Genotypic variability, heritability and correlation of yield and its components under heat stress in a recombinant inbred lines population of chickpea (*Cicer arietinum L.)*

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INTRODUCTION

Optimization of chickpea yields is a necessity to maintain its rank in the existing cropping system. High temperature is one of the most important climate factors reducing chickpea yield, which declined by up to 301 kg/ha per 1°C increase in mean seasonal temperature (Karla *et al*. 2010). High temperature prevailing at the beginning and end of the short winter season in Sudan and expansion production into warmer climates at central Sudan could adversely affect chickpea productivity. This study aimed to estimate genetic variability, heritability, genetic advance and correlation of seed yield of chickpea with its components under heat stress.

MATERIAL AND METHODS

Eighty eight recombinant inbred lines (RILs) of chickpea were evaluated under four environments (two sowing dates X two locations) in Sudan. The sowing dates were; mid Nov. (normal) and third week of Dec. (terminal heat stress). The two locations were Hudeiba, Lat.17° 34\` N, Long.33° 56\` E, 350 m above sea level, and Medani, Lat. 14° 24\` N, Long. 33° 29\` E, 405 m above sea level for season 2011/12 and 2012/13, respectively. An alpha lattice design was used with two replicates. All cultural practices were done as recommended. Data were collected for seed yield (g) per plant (YP), seeds number (SN), number of full pods (POD), 100-seed weight (g) (SW), harvest index (HI), biomass (g) per plant (BIOM) and plant height (cm), (PLHT). Phenotypic (σ^2ph), genotypic (σ^2g) variance and genotypic (GCV %), phenotypic (PCV %) coefficient of variation, heritability (h^2), genetic advance (GA) and phenotypic correlation were estimated.

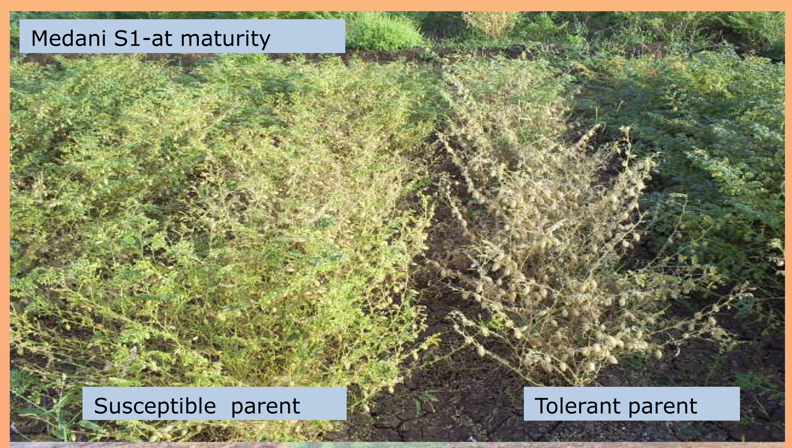
RESULTS AND DISCUSSION

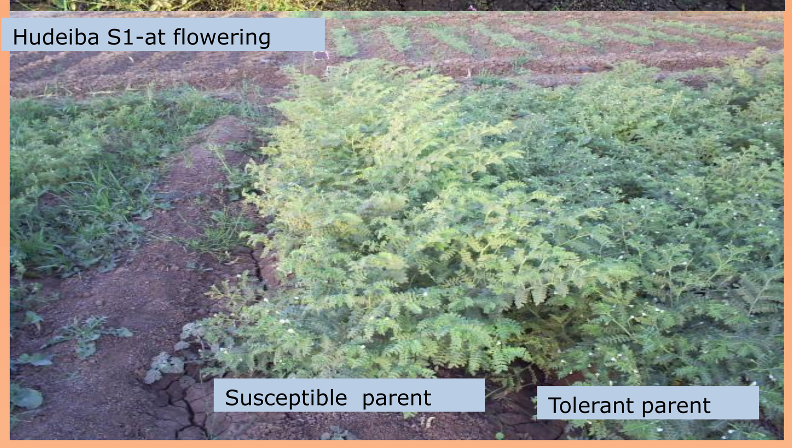
Effect of heat stress over different locations

There was drastic reduction in yield and the other traits due to heat stress in the two locations (**Table 1**). The average performance of the the 88 recombinant inbred lines and their parents was variable in the different locations.

