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Research Article

Grain Yield Response Of Rice Cultivars Under Upland Condition

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Abstract :
With a view to understand the differences in yield among rice cultivars under drought, a comparative study was done using 53 rice genotypes including three local land races in both controlled and upland conditions. Ten yield components were recorded in both the conditions. The correlation, path analysis and drought indices *viz*., relative yield (RY) and susceptibility index (S) were worked out. The correlation studies revealed that the single plant yield (SPY) was significantly positively correlated with number of leaves, number of tillers, number of productive tillers, number of primary branches per panicle, number of secondary branches per panicle, number of grains per panicle, number of chaffs per panicle and boot leaf breadth when evaluated under controlled irrigation condition. But none of the above traits had significant positive correlation with SPY in upland condition. In the path analysis, it was found out that number of productive tillers per plant has a high positive direct effect and most of other traits showed negligible or low direct effect in lowland condition, but in upland condition none of the factors are having high direct effects towards SPY. From the S and RY, it was found that the local land races and drought tolerant varieties MDU 5, TKM11 etc., performed well under upland condition.

Key words
Drought, drought tolerance, correlation, path analysis, susceptility index, relative yield

Introduction

Rice is the most important cereal crop, which is consumed by more than half of the world's population. Rice crop in India is irrigated to an extent of 48.3 per cent (19.6 m.ha) while the rest 51.7 per cent (24.6 m.ha) is grown as rainfed under varying moisture regimes and different ecological situations (Moorthy and Mishra, 2004). Ronald (1999) estimated that at least 30 per cent of the projected 70 per cent increase in global rice demand by the year 2025 must come from rainfed lands. In rain fed ecologies, drought is the serious yield-limiting factor, which is caused mainly due to inadequate or absence and uneven distribution of rainfall. In India, about 58 percent of total rice area is affected by drought, which becomes precarious year after year in terms of both area growth and severity of moisture stress. Thus, this problem receives greater attention in recent years. In order to design an efficient breeding programme for synthesis of varieties with high yield in drought/ upland condition, it is necessary to identify potential cultivars, which give high yield in both upland and lowland conditions. Before initiating any breeding programme, it is essential to obtain information regarding the inter-relationship between various yield-attributing characters and its behaviour under stress condition with grain yield. Apart from yield traits, Passioura (1983) and Blum (1996) clearly indicated that drought tolerance in crop species should be defined in terms of productivity. Fisher and Maurer (1978), Lin and Binns (1988) indicated that with the lack of sound information on specific drought tolerance and adaptation mechanism, selection for drought tolerance is still largely guided by grain yield and its stability under dry land conditions.

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Materials and Methods

Fifty-three genotypes that include varieties, hybrids, local cultivars and the genotypes that are in pipeline were selected at random, but keeping in view that they represent throughout the Tamilnadu state. They were raised in a randomized block design with three replications with two treatments namely a) controlled irrigation condition and b) upland condition with initial stress and terminal stress according to Laing and Fisher (1977), at Agricultural Research Station, Bhavanisagar. Ten quantitative characters that are

contributing to yield viz., number of leaves per plant (NOL/P), number of tillers per plant (NOT/P), number of productive tillers per plant (NOPT/P), number of primary branches per panicle (NOPB/P), number of secondary branches per panicle(NOSB/P), panicle length(PL), number of grains per panicle (NOG/P),number of chaffs per panicle (NOC/P), boot leaf length (BLL), boot leaf breadth (BLB) and single plant yield (SPY) were recorded. The correlation and the path analysis were calculated as per INDOSTAT package. Drought susceptibility indices (SI) was computed according to the formula of Fisher and Maurer (1978) as mentioned below:

$$SI = 1-(Ys/Yp/D)$$

where, S= drought susceptibility index, Yp= potential yield of a genotype under control moisture level. Ys= yield of a genotype under moisture stress level. Yp mean= mean yield of all genotype under control moisture level. Ys mean= mean yield of all the genotypes under moisture stress level, D= drought intensity

$$D= (1-Ys\ mean/Yp\ mean)$$

Superiority measures or relative yield (RY) was calculated from the formulas of Lin and Binns (1988). The relative yield under moisture stress was calculated as the yield of specific genotype under stress divided by that of the highest yielding genotype under moisture stress conditions.

