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Full Length Research Paper

An investigation of gene action on different traits of tobacco under irrigated and drought stress environment

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A diallel cross involving five Virginian tobacco genotypes were evaluated to determine the genetic behavior of tobacco genotypes across the environments. The experimental material was planted under irrigated as well as drought stress conditions. The data collected on yield and related traits revealed highly significant differences among genotypes under both sowing conditions. Graphical analysis showed that additive action of genes for dry leaf yield and leaf area index under irrigated conditions changed to over dominance under drought. However, it was also found that gene action for length of leaf, width of leaf and number of leaves remained the same over the environments. It was also observed that parental genotypes shifted their positions in the graphs from recessive to dominant or the midway or vice versa, showing different genetic constitution for the same trait in response to environmental change. Genotypes displaying similar constitution under both sowing conditions showed that they contain stable genes expression for those particular characters and may prove useful in future breeding strategies.

Key words: Diallel, drought stress, environment, genetic action, tobacco.

INTRODUCTION

Influence of environments on genetic architecture of the plant become evident as its phenotypic appearance. Thus, expression of plant traits depends upon the action of governing genes under prevailing environment. Butarac (2004) reported additive gene action for leaf area index and length of leaf while they indicated dominant gene action for plant height and width of leaf in tobacco. Shoaei and Honarnejad (1996) found additive gene action for plant height and width of leaf and reported over dominance for plant height, leaf area index and length of leaf. Korubin and Matterskim (2002) indicated the involvement dominant gene action for plant height, leaf area index, width of leaf and length of leaf. Legg and Collins (1996) found dominance for plant height and over dominance for number of leaves and leaf area index. Ogilive and Kozumplik (1995) reported that additive gene action for number of leaves under irrigated condition changed to over dominance under drought condition and over dominance for width of leaf and length of leaf under irrigated condition changed to partial dominance under drought, while gene action for plant height remained partial dominant under both sowing conditions. Xiaobing et al. (2005), reported over dominance for length of leaf and width of leaf. Similarly, Newaz and Uddin (1992) observed additive gene action for dry leaf yield, leaf area index and width of leaf while they observed over dominance for plant height and length of leaf.

This study was planned to ascertain the effects of different environments on some plant traits reflecting yield potential by making a comparative assessment of their performance under irrigated and drought stress conditions in terms of the type of gene action. This information would come in hand for putting together the necessary genetic setup of methods and materials in order to breed new tobaccos for drought related production situations in the country.

MATERIALS AND METHODS

The studies were conducted in the research area of the Tirtash

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Table 1. Analysis of variance for studied traits in a 5 × 5 diallel cross of tobacco.

Character	Condition	Mean squares		
		Replication	Genotype	Error
Number of leaves	IC	1.24	13.51**	1.26
	DC	1.61	15.39**	1.47
Length of leaf	IC	0.91	20.43**	3.03
	DC	3.75	18.86**	4.80
Width of leaf	IC	0.20	14.15**	1.49
	DC	0.10	15.37**	0.82
Leaf area index	IC	1.91*	6.100**	0.430
	DC	1.02	5.346**	0.560
Plant height	IC	19.81	748.47**	35.39
	DC	175.91*	538.75**	18.14
Dry leaf yield	IC	0.03	2.57**	0.142
	DC	0.04	2.05**	0.06

*, ** $P \leq 0.05$ and 0.01, respectively; IC = Irrigated condition, DC= drought condition; +DF for replication, genotypes and error mean squares is 2, 14 and 28, respectively.

Tobacco Research Center, Iran, during 2004 and 2006 cropping season. Five tobacco genotypes namely VE1, Coker254, NC89, K394 and Coker347 were crossed in a half diallel scheme in 2004. For each cross, enough female spikes were emasculated and bagged to avoid contamination with foreign pollen. Pollination with the pollen collected from the specific male parent was done when the ovaries became receptive. Seeds from each cross were harvested and saved separately.

Two experiments, one under irrigated condition and the other under drought stress condition were planted on May 11, 2006. Each experiment was laid out in a triplicated randomized complete block design. All ten F_1s along with their parents were planted apart in lines of 5 m length. All agronomic application such as, hoeing, weeding, fertilizing were practiced uniformly except irrigation which only was applied to the experiment conducted under irrigated conditions. Data for number of leaves, dry leaf yield, plant height, leaf area index, width of leaf and length of leaf were collected and subjected to basic analysis of variance (steel and Torrie,1985). Graphical analysis of gene action and determination of genetic components of variation were also conducted following Hayman (1954) and Jinks (1954).

RESULTS AND DISCUSSION

Presence of highly significant genotypic difference for all of the characters under irrigated and drought stress conditions (Table 1) allowed the performance of further genetic analysis.

Scaling test

To test the adequacy of additive – dominance model, two types of scaling tests (regression analysis and analysis of variance of (wr + vr and wr - vr) were done separately for the data collected from irrigated and drought stress conditions (Table 2). The results of the scaling tests under irrigated condition indicated that the adequacy of model for number of leaves, dry leaf yield, width of leaf and length of leaf, while the data regarding plant height and leaf area index showed partial adequacy due to the failure of the two scaling tests .Under drought condition, data for all the studied traits displayed complete adequacy. Thus, the whole of the data under irrigated and drought stress conditions were analyzed further to determine the genetic information.