Table 1: Means of yield and other traits of 88 recombinant inbred lines (RILs) and their parents under normal (S1) and heat stress (S2) conditions, at two locations (Hudeiba and Medani)

	Hudeiba		Medani	
	S1	S2	S1	S2
YP	9.6	3.1	4.0	0.4
SN	37.0	15.0	14.0	1.0
POD	32.0	12.0	14.0	2.0
HI	0.18	0.11	0.12	0.02
SW	27.4	21.6	26.3	17.6
BIOM	53.0	25.0	38.0	12.0
HI	69.2	50.0	64.0	47.0





Genotypic and phenotypic variability

Generally, there was a reduction in genotypic and phenotypic variability for most of studied traits under heat stress, indicating that gene expression changes with the change in environment. In contrast, there was an increase in phenotypic and genotypic coefficient of variation under heat stress conditions compared to non-stress environments for most of traits (**Table 2**). These results entail that when selecting for improving chickpea the target environment should be taken in consideration.

Table 2. **Phenotypic (σ^2ph), genotypic (σ^2g) variance, genotypic and phenotypic coefficient of variation ((GCV% and PCV %) for yield and yield components in chickpea recombinant inbred lines (RILs) under non-stress (S1) and heat stress (S2) at two locations Hudeiba and Medani.**

	σ^2g				σ^2ph				GCV%				PCV%			
	HUD		MED		HUD		MED		HUD		MED		HUD		MED	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
YP	0.35	0.17	0.69	0.02	0.77	0.76	2.26	0.13	19	24	24	16	29	52	43	41
SN	1.62	0.84	0.78	0.11	3.17	3.99	2.51	0.81	22	27	26	33	30	60	46	90
POD	1.44	0.61	0.22	0.11	2.92	3.26	0.56	0.93	22	26	23	31	32	61	38	88
SW	0.02	0.11	0.03	0.06	0.04	0.2 0	0.07	0.29	2.4	7.1	3.2	6.0	3.8	10	5.2	13
HI	0.23	0.11	0.24	0.02	0.32	0.32	0.36	0.16	5.8	4.3	6.3	1.8	6.9	7.2	7.7	5.6
BIOM	0.19	0.19	0.49	0.51	0.85	1.28	0.98	0.80	6.0	9.0	11	20	13	23	16	26
PLHT	0.26	0.11	0.09	0.29	0.42	0.40	0.29	0.42	6.1	4.7	3.8	8.0	7.8	8.9	6.7	10

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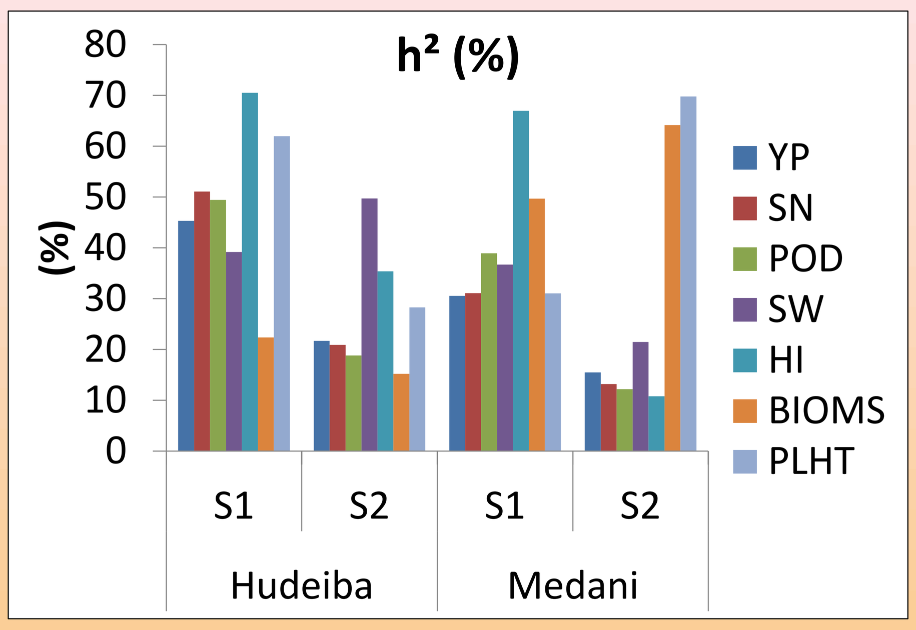
Heritability and genetic advance