Results and Discussion

The results of phenotypic and genotypic correlation under control and stress environments indicated that genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficient for most of the characters studied. The low phenotypic correlation might be due to the masking or modifying effect of the environment in genetic association between characters. Phundan Singh and Narayanan (1997) and Michael Gomez and Rangasamy (2002) also reported that the phenotypic value is lessened due to the significant interaction of environment. The genotypic correlation coefficients are presented in Table 1. The results indicated that the NOL/P, NOT/P, NOPT/P, NOPB/P, NOSB/P.NOG/P, NOC/P, and BLB were significantly correlated with SPY in the controlled irrigation environment. But at the same time, in the upland condition, the SPY was not significantly correlated with any one of the above-mentioned factors except NOC/P. The differential association between controlled and stress environment for these traits indicate that all these traits are highly influenced by drought stress. The trait NOC/P showed positive and negative relationship at under control and stress condition respectively. This indicated that the apparent association between the chaff number and single plant yield is highly influenced by the environment than any other characters. It is the most potential character in determining SPY under stress situation.

The inter correlation among the yield components shows the nature and the extent of the relationship with others which will help in the breeding programme for simultaneous improvement of different traits along with yield. The character NOL/P showed positive correlation with NOT/P, NOPT/P, NOPB/P, NOSB/P and NOC/P under both environments. However, NOL/P showed positive correlation with traits namely NOG/P, BLL and BLB under controlled situation but no association under stressed situation. The trait NOT/P showed positive association with NOPT/P under both situations. It showed positive association with BLL under stressed situation only. The character NOPT/P showed positive association with NOSB/P, NOG/P and negative association with BLL under controlled environment only. The trait NOPB/P recorded positive association with NOSB/P, NOG/P and NOC/P under both situations. This trait showed positive and negative association with BLL and BLB respectively under stress situation. NOSB/P showed positive association with NOG/P, NOC/P under both situation and positive association with BLL under stress situation only. The trait PL recorded positive association with BLL under both situation and positive association with BLB under control situation only. The trait NOG/P had positive association with NOC/P under both situation and positive association with BLB in stress situation only. NOC/P showed positive correlation with BLL in both situations. However it showed negative and positive association with BLB under control and stress situation respectively. The character BLL recorded positive and negative association with BLB under control and stress situations respectively. These results indicate the influence of stress on the expression of association between various traits. The influence of stress is most pronounced in BLL, BLB and NOC/P. Hence while formulating selection index under drought situation, more importance should be given to BLL, BLB and NOC/P for yield improvement programme.

From Table 2, it is obvious that yield and yield components were significantly reduced by the moisture stress. But the number of chaffs per panicle under stress condition is lesser or equal to that of controlled environment, but compared with number of grains per panicle, the grain yield under stress condition is lesser. So it might be due to the full

allocation of photosynthates to the developing grains in stress condition. It is well known fact as reported by many physiologists that under normal conditions, a portion of the stored assimilates is used for grain development and remaining assimilates can get from only current photosynthesis from boot leaf. In controlled situation, ADT 46 yielded more followed by CR 1009, Andhra masuri, Paiyur local and finally followed by ADT 44 whereas, in stressed environment, Paiyur local stood first in single plant yield followed by ADT 44, Dharmapuri local, CO 40 and TKM 11. The relative yield or superiority measure was highly found in Paiyur local as it leads to SPY under stressed condition. Drought tolerant variety is one which gives higher yield under drought condition. The susceptibility index was least in ADT 42,TKM11 and Pusa basumathi and SI was higher in ASD19, ASD 20 and TNRH 53. Paiyur local, a land race of drought prone area ,contributes better performance of yield in upland condition i.e., 18.33g/plant. Parameters employed to quantify and measure drought tolerance in terms of yield under stress conditions were drought susceptibility index (S) and vice versa (Fisher and Maurer, 1978; Bruckner and Frohberg, 1987). On the other hand, higher relative yield corresponds with high degree of tolerance (Lin and Binns, 1988; Nasir et al., 1992). As Paiyur local confers higher yield in upland condition, its relative yield was found to be unity and the susceptibility index was 0.58.

Regarding to yield contributing characters, number of productive tillers /plant (NOPT/P), number of grains per panicle (NOG/P) were significantly high in variety CR1009 and recorded high yield under controlled irrigation plot, but the variety was found to be susceptible to drought. The susceptibility index to drought and relative yield of the variety were found to be 0.75 and 0.73 respectively. Though, NOPT/P was high in variety IR50 in upland condition, it produced least yield in that condition and possessed susceptibility index of 0.67 and relative yield was only 0.24. From this, it was infered that more number of productive tillers in upland condition might not be considered as a selection criteria for obtaining high yield.