Number of leaves

The study of genetic components of variation (Table 3) showed that additive (D) and dominant (H) components were significant under both planting conditions which indicate the importance of additive as well as dominance effects for the control of number of leaves. However additive effects were more important. An unequal value of H_1 and H_2 indicates the dissimilar distribution of positive and negative genes. The value of F was positive and significant displaying the greater frequency of dominant genes under both environments. The value of the environmental component (E) was non- significant under both sowing conditions. Average degree of dominance under both irrigating conditions was less than 1 (0.7 and 0.6 for irrigated condition and drought condition,

Table 2. Adequacy test of additive-dominance model for a 5 × 5 diallel cross of tobacco.

Plant trait	Condition	Regression analysis		Analysis of variances		Remark
		b=0	b=1	Wr××Vr	Wr-Vr	
Number of leaves	IC	**	NS	**	NS	Both tests showed adequacy of the modal.
	DC	**	NS	NS	NS	
Length of leaf	IC	**	NS	NS	NS	Both tests showed adequacy of the modal.
	DC	*	NS	NS	NS	
Width of leaf	IC	**	NS	NS	NS	Both tests showed adequacy of the modal.
	DC	*	NS	NS	NS	
Leaf area index	IC	*	NS	**	**	Regression analysis invalidated the modal but analysis of arrays showed adequacy of the modal, thus, data were considered partially adequate.
	DC	*	NS	**	NS	Both tests showed adequacy of the modal.
Plant height	IC	*	NS	**	NS	Both tests showed adequacy of the modal.
	DC	NS	NS	NS	NS	Regression analysis invalidated the modal but analysis of arrays showed adequacy of the modal, thus, data were considered partially adequate.
Dry leaf yield	IC	*	NS	**	NS	Both tests showed adequacy of the modal.
	DC	*	NS	NS	NS	

*, ** P ≤ 0.05 and 0.01, respectively; IC=Irrigated condition; DC=drought condition; NS=non-significant; b=regression coefficient; Vr=array variance; Wr=covariance of array and parental values.

respectively) indicating an additive type of gene action for the control of number of leaves. Graphical representation of the data (Figure 1a, b) also depicted similar gene action for this trait under irrigated as well as drought stress conditions. Additive gene action for number of leaves was also reported by Shoaei and Honarnejad (1996). However, over dominance was reported by Korubin and Matterskim (2002). Similarly, Gopinath et al. (1996) reported that additive gene action for number of leaves under irrigated condition changed to over dominance under drought stress. Distribution of genotypes (Figure 1a) indicated that the genotype NC89 contained maximum dominant genes for number of leaves under irrigated closely followed by the genotype Coker254, while under drought stress conditions, (Figure 1b) maximum dominant genes for number of leaves were present in the genotype Coker254 followed by the genotype VE1. The varieties VE1 and NC89 contained the least dominant genes under both sowing conditions.

Length of leaf

Data for length of leaf (Table 3) also revealed significant variation due to both additive and dominance gene effect under both irrigating conditions. Unequal H_1 and H_2 components indicated different distribution of positive and negative genes under irrigated and drought stress conditions. The value of F was positive and non-significant under irrigated condition but significant under drought.

Average degree of dominance (2.16 and 2.82 for irrigated condition and drought condition, respectively) and graphical presentation of the data (Figure 2a and b) also depicted an over dominant gene action for length of leaf under both irrigated and drought stress conditions. These results are in conformity to the results of Pandia et al. (1985), and Gopinath et al. (1996), who observed an over dominant gene action for length of leaf. Butarac et al. (2004), however, reported that over dominant gene action for length of leaf under irrigated conditions changed to partial dominance under drought while Shoaei and Honarnejad (1996), observed addictive gene action with partial dominance for this trail. Distribution of array points (Figure 6a and b) indicated that the genotype NC89 contained maximum dominant genes while Coker 254 contained the least dominant genes under both conditions.

Table 3. Genetic components of variation for studied traits in 5 × 5 diallel cross of tobacco.

Component	Number of leaf		Length of leaf		Width of leaf		Leaf area index		Plant height		Dry leaf yield	
	IC	DC	IC	DC	IC	DC	IC	DC	IC	DC	IC	DC
D	28.63*±0.67	44.72*±1.9	6.36*±2.5	2.32*±1.4	4.02±0.40	44.7*±1.9	8.47*±0.32	6.68*±1.3	34±14..9	0.2*±0.06	2.88*±0.11	0.929±0.09
H1	17.92*±3.61	35.74*±2.3	118.8*±27	16.40*±2.0	25.01* ±4.3	35.7*±5.2	6.90*±0.16	15.5*±0.78	79.1*±5.3	1.3*±0.2	1.14*±0.09	5.92*±0.96
H2	16.24*±3.32	22.25*±2.0	91.84*±24	7.70*±1.45	22.05*±3.9	22.2*±4.7	6.43*±0.16	6.92*±0.63	36.7*±3.9	1.1*±0.02	3.12*±1.08	5.44*±0.86
F	36.1*±9.21	9.92*±2.8	17.70±12	1.4*±0.6	-8.24±3.9	-9.9±4.8	6.40*±9.3	1.62*±0.40	7.4±7.0	-0.03±0.2	-1.62±0.4	-0.51*±0.12
E	1.2±1.5	2.63±0.79	3.0±1.0	0.2±0.05	1.4±0.06	3.63*±0.7	3.6±1.3	0.03±0.02	5.52*±0.79	0.1*±0.02	0.14*±0.04	0.07*±0.03
(H1/D)1/2	0.70	0.60	2.16	2.82	1.02	0.60	0.83	1.54	1.14	2.30	0.76	1.23

