrigation during the entire growing period, T_1; 75 mm irrigation at tillering stage, and T_2; 75 mm irrigation at anthesis stage. The experiment was laidout in split plot design with three replications having irrigation levels in the main plots and genotypes in the subplots at AEARC, Tandojam during the years 1988-89 and 1989-90. Each genotype planted is six rows, 5m long, spaced 0.25 apart at seeding density of 100 kg ha^{-1}. Hand weeding was done when necessary.

Prior to planting, soil samples from 12 plots separated by 3 m buffer zone to prevent seepage, were collected from 0-15 cm, 16-30 cm and 31-60 cm depth and were analysed for various physico-chemical properties (Table 1). A neutron moisture meter was used to measure soil water content. Changes in soil water content in the 0.75 m soil profile in all the plots were measured once a week at 15, 30, 45, 60 and 75 cm depth. These values were periodically checked by gravimetric method. A change with time in the soil water content below field capacity to a particular depth, gave the soil water deficit for the depth and time. Volumetric soil water content was calculated by multipying percentage soil moisture, bulk density and depth of soil layer/100.

Data on various morpho-physiological traits were recorded using the standard procedures. Analysis of varience was carried out to test the significance of differences among the treatments and genoyptes by Duncan's New Multiple Range Test at 5% and 1% probablity. Correlation coefficient and stepwise multiple regession analyses were caluclated (Steel and Torrie 1980, Draper and Smith 1966).

Results and Discussion

The mean changes in soil water deficit for the 0.75 m soil profile for different treatments are depicted in fig. 1. The water content in the soil profile for T_3 was kept relatively constant due to irrigation whereas marked changes in water content were more apparent in the stress treatments. In the initial stages of the soil drying out, no difference in the amount of water extracted was observed (30 days). In T_0 & T_2, whole soil profile became below wilting point (WP) on 71th day after planting which continued upto maturity in T_0. The soil moisture content in T_1 dropped below WP

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immediately after anthesis and continued upto maturity. Soil moisture extraction was the highest in T_0, followed by T_1, and T_2 at harvest. Plants in T_0 extracted 30 mm and 45 mm soil water more than T_1 and T_2 respectively. The pattern of soil moisture depletion and its effects on plant growth in stress treatments in the present study is similar to those reported earlier (Ratliff *et al.,* 1983 and Cutforth *et al.*, 1991).

Estimates of phenotypic correlations among grain yield and morpho-physiological traits under terminal stress (Table 2) showed that grain yield had highly significant positive association with all other characters except vegetative tillers and top root ratio at maturity. These two characters indicated also similar relationships under pre anthesis stress (Table 3). Grain yield showed the highest positive correlation with harvest index and negative with top root ratio at maturity under post anthesis stress (Table 4). Similar association of grain yield with various characteristics was reported by Turner and Nicolas (1987). Winter *et al.,* (1988). Ludow and Muchow (1990) and Chowdary and Mandal (1991).

The high positive correlation coefficient of grain yield with morpho-physiological traits indicated their contribution for obtaining high stress yield. As more variables were included in correlation studies, the direct association became complex and important. In such situation, stepwise multiple regression analysis has been found useful as it measures the relative contribution of each causal factor.

Stepwise mutiple regression analysis (Table 5) showed that harvest index, biological yield, root dry weight at 5 leaf stage, and leaf osmotic potential explained 99.89% variation in grain yield under terminal stress. Both R^2 and RMS indicated that harvest index and biological yield were the major yield components.

Under pre anthesis stress spike yield, harvest index and biological yield accounted for 99.84% variation in grain yield. Both R^2 and RMS showed that spike yield and harvest index were the major yield components. Under post anthesis, harvest index and biological yield were again the major yield components, Aggarwal *et al.,* (1986) emphasized also the importance of harvest index in obtaining high grain yield under terminal stress.

From the stepwise multiple regression analysis it may be inferred that the selection based on harvest index, biological yield and spike yield would be effective in improving the grain yield in stress enviroments. However, harvest index as a selection criterion seems to be more important in regulating

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stress yield. These selection criteria are easy to measure under field studies.