Conclusion

Based on the above result, the differential association between controlled and stress environment for these traits indicate that all these traits are highly influenced by drought stress. The trait NOC/P is the most potential character in determining SPY under stress situation. The influence of stress is most pronounced in BLL, BLB and NOC/P. Hence while formulating selection index under drought situation, more importance should be given to BLL, BLB and NOC/P for yield improvement programme. The mean performance over environment revealed that the varieties which had lesser drought susceptibility index and higher relative yield, might be considered for improving drought tolerance through formulation of suitable breeding programmes. Based on the results, five genotypes *viz*., Paiyur local, ADT 44, Dharmapuri local, CO 40 and TKM 11 which showed drought tolerance might be utilized as donors in breeding programmes for improving yield under moisture stress condition.

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Table 1: Genotypic and phenotypic correlation in the controlled and stressed environment

Characters	Environ.	NOL/P	NOT/P	NOPT/P	NOPB/P	NOSB/P	PL	NOG/P	NOC/P	BLL	BLB
NOT/P	Control	0.52**									
	Stress	0.31*									
NOPT/P	Control	0.41**	0.81**								
	Stress	0.36**	0.82**								
NOPB/P	Control	0.32*	0.03	-0.02							
	Stress	0.48**	-0.11	-0.05							
NOSB/P	Control	0.49**	0.21	0.33*	0.47**						
	Stress	0.46**	-0.09	-0.16	0.51**						
PL	Control	0.10	-0.20	-0.17	0.27	0.03					
	Stress	0.22	0.06	-0.20	0.14	0.31					
NOG/P	Control	0.47**	0.26	0.34*	0.40**	0.70**	-0.05				
	Stress	0.19	-0.12	-0.16	0.96**	0.76**	0.18				
NOC/P	Control	0.43**	0.12	0.06	0.63**	0.63**	0.05	0.32*			
	Stress	0.36**	-0.28	-0.13	0.85**	0.54**	0.15	0.37**			
BLL	Control	0.43**	-0.02	-0.44**	0.14	0.26	0.45**	0.12	0.44**		
	Stress	0.32	0.39**	-0.08	0.87**	0.32*	0.60**	0.21	0.38**		
BLB	Control	0.28*	0.17	0.12	0.26	0.18	0.38*	0.09	0.35*	0.33*	
	Stress	-0.27	-0.15	-0.14	-0.51**	-0.13	-0.27	0.56**	-0.37**	-0.60**	
SPY	Control	0.56**	0.45**	0.60**	0.34*	0.54*	0.09	0.54*	0.33*	0.19	0.39**
	Stress	-0.07	0.19	0.11	-0.11	0.02	0.10	0.24	-0.41**	0.08	0.01

*,** significant at 5 and 1% level respectively

Table 2. The comparison of yield characters in both controlled and moisture stress environments

Genotype	Environ.	NOL/P	NOT/P	NOPT/P	PL	NOG/P	NOC/P	SPY	SI	RY
Ponni	Control	43.67	29.00	26.67	26.00	261.67	21.33	44.00		
	Stress	51.33	10.00	8.00	24.00	150.67	30.33	8.33	0.74	0.45
C10	Control	33.67	11.67	11.00	19.37	139.67	16.33	32.50		
	Stress	29.00	11.67	10.33	19.73	93.00	5.67	14.00	0.40	0.76
TKM9	Control	69.33	19.67	14.67	21.47	112.33	2.67	37.00		
	Stress	17.67	5.67	5.33	20.00	80.00	12.00	6.67	0.75	0.36
Thulasi	Control	30.00	17.33	14.00	22.10	92.00	3.33	29.00		
	Stress	20.00	7.33	6.67	19.07	70.33	5.33	4.33	0.79	0.24
IR580-25B	Control	51.33	16.00	13.00	25.83	107.67	11.33	30.50		
	Stress	11.00	8.33	7.00	18.67	106.33	18.33	8.33	0.62	0.45
CORH2	Control	34.67	12.00	11.33	24.87	172.33	31.00	31.50		
	Stress	15.00	9.00	7.67	20.00	82.67	7.33	16.67	0.27	0.91
IR66R	Control	63.00	16.33	13.00	26.30	139.33	31.33	33.00		
	Stress	29.00	10.33	8.33	20.00	66.00	9.33	8.33	0.65	0.45
Annada	Control	55.33	21.33	18.00	25.23	173.00	8.00	31.50		
	Stress	25.00	5.33	6.00	20.50	65.33	16.33	8.67	0.62	0.47