IC= Irrigated condition; DC= drought stress condition; D= additive variation; H_1=variation dominant effect genes; H_2= variation due to dominant effect of genes correlated for gene distribution; F= relative frequency of dominant and recessive alleles; E= environmental variation, $(H1/D)^{1/2}$= average degree of dominance; *significant value

Width of leaf

Determination of genetic components of variation for width of leaf (Table3) revealed that D and H components were significant under irrigated as well as drought stress conditions. H_1 and H_2 components were unequal which indicated the different distribution of dominant and recessive genes among the parent. The value of F was negative but non-significant under both conditions. The effect of environment was non-significant under irrigated condition and significant under drought stress condition. Under irrigated condition, the average degree of dominance (1.02) (Table 3) showed an over dominant gene action. However, the Wr/Vr graph (Figure 3a) displayed a complete dominance effect. Under drought stress, both the average degree of dominance (0.62) and graphical analysis of the data (Figure 3b) indicated an additive type of gene action. Additive gene action with partial dominance for width of leaf was also reported by Shoaei and Honarnejad (2003) and Newaz and Uddin (1992), while over dominance gene action for this trait was reported by Ogilive and Kozumplik (1995). Ukai (1991) found that never dominant gene action for width of leaf under irrigated conditions changed to partial dominance under drought. Distribution of array points (Figure 3a) depicted that the genotype NC89 was located near to the origin, and so, had the most dominant genes under irrigated condition while Coker347 had the farthest distance from the origin containing the least dominant genes under drought stress condition(Figure 3a). In contrast, Coker347 which had maximum dominant genes was closer to the origin and VE1 with furthest distance to origin had the least dominant genes.

Leaf area index

Under both condition, the significance of D and H variation (Table 3) for leaf area index was revealed. Unequal values of H_1 and H_2 indicate the different distribution of dominant and recessive genes among the parents. Positive and significant values of F (6.40 and 1.62) indicate the higher frequency of dominant genes under both conditions. Environmental component of variation (E) remained non–significant under both irrigation conditions. Average degree of dominance under irrigated conditions (0.83) and the graphical analysis (Figure 4a) displayed the presence of additive type of gene action for leaf area index. Average degree of dominance (1.54) for leaf area index under drought stress conditions indicated an over dominant type of gene action. Similar gene action was displayed in Wr/Vr graph (Figure 4b) for this trait under study where the regression line cut the Wr – axis below the origin. Over dominant gene action for grains per spike was also reported by Patel et al. (1991), however, Marani and Sachs (1991), and Shoaei and Honarnejad (2003), found additive gene action with partial dominance for leaf area index. Distribution of array points in the graphs indicated the dominant gene distribution in the parental genotypes. It was observed that K394 contained the maximum dominant genes for leaf area index under both conditions. However, Coker347 had the least dominant genes under irrigated condition and NC89 contained least dominant genes under drought stress condition.

Plant height

Under irrigated condition, dominant gene effects (significant H components) were important for number of plant height. However, unequal distributions of dominant and recessive gene among parents were indicated by unequal values of H_1