Generally there was a decrease in estimates of heritability under heat stress condition. High to moderate estimates of heritability under normal and heat stress conditions were obtained for plant height. Moderate heritability coupled with high genetic advance was obtained for number of full pod, seed number and biomass under normal and stress conditions, indicating that selection based on these characters would be rewarding and useful in improvement of chickpea under favorable as well as heat stress conditions (**Figure 1**).



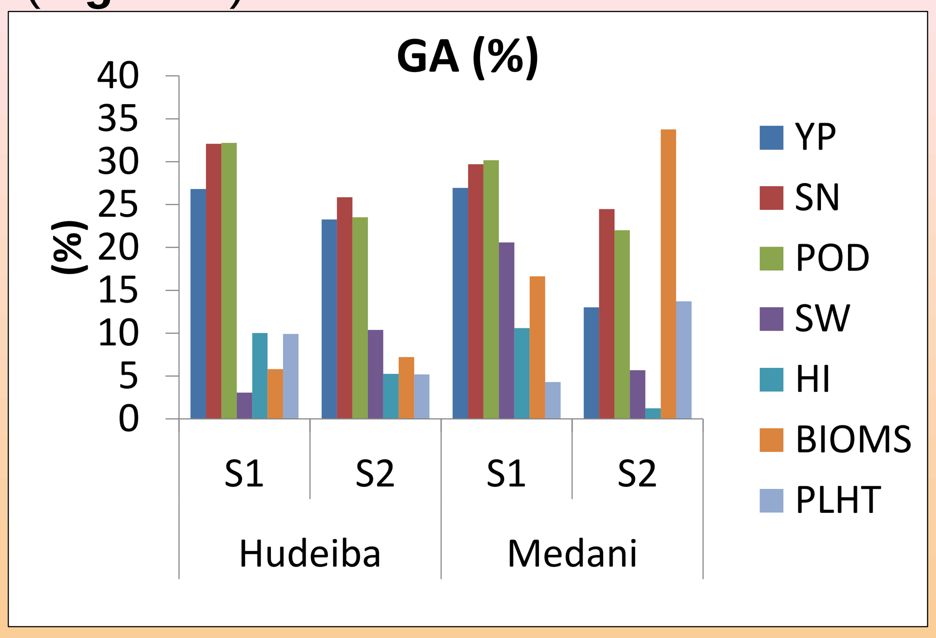


Figure1. **Heritability (h^2) and genetic advance (GA) for yield and yield components in chickpea under normal (S1) and heat stress (S2) at two locations (Hudeiba and Medani).**

Correlations between yield, its components and other traits

Generally, there was an increase in correlation under heat stress condition compared to non-stress one (**Table 3**). In all environments, seed yield was positively and strongly correlated with POD, SN and HI, this indicates that the associations between these traits are genetically controlled and are partly influenced by the environment. Non significant correlation under normal condition compared to significant correlation under heat stress condition was found for BIOM and SW with all other traits at Hudeiba. Negative significant correlation under normal condition was observed for plant height with most of the traits, however, non-significant correlations under normal condition compared to heat stress were observed at Medani. This indicates that value and sign of correlation between traits change with the change in environmental conditions.

Table 3. Phenotypic coefficient of correlations between different traits of chickpea under normal (S1) and heat stress (S2) conditions at two locations (Hudeiba and Medani).

