Emergence of Tepary and Navy Beans With Increasing Salinity

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INTRODUCTION

Navy beans (Phaseolus vulgaris L.) often do not produce well in arid environments due to their sensitivity to low moisture (both soil and air), high temperatures and salt. Yet tepary bean (Phaseolus acutifolius Gray) is native to one of these arid regions, the Sonoran Desert, where all of these environmental stress are common. Thus, tepary beans must have adapted some type of mechanisms to overcome the stresses.

Several reports have documented that tepary beans are indeed more tolerant to low soil moisture than navy beans. A few reports have demonstrated that tepary has a greater tolerance to high temperature than navy bean. However, few have studied the salt tolerance of tepary beans. We have reported previously that tepary beans were more tolerant to salt than navy beans at germination.

The purpose of the current studies was to compare the salt tolerance of navy and tepary beans at another developmental stage, i.e. emergence. These data will help us understand how the salt tolerance of both bean types may change in relation to each other and to different developmental stages. By better understanding how plants such as tepary bean tolerate salt, we may be able to improve the salt tolerance of plants which do not tolerate salt, such as navy bean.

PROCEDURES

Seeds of two tepary bean accessions (a white and a brown - both originated from W.D. Hood) and one navy bean (cv. Fleetwood) were placed in trays with vermiculite saturated with 0, -0.3, -0.6, -0.9, -1.2, and -1.5 MPa of NaCl solution (1 MPa $\simeq$ 12000 ppm NaCl). Each tray contained 20 seeds of each bean type and each salt level was replicated three times. Trays were weighed and placed in a growth chamber at 25^{o}C for 14 days. Every two days, trays were reweighed and distilled water was added to return trays to original weights. At the same time, the stage of seedling emergence was recorded for each plant.

Seedling emergence was described by six stages, i.e. 0 = no seedling visible at surface of media, 1 = bend in hypocotyl hook just visible through surface of media, 2 = hypocotyl hook and shoot tip emerged beyond surface of media, 3 = hypocotyl hook unfolded but cotyledonary leaves not fully expanded, 4 = cotyledonary leaves fully expanded and first true leaves visible, and 5 = first true leaves well expanded. After 14 days, fresh weight of the entire plant was taken and leaf area was determined with a leaf area meter. Final emergence stages were analyzed using analysis of variance followed by Duncan's multiple range test.

RESULTS AND DISCUSSION

Table 1 shows effects of NaCl on final emergence stage of navy and tepary beans after 14 days. With no salt (0 MPa), plants of all three genotypes had developed to stages with cotyledonary and first true leaves expanding. Although the two tepary beans were slightly more developed than the navy bean, the difference was not significant and probably was due to experimental variability since the difference was no longer apparent at -0.3 MPa.

With increases in NaCl, delays in emergence stages were first observed at -0.6 MPa, where emergence was delayed relative to lower salinities for all three genotypes. For salinities at and above -0.6 MPa, emergence was delayed more in navy than the two tepary beans for all salinities, although this difference between genotypes was only statistically significant at -1.2 MPa. The delay in emergence also tended to be greater for brown tepary than white tepary beans, although the differences between these two was never statistically significant. Thus, with increases in salt, decreases in emergence were observed for all cultivars, but the decreases were greater for navy than for tepary beans.

Table 2 shows effects of NaCl on leaf area of the three genotypes after 14 days. The highest salinity shown is -0.9 MPa because no leaves emerged to measure their areas at the two higher salinities. With no salt (0 MPa), navy had a much greater leaf area than the two tepary beans. Little change in leaf area was noted for any of the genotypes with an increase in salinity to -0.3 MPa. However, with further increases in salinity to -0.6 MPa and -0.9 MPa, decreases in leaf area were observed for all three genotypes. At -0.6 MPa, leaf areas were reduced more for brown tepary and navy than for white tepary beans (i.e. 59 and 55 vs. 72%). However, at -0.9 MPa, leaf area was reduced more for navy than for white or brown tepary beans (i.e. 16 vs. 28 and 24%). Thus leaf area was decreased for all genotypes as NaCl was increased, although the magnitude of the decrease differed. The effects were least for white tepary bean, greatest for navy bean, and intermediate for brown tepary bean, whose response relative to other genotypes depended on the NaCl level.

Table 3 shows effects of NaCl on fresh weight of the three genotypes after 14 days. As for leaf area, the two higher salinities are not reported. At 0 MPa, fresh weight of navy beans was somewhat higher than those of the two tepary beans, although the difference was not great. At -0.3 MPa, a slight increase in fresh weight was observed for navy bean while those of the two tepary beans remained the same. With an increase in NaCl to -0.9 MPa, fresh weight of the brown tepary bean is decreased more than that of the white tepary and navy bean (i.e. 68 vs. 88 and 95%). However, with a further increase to -0.9 MPa, all three genotypes show fresh weights which are 51 to 59% of the fresh weight found at 0 MPa. Thus, although navy beans appear to have a higher fresh weight than tepary beans at the lower salinities, their fresh weights are very similar at the highest salinity.

In summary, tepary beans are more tolerant to NaCl than navy beans. Emergence stages and leaf areas gave a consistent evaluation of relative salt tolerance between genotypes at all salinities, whereas fresh weight did not. Further studies are being done to compare salt tolerances of these three genotypes at later developmental stages and in field conditions. However, it appears that tepary beans are more salt tolerant than navy beans and are a potential source of salt resistance for use in bean improvement programs. We are currently attempting to identify specific mechanisms which might be used as markers to identify salt tolerance.

Table I. Final emergence stage[z] of tepary and navy beans after 14 days at 25°C with increasing NaCl.

	NaCl CONCENTRATION (MPa)					
GENOTYPE	0	-0.3	-0.6	-0.9	-1.2	-1.5
White Tepary	4.65 a[y]	4.64 a	4.34 a	3.86 a	1.55 a	0.08 a
Brown Tepary	4.73 a	4.59 a	4.23 a	3.68 a	1.35 a	0.11 a
Navy	4.29 a	4.58 a	4.11 a	3.45 a	0.48 b	0.00 a

[z]See procedures for explanation of system used to describe stages.
yMean separation within columns by Duncan's multiple range test, 5% level.

Table 2. Leaf area (cm^2) of navy and tepary beans after 14 days at 25°C with increasing NaCl.

	NaCl CONCENTRATION (MPa)			
GENOTYPE	0	-0.3	-0.6	-0.9
White Tepary	14.3 (100)[z]	14.0 (98)	10.3 (72)	4.0 (28)
Brown tepary	16.0 (100)	16.0 (100)	9.5 (59)	3.8 (24)
Navy	25.2 (100)	24.5 (97)	13.8 (55)	4.0 (16)

[z]Values in parentheses represent the leaf area for a given treatment as a percentage of the leaf area at 0 MPa.

Table 3. Fresh weight (g) of shoots and roots of navy and tepary beans after 14 days at 25°C with increasing NaCl.

	NaCl CONCENTRATION (MPa)			
GENOTYPE	0	-0.3	-0.6	-0.9
White Tepary	1.60 (100)[z]	1.55 (97)	1.40 (88)	0.95 (59)
Brown Tepary	1.75 (100)	1.75 (100)	1.20 (68)	0.90 (51)
Navy	1.95 (100)	2.20 (113)	1.85 (95)	1.15 (59)

[z]Values in parentheses represent the fresh weight for a given treatment as a percentage of the fresh weight at 0 MPa.