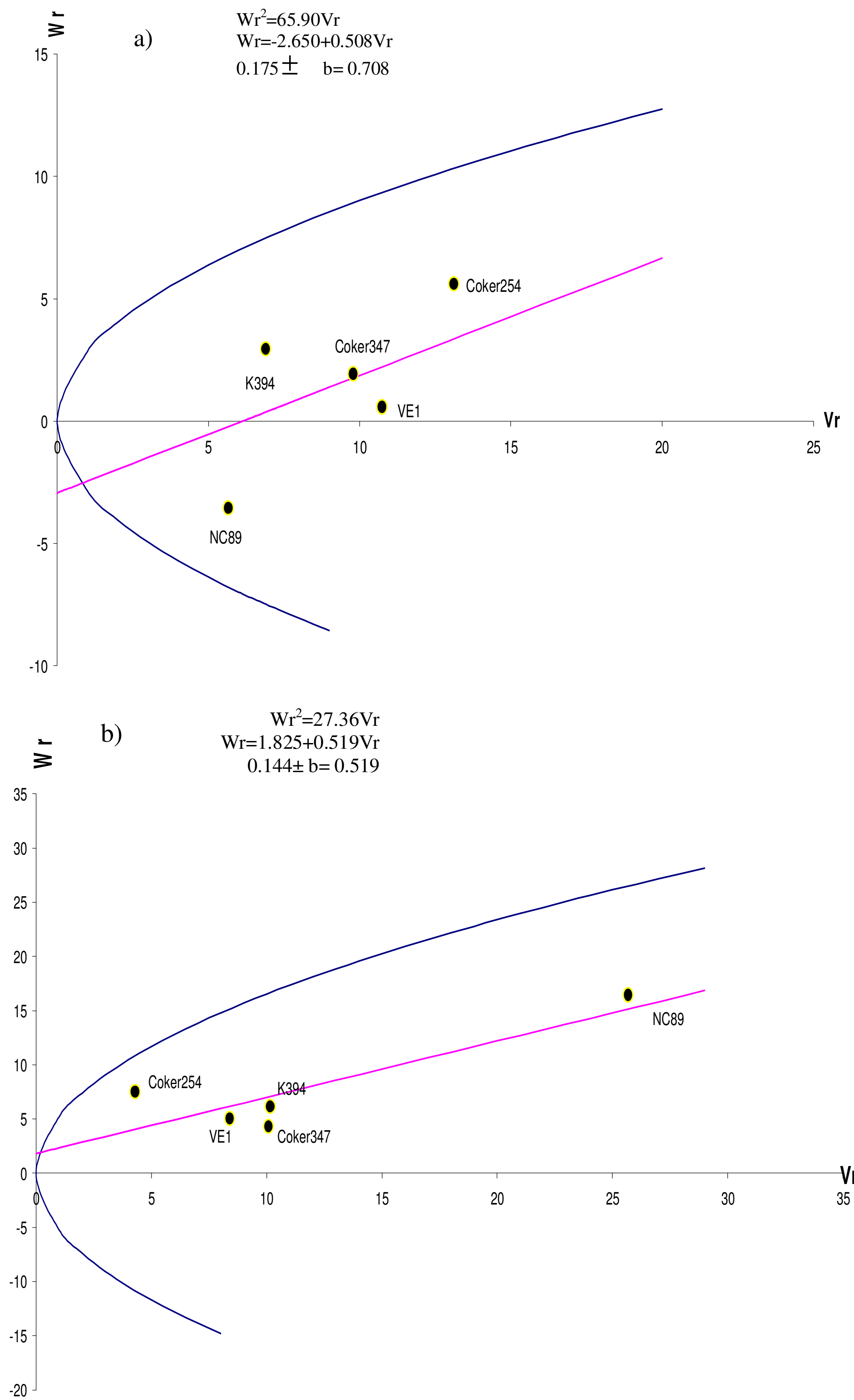

Figure 1. Wr/Vr graph for number of leaves under irrigated (a) and drought stress (b) conditions.