		HUDEIBA						MEDANI					
Traits		SN	POD	SW	HI	BIOM	PLHT	SN	POD	SW	HI	BIOM	PLHT
YP	S1	0.96**	0.95**	0.20	0.89**	0.12	-0.56**	0.91**	0.92**	0.40**	0.76**	0.24*	-0.05
	S2	0.99**	0.97**	0.48**	0.85**	0.78**	0.26*	0.96**	0.97**	0.45**	0.79**	0.10	0.13
SN	S1		0.97**	0.10	0.87**	0.10	-0.57**		0.97**	0.39**	0.70**	0.26*	-0.05
	S2		0.98**	0.44**	0.88**	0.78**	0.25*		0.99**	0.31**	0.64**	0.01	0.13
POD	S1			0.12	0.84**	0.14	-0.53**			0.38**	0.69**	0.24*	-0.05
	S2			0.41**	0.78**	0.78**	0.27*			0.32**	0.67**	0.05	0.09
SW	S1				0.14	0.05	-0.08				0.21*	0.12	-0.16
	S2				0.61**	0.35**	0.12				0.40**	0.49**	0.30*
HI	S1					-0.30**	-0.71**					-0.20	-0.07
	S2					0.47**	-0.007					-0.06	-0.02
BIOM	S1						0.40**						0.05
	S2						0.62**						0.21

Correlation between yield under normal and heat stress

The correlation between yield under normal (S1) condition and under heat stress (S2) was strong and positive (r=0.57**) (**Figure 2**). The recombinant inbred lines DR1-27-5 and DR1-49 gave high yield under both normal and heat stress conditions. However the line DR1-109 showed very low reduction under heat stress compared to non-stress, i.e., it was more stable across environments compared to others.

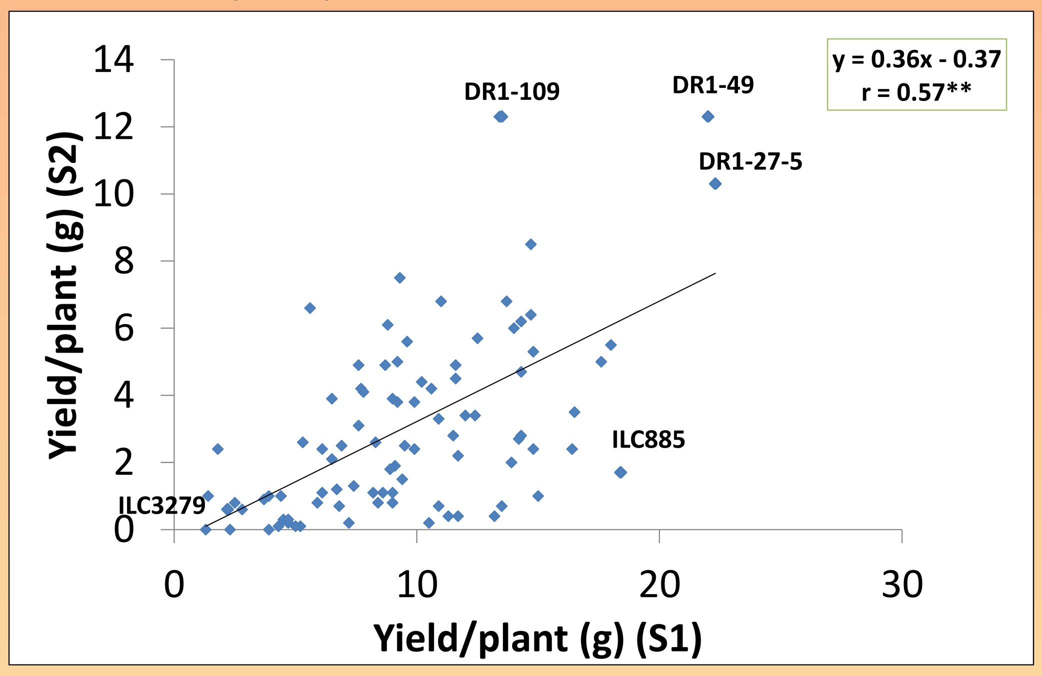


Figure 2. Correlation between yield under normal (S1) and heat stress (S2) among 88 recombinant inbred lines (RILs) and their parents of chickpea at Hudeiba location.

CONCLUSION

Based on this result it could be concluded that estimate of genetic variability could change with change in environment. Moreover, number of full pods and number of seeds per plant could be used as selection criteria for improvement of chickpea yield under both favorable and heat stress environments. Some of the tested recombinant inbred lines could be selected for improving heat tolerance in chickpea, e.g., the line DR1-49 which was the best under both normal and heat stress conditions.