Research Application Summary

Inheritance of tolerance to drought stress in selected common bean genotypes

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Abstract

The levels of tolerance to cyclic drought stress in selected common bean (*Phaseolus vulgaris*) lines were evaluated. Findings from this screening showed significant differences in levels of drought tolerance among the parental lines. The genetics governing drought tolerance in the selected common bean genotypes is being investigated in order to contribute to the generation of knowledge that will enhance further breeding work in Uganda.

Key words: Cyclic, genetics, *Phaseolus vulgaris*, Uganda

Résumé

Les niveaux de tolérance au stress hydrique cyclique dans certaines lignées communes de haricots (*Phaseolus vulgaris*) ont été évalués. Les résultats de ce dépistage ont montré des différences significatives dans les niveaux de tolérance à la sécheresse chez les lignées parentales. La génétique régissant la tolérance à la sécheresse dans les génotypes communs sélectionnés des haricots est à l'étude dans le but de contribuer à la production de connaissances qui permettra d'améliorer dans l'avenir le travail de sélection en Ouganda.

Mots clés: cycliques, génétique, *Phaseolus vulgaris*, Ouganda

Background

Dry bean production in Uganda is being threatened by frequent droughts resulting from the variability in climate. Drastic reductions (47%) in bean yield have thus occurred in last few years. The effects of drought are especially are wide-spread in Uganda because irrigation is very limited. . Consequently, developing high-yielding and drought-tolerant bean cultivars will significantly increase and stabilise yield in drought-prone environments. However, there is need to generate knowledge on inheritance of drought tolerance in genotypes relevant to Uganda in order to enhance further breeding efforts. This study was therefore conducted to determine the level of drought tolerance in selected bean lines and to understand the nature of

inheritance of drought tolerance in crosses of selected Ugandan bean genotypes with drought tolerant CIAT lines.

Literature Summary

In breeding for drought tolerance, selection may be made for early maturing varieties that escape stress, or a hybridisation program where tolerance genes are transferred into superior genotypes (Beebe *et al.*, 2010). Drought tolerance is quantitatively inherited and can only be estimated by comparing the performance of breeding lines under stress and non-stress conditions. Genotypic differences in biomass partitioning are reflected through two key traits that include: pod partitioning index and pod harvest index (Rao *et al.*, 2004). In general, selection for drought tolerance is based mainly on phenotypic traits (Acquaah, 2007) and direct measurement of seed yield is the most efficient way to screen for drought tolerance (White and Singh, 1991). Ramirez and Kelly (1998) confirmed that selection based on high geometric mean seed yields followed by selection for low drought susceptibility index values are effective approaches to select for drought tolerance in beans. In Beebe *et al*. (2008) and International Center for Tropical Agriculture (CIAT) studies on drought tolerance, superior pod harvest index and pod partitioning index were found to be important phenotypic traits that reflected a greater ability to mobilise photosynthates to grain under drought stress. Therefore, this research focused on remobilisation of photosynthates from vegetative shoot structures to the pods, and from pod walls to grain, as an important mechanism of drought tolerance.

Study Description

The study was conducted at the National Crops Resources Research Institute of Uganda, located in Namulonge, 28km north of Kampala, Wakiso District, (32^{o} 34'E, 0^{o}32'N) at 1200m above sea level. The area receives an average rainfall of 1300mm, average annual temperature of 22^{o}C with annual minimum and maximum temperatures of 16 and 28^{o}C, respectively. Eight genotypes were used in this research, 5 previously characterised by CIAT as tolerant to drought and 3 market preferred but drought sensitive. . Parental lines were screened for two seasons under screen house conditions in a split-plot design with 12 replications. Four watering regimes were used in which the water-stressed seedlings were watered once a day in the late morning hours on the appropriate days starting on the 14th day after planting. The non water-stressed trial was irrigated daily throughout the growth cycle. Data were collected on potential physiological drought indicators based on leaf measurements and on yield associated parameters. Indicators based on leaf

measurements were days to 50 % flowering, pod set & maturity, leaf relative water content (RWC), trifoliate leaf number, leaf chlorophyll content, abscission, roll and lamina drooping, and root spread and biomass. Yield associated parameters were – plant biomass (at mid pod filling & harvest), number of pods & seeds.