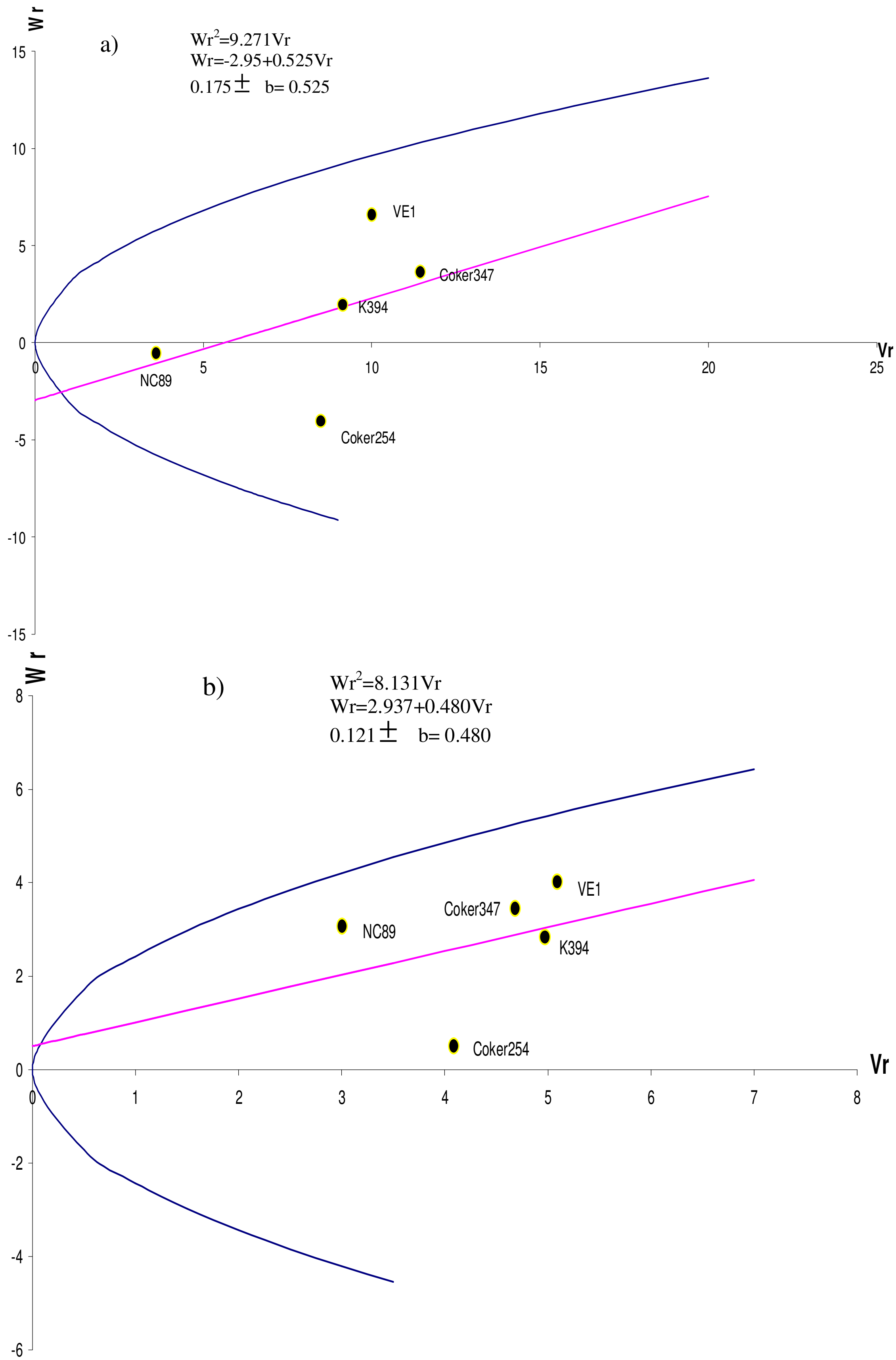

Figure 2. Wr/Vr graph for length of leaf under irrigated (a) and drought stress (b) conditions.

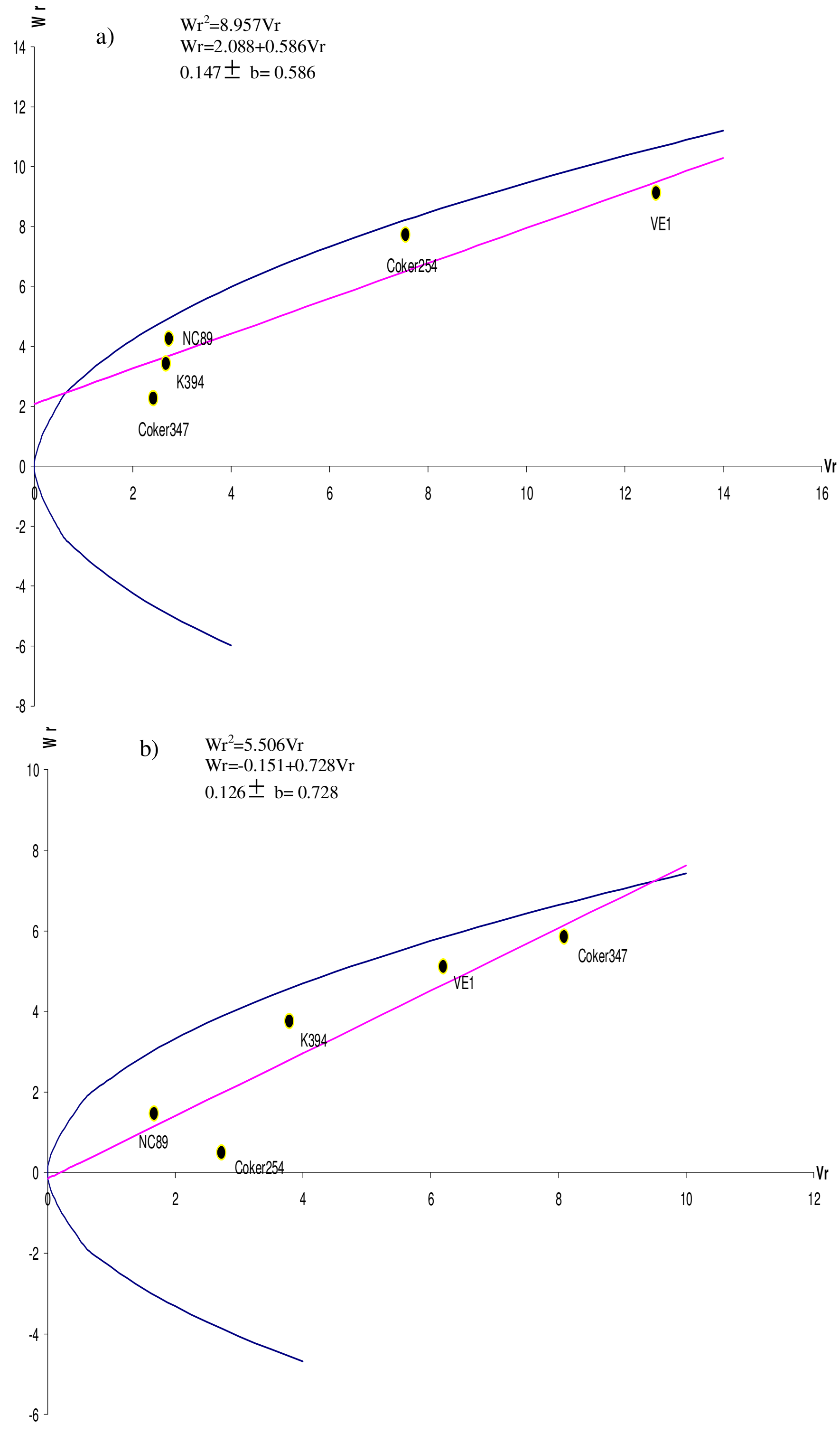

Figure 3. Wr/Vr graph for width of leaf under irrigated (a) and drought stress (b) conditions.

and H_2 .The F value was positive but non–significant. Average degree of dominance (1.14) also displayed an over dominance type of gene action which controls the trait expression.