TNRH53	Control	52.00	26.67	21.33	23.93	199.00	27.67	57.75		
	Stress	27.00	6.00	5.67	19.17	113.33	33.67	8.33	0.80	0.45
IR64	Control	52.33	20.33	19.33	24.73	109.33	3.67	40.50		
	Stress	23.00	7.67	7.00	21.00	77.67	5.67	10.00	0.66	0.55
ASD18	Control	30.00	17.33	13.67	24.63	88.33	4.00	20.25		
	Stress	30.00	6.67	6.00	19.77	42.00	19.00	7.67	0.47	0.42
ASD19	Control	80.67	24.00	24.00	26.20	155.67	11.00	44.25		
	Stress	47.67	13.67	10.00	22.67	70.00	32.00	5.60	0.82	0.31
ASD20	Control	42.00	34.00	27.33	21.50	94.33	21.67	30.25		
	Stress	24.67	7.00	6.00	19.90	72.67	27.67	4.33	0.80	0.24
Bhavani	Control	45.00	14.00	12.33	25.70	132.67	16.33	28.00		
	Stress	46.67	7.33	6.00	24.23	68.33	17.00	5.67	0.72	0.31
CO46	Control	27.00	11.00	11.33	29.13	73.33	19.00	21.75		
	Stress	24.67	6.33	6.00	28.50	127.33	18.33	7.33	0.53	0.40
CO47	Control	50.67	17.00	14.67	20.17	152.33	30.33	29.50		
	Stress	30.67	5.67	4.67	20.07	131.00	9.00	8.33	0.61	0.45
IW Ponni	Control	73.33	14.00	10.00	26.33	266.67	27.33	30.00		
	Stress	69.00	11.00	10.33	26.00	113.33	32.67	6.00	0.72	0.33
IR50	Control	44.00	31.00	12.00	21.87	88.00	10.67	18.25		
	Stress	36.67	16.00	15.00	17.57	69.33	10.67	4.33	0.67	0.24
ASD16	Control	30.00	9.67	10.00	25.57	169.00	6.67	22.25		
	Stress	27.67	10.67	7.33	23.37	82.33	6.00	4.33	0.73	0.24
GEB24	Control	63.00	19.33	13.67	26.77	144.60	9.67	37.00		
	Stress	46.33	14.00	11.00	24.50	58.67	5.33	13.33	0.50	0.73
IR20	Control	74.00	15.00	12.67	23.67	179.00	26.33	35.25		
	Stress	38.64	8.00	7.00	22.33	94.00	31.67	10.33	0.59	0.56
CR1009	Control	142.33	33.00	13.33	20.33	313.33	19.67	74.25		
	Stress	53.00	11.67	10.00	19.83	63.67	13.00	13.33	0.75	0.73
1R72	Control	52.67	18.33	16.67	23.50	131.33	7.67	35.25		
	Stress	22.00	16.00	14.33	21.57	83.33	12.33	12.67	0.50	0.69
PMK3	Control	42.67	16.00	7.00	31.63	131.33	10.33	37.25		
	Stress	22.67	10.33	9.33	20.00	80.67	16.33	13.33	0.50	0.73
PRR16	Control	65.33	16.67	14.33	28.00	213.00	18.67	57.00		
	Stress	22.00	8.67	6.67	26.33	115.33	8.67	16.00	0.61	0.87
TKM11	Control	62.00	20.33	10.00	21.83	157.00	21.00	22.75		
	Stress	40.00	8.67	7.67	26.27	130.67	12.67	17.33	-0.06	0.95
Ajaya	Control	72.67	25.67	14.67	23.63	128.00	14.67	33.25		
	Stress	24.67	8.00	5.33	23.90	60.33	13.67	9.33	0.61	0.51
Sasyashree	Control	86.67	19.00	15.67	25.40	139.67	10.33	35.75		
	Stress	38.67	7.00	7.00	19.73	84.00	12.00	10.00	0.61	0.55
Jaya	Control	43.67	18.33	16.67	26.50	155.00	8.67	46.75		
	Stress	21.00	7.67	5.67	19.33	83.00	7.00	8.67	0.74	0.47
C20	Control	37.00	17.67	12.67	22.13	117.67	11.00	32.50		
	Stress	38.00	5.67	5.67	26.53	78.00	14.00	14.00	0.40	0.76
MDU5	Control	18.67	15.00	8.00	24.33	94.00	11.33	34.00		
	Stress	20.00	10.67	9.00	25.47	73.00	4.33	16.67	0.32	0.91
Pusa basumati	Control	28.67	15.67	12.00	29.00	87.33	10.67	17.50		
	Stress	27.00	11.67	11.00	17.00	60.67	8.00	9.30	0.26	0.51
ADT36	Control	47.00	18.67	17.00	26.33	163.00	11.00	48.75		
	Stress	20.00	7.33	6.00	19.57	79.33	4.33	16.67	0.53	0.91
ADT43	Control	41.00	25.33	15.33	22.67	96.00	6.67	19.00		
	Stress	40.00	11.67	10.67	16.20	86.33	3.33	11.69	0.15	0.64