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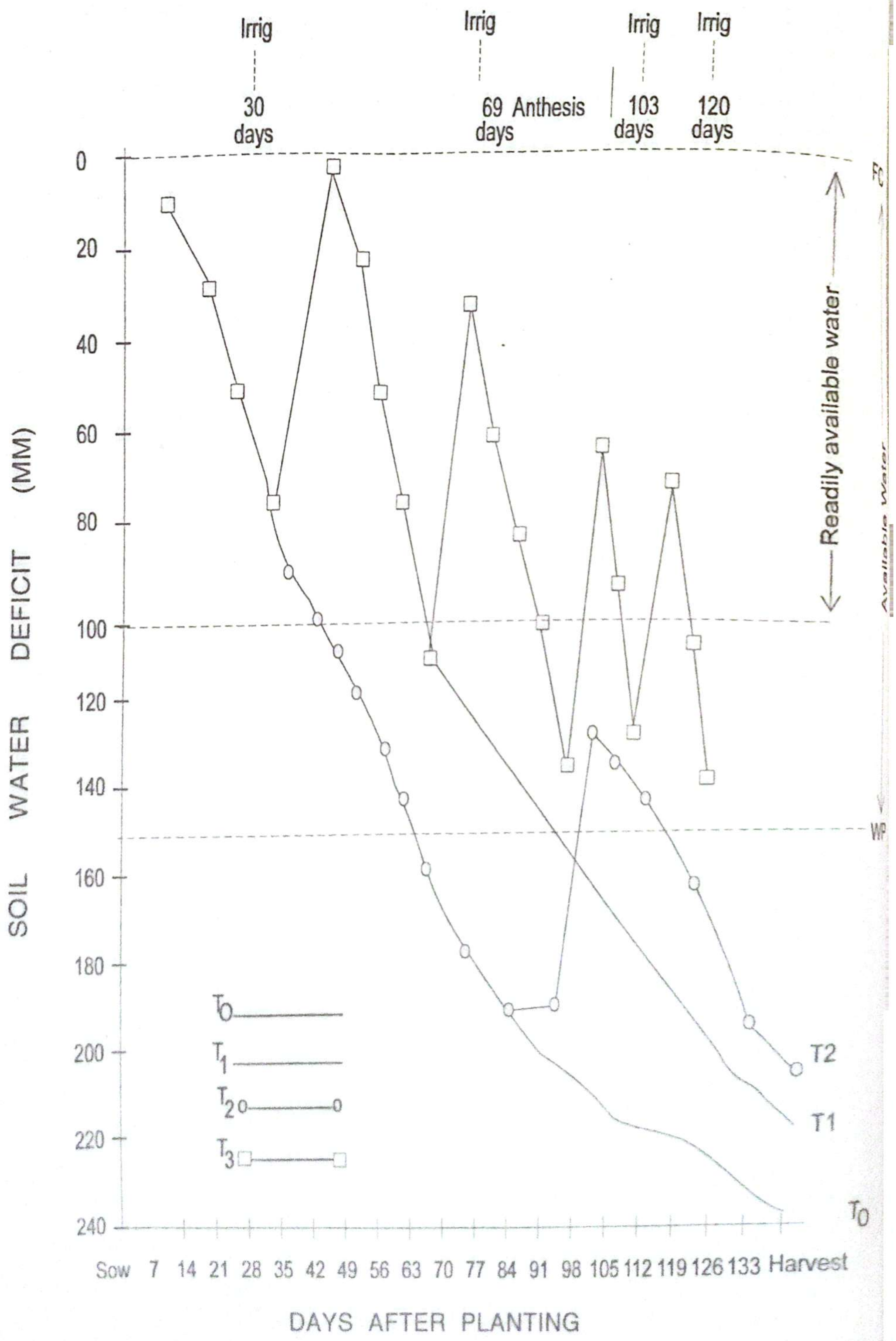

Fig. 1. Soil moisture depletion from field capacity for the whole profile during the growing season.

Table-1 Soil Characteristics of Experimental Site

Characteristic	Soil Profile		
	0-15 cm	16-30 cm	31-60 cm
A. Physical			
Sand %	41.18	46.07	48.57
Clay %	33.55	28.56	23.56
Silt %	25.27	25.37	27.87
Texture	Loam	Clay loam	Clay loam
Bulk density g cm$^{=3}$	1.42	1.42	1.42
Water holding Capacity %	40.25	39.35	39.00
Field capacity % (-0.03 M pa)	29.75	27.50	27.25
Wilting point % (-1.5 M pa)	14.50	13.00	13.00
B. Chemical			
Nitrogen %	0.06	0.05	0.03
Available P ppm	6.00	4.50	3.00
Exchangeable K ppm	158.00	146.00	142.00
Organic matter %	0.84	0.64	0.37
EC Sm^{-1}	0.22	0.23	0.21
pH	7.35	7.31	7.34
HCO_3 meql^{-1}	2.11	2.13	2.02
Cl meql^{-1}	6.02	6.40	7.63
SO_4 meql^{-1}	13.36	12.80	11.59
Ca+Mg meql^{-1}	11.30	10.93	10.77
Na meql^{-1}	11.02	10.64	10.49
SAR	4.59	4.54	4.44