Genetic components of variation under drought stress revealed significant additive as well as dominant variation. Unequal values of H_1 and H_2 displayed asymmetry of gene distribution among the parents. F was negative but non–significant. Significant effect of environment (E) was also indicated. Average degree

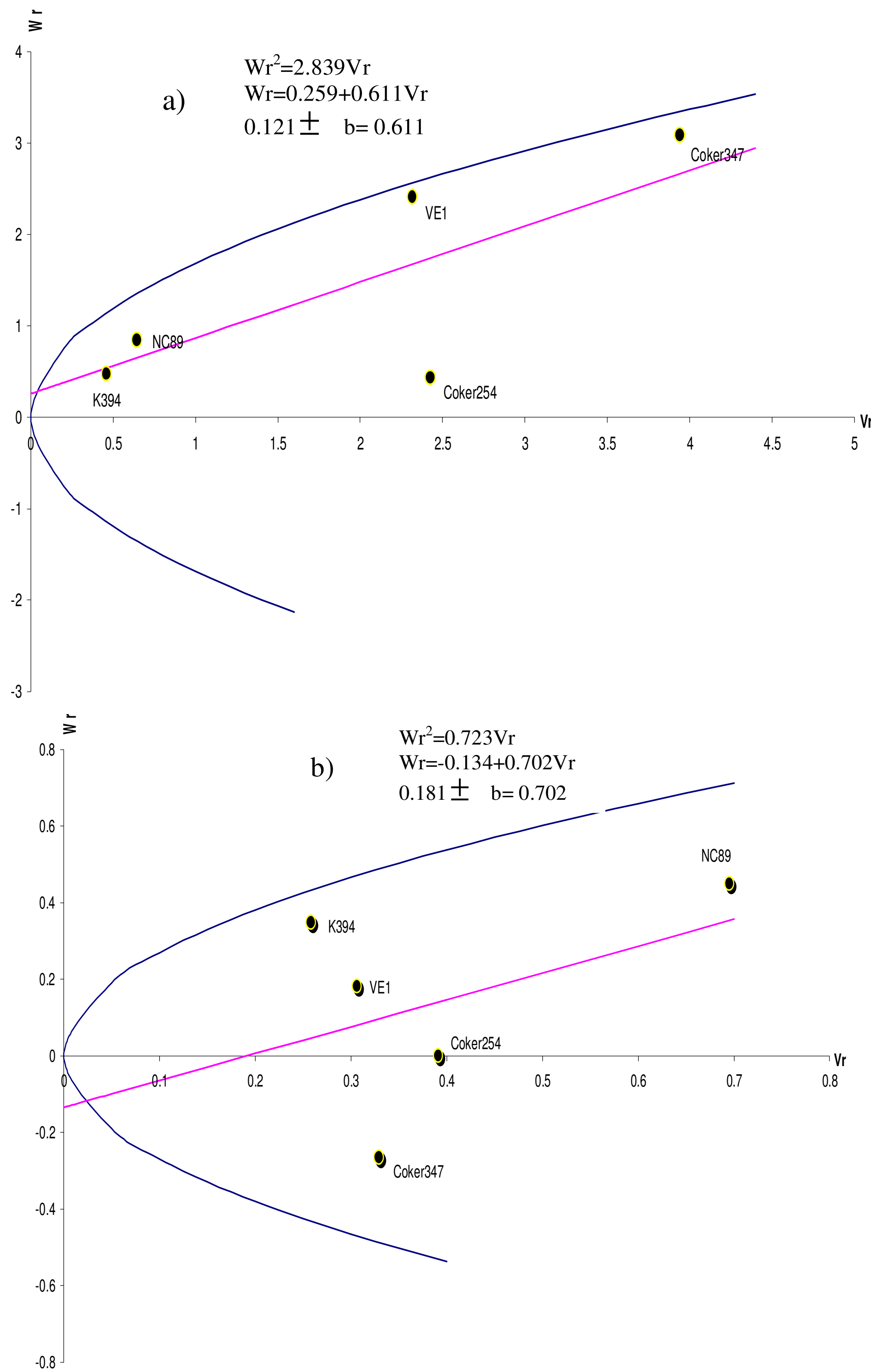

Figure 4. Wr/Vr graph for leaf area index under irrigated (a) and drought stress (b) conditions.

ofdominance (2.30) indicated an over dominant type of gene action for plant height under drought condition.

Graphical presentation of the data (Figure 5) also depicted an over dominant type of gene action controlling plant height under both conditions. The regression line cut the Wr axis below the origin in both cases. These