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The genotypes showed significant differences ($P \leq 0.05$) for key traits used to differentiate between drought tolerant and drought sensitive common bean lines (Table 1).

Table 1. Mean performance of 8 parental common bean genotypes screened for drought tolerance in two seasons (2011/2012) at NaCRRI, Namulonge, Uganda.

Entries	Pod partitioning index (PPI)	Pod harvest index (PHI)	Geometric mean seed yield (GM)	Drought susceptibility index (DSI)	Percent reduction in yield (PR)
SEN 98	43.4	53.0	1.36	0.76	70
SEN 99	43.0	47.1	1.23	0.77	71
SCR48	42.7	45.9	1.20	0.72	67
SCN 6	25.8	42.9	0.76	0.76	71
SCN 9	26.2	38.1	0.52	0.77	71
NABE 15	30.3	53.7	0.94	0.72	67
NABE 4	26.0	37.1	0.53	0.77	71
KI32	16.7	31.2	0.42	0.77	71
Average	31.6	43.6	0.87	0.87	70
SEM	4.55	7.01	0.12	0.02	2.91
LSD (5%)	12.9	23.4	0.41	0.06	8
CV (%)	49	45	40	10	12
Significance level	***	+	**	ns	ns

** - $P \leq 0.01$; ***- $P \leq 0.001$; ns- not significant at $P \leq 0.05$.

Three of the five drought tolerant lines obtained from CIAT, SEN 98, SCR48 and SEN 99, including NABE 15, presumed a drought sensitive genotype emerged superior in pod partition index, pod harvest index, and geometric mean (Table 1). SEN 98, SCR48 and NABE 15 also had low percent reduction in seed yield and low drought susceptibility index values. Superior pod harvest index, and pod partitioning index are important phenotypic traits that reflect a greater ability to mobilise photosynthates to grain under drought stress. However, selection based on high geometric mean seed yields followed by selection for low drought susceptibility index values are most effective approaches to select for drought tolerance in beans. Thus, SEN 98, SCR 48 and SEN 99 expressed tolerance to water stress. NABE 15's superiority arose due to drought escape mechanism

Table 2. Parental mean performance for two seasons in four watering regimes in 2011, 2012 at NaCRRI, Namulonge.

Entries	Season	Pod partitioning index				Pod harvest index				Geometric mean			
		CON	ML	MOD	SEV	CON	ML	MOD	SEV	CON	ML	MOD	SEV
K 132	One	64	40	5	1	80	48	11	0	1.83	0.32	0.00	0.00
K 132	Two	35	14	3	0	72	26	12	0	0.98	0.21	0.04	0.00
NABE 15	One	50	38	10	13	89	72	26	19	1.78	1.04	0.24	0.12
NABE 15	Two	87	24	13	6	95	51	48	30	2.82	0.82	0.48	0.23
NABE 4	One	61	9	11	0	83	19	8	0	2.14	0.18	0.00	0.00
NABE 4	Two	55	27	6	9	71	31	48	36	1.26	0.38	0.17	0.13
SCR 48	One	98	44	38	21	83	60	37	28	3.62	0.97	0.47	0.24
SCR 48	Two	93	18	24	4	79	36	36	9	2.74	0.58	0.74	0.23
SEN 98	One	98	71	33	24	85	64	51	28	3.64	1.25	0.60	0.13
SEN 98	Two	106	7	5	1	87	44	33	31	3.78	0.76	0.50	0.19
SEN 99	One	99	61	41	13	76	70	52	18	3.86	1.21	0.42	0.15
SEN 99	Two	80	22	21	7	74	43	22	21	2.78	0.97	0.32	0.13

CON - control, ML - mild stress, MOD - moderate stress, SEV - severe stress.

linked to early maturity. Table 2 shows performance of genotypes across four watering regimes in the two seasons for parameters that showed significant differences among genotypes. Genotype performance in the water stressed treatments considered as moderate and severe was poor because of high drought intensity.

The variability observed among the parental genotypes provide a basis for studying the inheritance of drought tolerance in the crosses of the 5 CIAT lines and the 3 market preferred genotypes to generate knowledge that will enhance improvement of the drought sensitive lines. NABE 15 escaped drought, it is possible that it could be successfully grown in areas with terminal or short intermittent drought.

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