CO43	Control	22.67	8.33	7.33	26.00	98.00	31.33	44.25		
	Stress	39.67	7.00	6.67	23.67	101.67	16.33	11.67	0.63	64.00
BPT5204	Control	119.00	31.00	27.33	24.00	175.67	31.33	47.00		
	Stress	68.00	12.00	11.00	20.00	139.33	11.00	12.69	0.63	0.69
CO40	Control	61.00	17.00	14.00	22.83	136.33	26.67	56.25		
	Stress	23.00	7.67	4.67	18.07	140.67	18.00	17.33	0.57	0.95
CO37	Control	51.67	23.00	19.67	23.77	82.00	6.00	39.25		
	Stress	17.33	5.67	8.67	18.63	69.33	3.33	9.33	0.67	0.51
CO31	Control	101.00	35.33	14.67	28.03	141.00	46.33	51.25		
	Stress	31.67	12.33	7.33	22.30	136.67	21.33	16.00	0.57	0.87
CO45	Control	72.67	19.00	15.00	30.33	188.67	17.67	52.00		
	Stress	32.00	12.00	7.00	27.33	82.67	9.33	13.33	0.64	0.73
TPS3	Control	105.67	22.67	16.00	26.00	98.00	22.67	29.75		
	Stress	37.67	14.00	7.67	25.60	84.00	20.33	6.67	0.69	0.36
Paiyur 1	Control	106.00	26.00	14.67	25.00	304.00	18.00	57.70		
	Stress	31.00	12.00	10.00	19.63	53.67	3.67	14.70	0.65	0.80
TRY 2	Control	51.00	21.00	16.67	25.00	75.33	11.00	40.25		
	Stress	32.33	15.67	8.67	31.03	52.00	2.67	13.33	0.54	0.73
ADT44	Control	107.33	28.00	25.00	28.00	162.00	22.00	60.50		
	Stress	35.00	15.00	8.67	21.00	119.33	11.00	17.67	0.59	0.96
ADT39	Control	55.67	11.00	9.33	25.67	187.00	35.67	31.75		
	Stress	21.67	8.00	6.67	21.37	52.00	13.67	10.00	0.56	0.55
ADT40	Control	92.67	12.00	10.33	28.67	81.00	27.00	60.25		
	Stress	23.67	9.00	6.67	25.33	115.67	4.33	15.67	0.64	0.85
Andhra masuri	Control	138.33	33.33	28.67	24.67	217.67	31.33	61.25		
	Stress	36.67	10.67	6.33	25.43	110.67	10.33	9.33	0.79	0.51
ADT46	Control	92.00	31.67	26.00	30.10	111.00	9.33	75.75		
	Stress	24.33	14.00	8.00	28.67	75.33	4.67	14.00	0.74	0.76
ADT45	Control	62.67	27.33	21.33	34.00	148.00	7.67	49.25		
	Stress	23.33	7.33	7.00	18.33	101.33	15.00	13.33	0.62	0.73
Dharmapuri local	Control	82.67	20.33	16.67	24.37	161.33	20.33	59.50		
	Stress	45.33	9.00	7.00	22.57	59.67	7.33	17.33	0.60	0.95
Paiyur local	Control	105.67	22.33	18.00	25.13	172.00	50.67	60.75		
	Stress	27.33	7.00	4.67	25.03	121.33	24.33	18.33	0.58	1.00
Hosur local	Control	92.67	15.33	11.67	31.40	178.67	11.00	45.00		
	Stress	31.00	8.33	6.00	27.67	66.00	11.00	12.67	0.61	0.69
ADT42	Control	84.00	10.00	8.67	28.00	85.67	12.00	22.75		
	Stress	35.00	9.67	10.33	20.43	100.00	6.67	16.67	-0.02	0.91