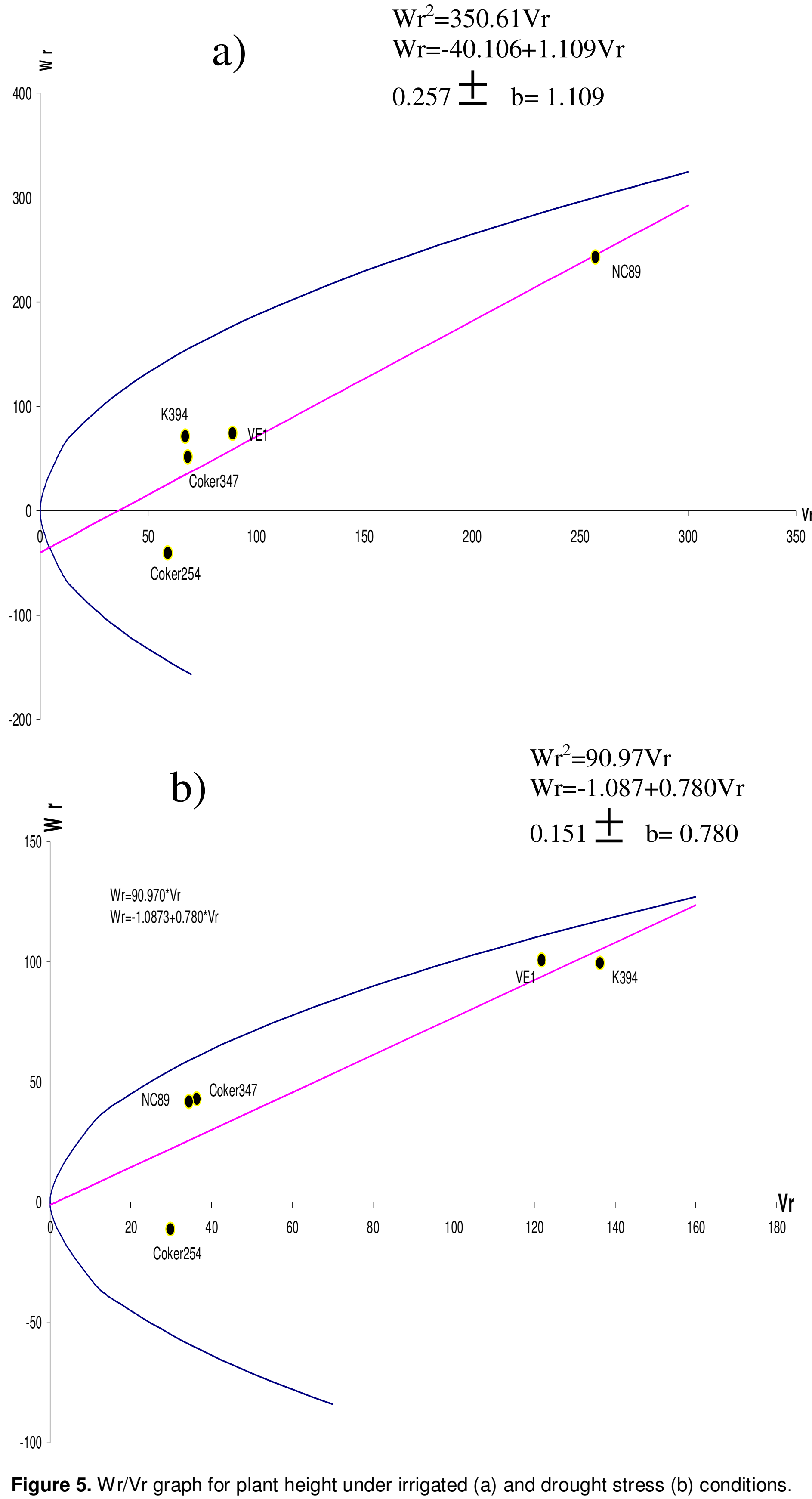

Figure 5. Wr/Vr graph for plant height under irrigated (a) and drought stress (b) conditions.