Water table depth 3m

Table-5 Stepwise multiple regresion for grain yield and morpho-physiological traits under different water regime

Vatiable	$R^{2\%}$	Change in R^2	RMS	Change in RMS	Partial R^2	SE Regre-ssion	F Value
(1) Terminal stress Harvest Index (x9)	97.22	-	4363.8		0.97	66.1	663.4
Biological yield (x2)	99.58	0.36	690.2	3673.6	0.85	26.3	2148.4
Root dry wt. (5 leaf) (x16)	99.78	0.20	381.7	308.5	0.48	19.5	2595.4
Leaf Osmotic Potential (x6)	99.89	0.11	197.1	184.6	0.51	14.0	2773.8
Vegetative tillers (x3)	99.93	0.04	136.5	60.6	0.35	11.7	4361.2
(2) Preanthesis stress spike yield (x11)	94.22	–	4776.2	–	0.84	86.3	309.6
Harvest index (x9)	97.98	3.76	2749.7	4696.5	0.65	52.4	436.0
Biological Yield (x2)	99.84	1.86	231.8	2517.9	0.92	15.2	3513.4
Root dry wt. (5 leaf) (x16)	99.92	0.08	117.4	114.4	0.52	10.8	5206.8
Vegetative tillers (x3)	99.94	0.02	96.6	20.8	0.22	9.8	5962.1
(3) Postanthesis stress Harvest index (x9)	87.61	–	17182.4	–	0.99	131.1	134.3
Bological yield (x2)	99.78	12.17	326.0	16856.4	0.98	18.1	4031.3
Leaf water potential (x7)	99.88	0.10	181.4	144.6	0.47	13.5	4836.6
Cumulative GLA (x10)	99.94	0.06	102.2	79.2	47	10.1	6440.8
Turgor Potential (x8)	99.98	0.04	64.1	38.1	0.41	8.1	8218.7

Table-2

Correlation coefficient among grain yield and morpho-physiological traits under terminal stress (T0).

Traits	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
X3	-.38^{NS}														
X4	.78**	.20^{NS}													
X5	.91**	-.122^{NS}	947**												
X6	.94**	-.42^{NS}	.75**	.86**											
X7	.85**	-.32^{NS}	.76**	.88**	.95**										
X8	.78**	-.51*	.43*	.60**	.73**	.48*									
X9	.85**	-.01^{NS}	.90**	.92**	.82**	.78**	.61**								
X10	.95**	-.28^{NS}	.82**	.93**	.90**	.85**	.66**	.48**							
X11	.83**	-.12^{NS}	.85**	.90**	.85**	.80**	.64**	.79**	.88**						
X12	.91**	-.13^{NS}	.85**	.91**	.88**	.85**	.60**	.50**	.92**	.97**					
X13	-.89**	.32^{NS}	-.76**	-.87**	-.82**	-.71**	-.75**	-.12**	-.87**	-.93**	-.87**				
X14	.90**	-.26^{NS}	.78**	.88**	.93**	.95**	.96**	.05**	.92**	.84**	.92**	-.73**			
X15	.96**	-.43^{NS}	.74**	.86**	.93**	.82**	.82**	.86**	.92**	.91**	.90**	-.95**	.84**		
X16	.94**	-.31^{NS}	.76**	.88**	.88**	.81**	.70**	.87**	.96**	.93**	.96**	-.92**	.89**	.95**	
X1	.92**	-.10^{NS}	.90**	.95**	.87**	.81**	.67**	.86**	.91**	.98**	.97**	-.94**	.86**	.93**	.94**

X1 = Grain yield.
X2 = Biological yield.
X3 = Vegetative filters.
X4 = Productive filters.
X5 = Servival filters.
X6 = Leaf osmotic potential.
X7 = Leaf water potential.
X8 = Turger potential.
X9 = Harvest index.
X10= Cumulative green leaf area.
X11= Spike yield.
X12= Root dry weight maturity.
X13 = Top root maturity.
X14 = Glycinebetaine.
X15 = Top dry wt. five leaf stage.
X16 = Root dry wt. five leaf stage.

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Table-3

Correlation coefficient among grain yield and morpho-physiological traits under terminal stress (T2).

