Drought Stress and Rhizobium Nodules Interactions in chickpea

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Abstract:
Two hundred four genotypes of chickpea were assessed for various nodule characteristics and morphological traits under two environments, irrigated (well-watered) and rain-fed (water stress). The field experiment was conducted in the dry seasons of 2015/2016 and 2016/2017 in two site Terbol, Kfardan in Lebanon with Alpha Lattice design and two replications. Three parameters (nodule biomass (m3), nodule dry weight (g), nodule fresh weight (g) were collected to assess the Rhizobium nodulation, and four other traits (plant height (cm), grain yield (g), biological yield (g) and 100 seed weight (g) were measured for grain and morphological yield related traits. The genotypes were scored for drought tolerance by using a drought tolerance score (DTS 1-9 scale). Nine genotypes showed the best yield under both drought and well-watered condition (DTS<4). Among these genotypes, two (IG 71832 and IG 132032) were performed high nodulation under both environments. This result suggested these two genotypes will be help to improve the yield and nodulation under drought stress.

Introduction:
Chickpea (Cicer arietinum L.) is one of the major pulse crops throughout the world. It is cultivated on a large scale in arid and semi-arid environment, and has considerable importance as food, feed and fodder. Generally, legumes are highly sensitive to water stress and have significant genetic variation in their ability to fix N2 under drought conditions. Drought conditions may limit production of legumes by affecting nodule functioning. Direct selection for high yield under drought stress has been the main strategy for breeding for drought resistance in chickpea. Drought stress reduced nitrogen fixation in leguminous species including chickpea. Yield potential of this legume depends on the rhizobia association and plant genotype, together influencing the symbiotic performance. Symbiotic nitrogen fixation in legumes is limited by environmental stresses, mainly drought, resulting in decreased yield. Therefore, recognition of drought tolerance mechanisms of legumes is important in order to improve their agronomic performance. The objective of this study was to determine the best genotypes performing high nodulation and high yield under drought and well-watered conditions.

Table 1. Mean comparisons of nodule characteristics, yield and some morphological traits of chickpea under water stress conditions.

Traits	Water stress	Well-watered	Reduction (%)
PLH (cm)	30.1±7.58 **a**	38.6±8.17 **b**	22
GY (g)	25.5±16.76 **a**	29.3±22.81 **b**	13
BY (g)	67.1±50.01 **a**	79.7±55.84 **b**	15
100SW (g)	22.6±9.45 **a**	23±8.51 **a**	1.7
NDW (g)	0.29±0.31 **a**	0.37±0.51 **b**	21
NFW (g)	1.75±1.82 **a**	2.13±2.40 **b**	18
NB (g)	1.69±1.78 **a**	2.15±4.28 **b**	21

Material and methods:
Two hundred four genotypes (subset) selected from the genetic resource section (GRS), of ICARDA based on the passport date using focused identification of germplasm strategy (FIGS) for NF screening under water stress and well-watered conditions in chickpea. The experiment will be planted in the dry seasons of 2015/2016 and 2016/2017 in two locations Terbol (537 mm) and Kfardan (436 mm) in Lebanon with Alpha Lattice design, 35cm distance between rows and 2.5 m row length (25 Plants/row). Several reliable, cheap and rapid parameters will be used for evaluating drought tolerant chickpea varieties. Nodule biomass (NB), nodule dry weight (NDW), nodule fresh weight (NFW) were collected to assess the Rhizobium nodulation, and plant height (PLH), grain yield (GY), biological yield (BY) and 100 seed weight (100SW) were measured for grain and morphological yield related traits under water stress conditions.

Table 2. Simple correlation coefficients among nodules and morphological traits.

Trait	PLH	GY	BY	100SW	NDW	NFW	NB
PLH		**0.48*** **	**0.43*** **	**0.25*** **	**0.35*** **	**0.36*** **	**0.33*** **
GY	0.54***		**0.66*** **	**0.26*** **	**0.35*** **	**0.37*** **	**0.34*** **
BY	0.60***	0.83***		**0.19*** **	**0.36*** **	**0.38*** **	**0.37*** **
100SW	0.24***	0.25***	0.24***		**0.22*** **	**0.24*** **	**0.23*** **
NDW	0.43***	0.44***	0.46***	0.16***		**0.89*** **	**0.88*** **
NFW	0.50***	0.49***	0.53***	0.16***	0.88***		**0.96*** **
NB	0.28***	0.24***	0.28***	0.13***	0.47***	0.56***	

*** = Significant at p<0.001. Upper diagonal in bold represents the plants grown under drought stress conditions and lower diagonal represents the plants grown under well-watered conditions.

Result and conclusion:
The results indicated that all studied traits under the drought stress during flowering stage were significantly decreased (P<0.05) except 100 seed weight (Table 1). Water stress caused 21%, 18% and 21% reduction for each of the NDW, NFW and NB respectively. As compared to the well water treatment, yield and yield related traits reduced 22%, 13%, 15% and 1.7% under drought stress for each of in PLH, GY, BY and 100 SW respectively (Table 1). Positive and significant correlations were observed between yield, morphological and nodule traits. Under water stress treatment, a strong positive correlation among nodule traits were observed (Table 2). Our results indicated that two genotypes (IG 71832 and IG 132032) showed the best performance for high nodulation and yield under drought stress and well-watered condition.