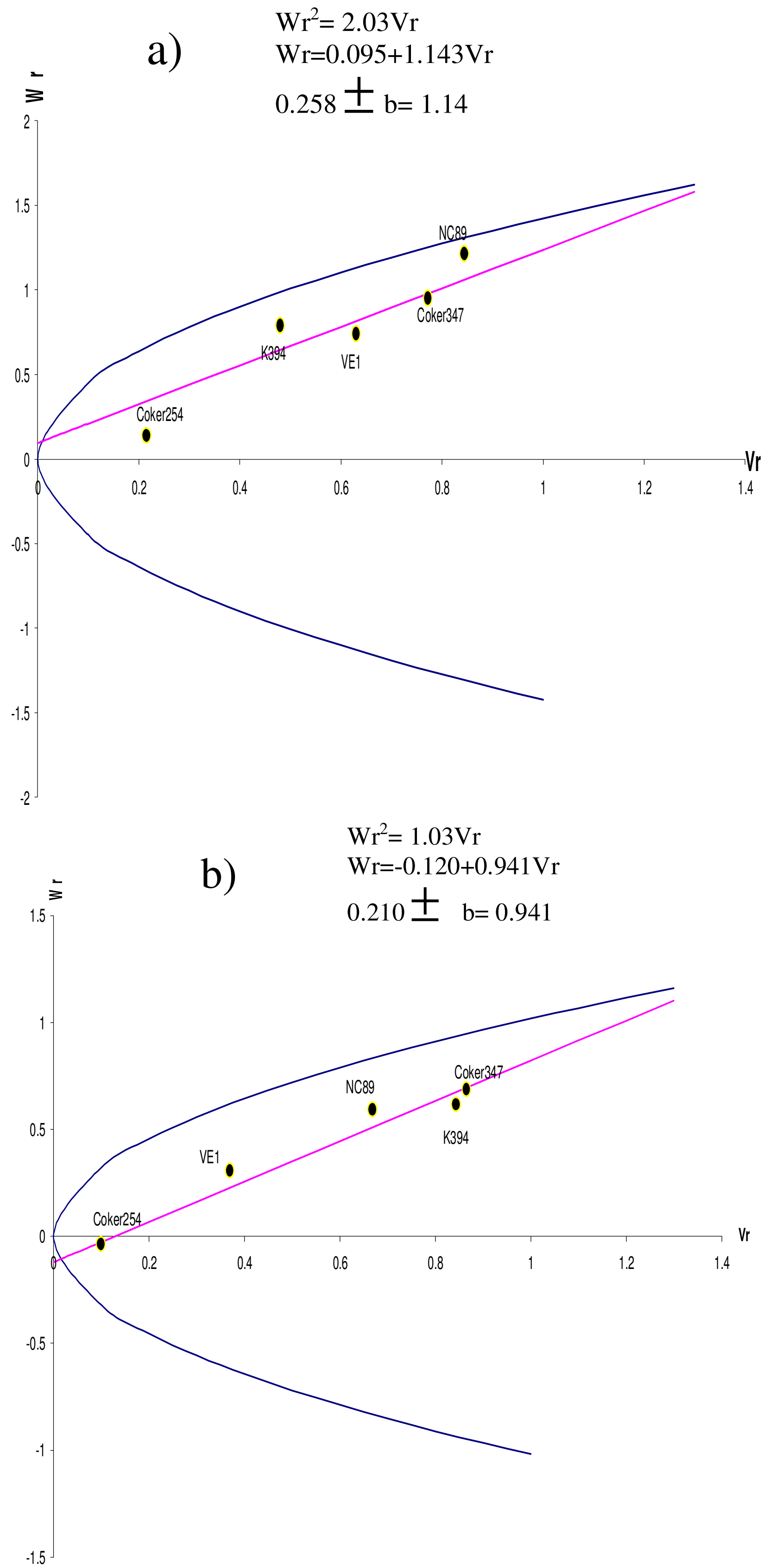

Figure 6. Wr/Vr graph for dry leaf yield under irrigated (a) and drought stress (b) conditions.

results are in agreement with the findings of Gupoyl et al. (1987), and Chang and Shyu (1991) who also reported an over dominant gene action. However, Pan (2001) reported a partial dominance for the plant height under irrigated as well as drought stress conditions while Ukai (1991) reported complete dominance for this trait. Distribution of array points displayed that under irrigated condition (Figure 5a) genotype Coker254 and K394 contained the most dominant genes for plant height while NC89 had the minimum number of dominant genes. In the case of drought stress, (Figure 5b) Coker254 and NC89 contained the highest dominant genes and k394 had the lowest dominant genes.

Dry leaf yield

Estimation of genetic components of variation (Table 3) for dry leaf yield under irrigated condition revealed significant D and H effects. Unequal H components indicated unequal distribution of dominant and recessive genes among the parents. The F component was negative but non-significant. Significant effect of the environment was also indicated. The average degree of dominance (0.76) indicated an additive type of gene action controlling the dry leaf yield. The estimation variation's components under drought stress condition revealed non–significant additive effects but significant dominant effects. Unequal values of H_1 and H_2 represented the dissimilar distribution of dominant and recessive genes among parents. The value of F was negative and significant. Significant influence of environment was also indicated. The average degree of dominance (1.26) indicated an over dominance type of gene action.

Graphical analysis of the data under irrigated conditions (Figure 6a) displayed that the intercept of the regression line was positive showing an additive type of gene action, while under drought stress condition (Figure 6b), the intercept of the regression line was negative displaying an over dominant type of gene action. The additive gene action for dry leaf yield was also reported by Shoaei and Honarnejad (1996) and Chen (2000). However, an over dominance gene action was reported by Ogilivie and Kozumplik (1995). Distribution of array points under irrigated condition (Figure 6a) depicted that the genotypes Coker254 contained maximum dominant genes while NC89 with farthest distance to the origin had the least dominant genes. Under drought stress condition (Figure 6b), the genotype Coker254 had the maximum number of dominant genes while the minimum numbers of dominant genes were observed in Coker347.

Conclusions

The overall results indicate the influence of environmental change on the expression of some traits and the genetic constitution of parental genotypes. The average degree of dominance indicate that over dominance gene action for width of leaf under irrigated conditions changed to additive gene action under drought while additive gene action for dry leaf yield and leaf area index under irrigated conditions changed to over dominance under drought. On the other hand, graphical analysis revealed that addictive action of genes for dry leaf yield and leaf area index under irrigated conditions changed to over dominance under drought. It was observed that parental genotypes shifted their positions in the graphs from recessive to dominant or vice versa, showing different genetic constitution for the same trait in response to environmental change. However, it also revealed gene action, because some characters remained the same over the environments. Moreover, the study of genotypes with similar constitution under both conditions showed that they contain stable genes for those particular characters and may prove useful in future breeding strategies.

The importance of G × E (genotype × environment interaction) became evident which may limit the possibilities of selection for quantitative traits like dry leaf yield and leaf area index, width of leaf, etc. This emphasizes the need of testing the selected material over different sites and locations for stable performance.

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