Traits	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
X3	-.40^{NS}														
X4	.66**	.29^{NS}													
X5	.84**	-.16^{NS}	90**												
X6	.78**	-.48^{NS}	.39**	.62**											
X7	.71**	-.22^{NS}	.75**	.87**	.64**										
X8	.08^{NS}	-.31*	.43*	-.29^{NS}	.43^{NS}	.42^{NS}									
X9	.62**	-.20^{NS}	.01**	.74**	.30^{NS}	.66**	.42^{NS}								
X10	.86**	-.16^{NS}	.87**	.97**	.68**	.87**	-.22^{NS}	.66**							
X11	.88**	-.07^{NS}	.80**	.85**	.56**	.69**	-.16^{NS}	.88**	.83**						
X12	.92**	-.11^{NS}	.81**	.89**	.76**	.77**	-.01^{NS}	.80**	.91**	.94**					
X13	-.88**	30^{NS}	-.74**	-.90**	-.62**	-.85**	.27^{NS}	-.84**	-.87**	-.93**	-.90**				
X14	.86**	-.10^{NS}	.80**	.87**	.69**	.79**	-.11^{NS}	.87**	.86**	.93**	.96**	-.92**			
X15	.96**	-.38^{NS}	.70**	.90**	.68**	.79**	-.13^{NS}	.71**	.89**	.92**	.91**	-.96**	.88**		
X16	.94**	-.22^{NS}	.80**	.93**	.68**	.74**	-.06	.73**	.93**	.93**	.95**	-.91**	.91**	.95**	
X1	.85**	-.02^{NS}	.84**	.87**	.54**	.75**	-.24^{NS}	.94**	.83**	.90**	.94**	-.94**	.96**	.90**	.91**

X1 = Grain yield.
X2 = Biological yield.
X3 = Vegetative filters.
X4 = Productive filters.
X5 = Servival filters.
X6 = Leaf osmotic potential.
X7 = Leaf water potential.
X8 = Turger potential.
X9 = Harvest index.
X10= Cumulative green leaf area.
X11= Spike yield.
X12= Root dry weight maturity.
X13 = Top root maturity.
X14 = Glycinebetaine.
X15 = Top dry wt. five leaf stage.
X16 = Root dry wt. five leaf stage.

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Table-4

Correlation coefficient among grain yield and morpho-physiological traits under terminal stress (T1).

Traits	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
X3	-.36^{NS}														
X4	.05**	.71^{NS}													
X5	.34**	-.58^{NS}	.83**												
X6	.87**	-.31^{NS}	.12^{NS}	.32^{NS}											
X7	.60**	-.35^{NS}	-.07^{NS}	.13^{NS}	.74**										
X8	.40^{NS}	.02^{NS}	.26^{NS}	-.29^{NS}	.43**	.25^{NS}									
X9	.60**	-.38^{NS}	.49**	.62**	.63**	.39^{NS}	.38^{NS}								
X10	.89**	-.40^{NS}	.05^{NS}	.38^{NS}	.69**	.50**	.32^{NS}	.47**							
X11	.80**	-.16^{NS}	.07^{NS}	.30^{NS}	.83**	.56^{NS*}	.44*	.83**	.72**						
X12	.85**	-.10^{NS}	.12^{NS}	.43^{NS}	.56**	.39^{NS}	.29^{NS}	.57**	.80**	.72**					
X13	-.2^{NS}	-.17^{NS}	.20^{NS}	.10^{NS}	.02^{NS}	.15^{NS}	.23^{NS}	-.33^{NS}	-.84^{NS}	-.22^{NS}	-.15^{NS}				
X14	.80**	-.22^{NS}	.13^{NS}	.27^{NS}	.84**	.50**	.43^{NS}	.76**	.67**	.91**	.51**	-.10^{NS}			
X15	.95**	-.38^{NS}	-.08^{NS}	.21^{NS}	.86**	.70**	.29^{NS}	.67**	.85**	.93**	.80**	-.25^{NS}	.83**		
X16	.96**	-.31^{NS}	.07^{NS}	.37^{NS}	.83**	.54**	.48*	.70**	.92**	.93**	.83**	-.11^{NS}	.86*	.96**	
X1	.84**	-.11^{NS}	.37^{NS}	.58**	.80**	.52**	.50**	.94**	.72**	.94**	.76**	-.22^{NS}	.86**	.86**	.89**

X1 = Grain yield.
X2 = Biological yield.
X3 = Vegetative filters.
X4 = Productive filters.
X5 = Servival filters.
X6 = Leaf osmotic potential.
X7 = Leaf water potential.
X8 = Turger potential.
X9 = Harvest index.
X10= Cumulative green leaf area.
X11= Spike yield.
X12= Root dry weight maturity.
X13 = Top root maturity.
X14 = Glycinebetaine.
X15 = Top dry wt. five leaf stage.
X16 = Root dry wt. five leaf stage.