Exploring Relationships Among Above- and Belowground Phenotypic Traits in Guar (*Cyamopsis tetragonoloba* L. Taub).

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Introduction

- Guar (*Cyamopsis tetragonoloba* (L.) Taub) is a multipurpose crop adapted to semi-arid conditions with excellent salinity, heat, and drought tolerance.
- The U.S. is the largest consumer/importer of guar gum products in the world for use in many industries, including oil and gas, paper, textiles, mining, explosives, and pharmaceuticals.
- U.S. guar production is limited and unstable, primarily based in the plains of Texas, New Mexico, and Oklahoma.
- The last major guar variety releases in the U.S. occurred around 1985, with some oil and gas-specific releases around 2005.
- In addition to a marketable seed product, a primary motivation for producing guar is often the anticipated soil-N (Nitrogen) credits through legume-rhizobium symbiotic relationship.
- Improvement of U.S. guar germplasm depends on better understanding of both yield and N-fixation traits.

Figure. 1 Guar genotypes in the experimental setup

Materials and Methods

- 50 guar accessions, obtained from the Plant Genetic Resources Conservation Unit (Griffin, GA), were grown in a greenhouse at the Texas A&M AgriLife Research Center, Vernon, TX.
- Experimental units: pots of 7.6 L (2 gallon) volume laid out in a completely randomized design (CRD) with 4 replications.
- A loamy sand soil was used, and seeds were inoculated with a custom inoculant at 100 mg/g seed following germination.
- Irrigation was managed at 100% ET (Evapotranspiration) replacement using a gravimetric technique.
- Growth occurred for 50 days, followed by assessments of root nodulation, biomass productivity, and plant development parameters.

Objective

To characterize phenotypic variation within measured plant parameters and establish pertinent relationships among above- and belowground traits.

List of Genotypes

Results and Discussion

Table 1. Biometrics on nodulation, growth and development parameters across 50 guar genotypes

Variable	Mean	Min.	Q1	Q2	Q3	Max.	SD	CV
Nodule number	17.4	10.0	16.0	17.0	20.0	27.0	3.6	20.5
Nodule wt. (mg)	892.0	602.0	775.0	875.0	1000.0	1150.0	144.2	16.2
N-percent (%)	3.1	2.7	3.0	3.1	3.2	3.6	0.2	6.5
N-content (g)	0.7	0.5	0.6	0.7	0.7	0.8	0.1	10.1
Total biomass (g)	21.5	16.1	20.3	21.9	22.7	26.2	2.0	9.5
Stem wt. (g)	8.8	5.1	8.0	8.9	9.8	11.6	1.4	15.8
Reproductive wt. (g)	1.6	0.0	1.0	1.5	2.2	6.0	1.0	62.4
Leaf wt. (g)	11.2	8.6	10.4	11.3	12.0	13.6	1.0	9.3
Leaf area (cm^2)	2337.0	1782.0	2154.0	2323.0	2472.0	2965.0	252.0	10.8
SLA ($cm^2 g^{-1}$)	211.0	171.0	198.0	214.0	224.0	240.0	17.0	8.1
Primary node number	20.0	18.0	19.0	20.0	21.0	23.0	1.4	6.7
Height (cm)	58.4	45.8	56.6	59.0	61.1	66.1	4.3	7.4
Branch number	8.4	0.0	4.0	10.0	12.0	13.0	4.3	50.9
Stem diameter (mm)	6.1	5.0	5.8	6.0	6.3	9.0	0.7	11.1

Table 2. Pearson's correlation coefficients between measured variables for 50 guar genotypes.

Parameters	Nodule wt.	N-percent	N-content	Total biomass	Stem wt.	Reproductive wt.	Leaf wt.	Leaf area	SLA	Node number	Height	Branch number	Stem diameter
Nodule number	0.13 NS	0.19 **	0.12 NS	0 NS	0.05 NS	-0.04 NS	-0.02 NS	0.08 NS	0.11 NS	0.05 NS	-0.05 NS	-0.09 NS	0.24 ***
Nodule wt.	1	0.04 NS	0.56 ***	0.54 ***	0.43 ***	0.14 *	0.48 ***	0.35 ***	-0.18 **	0.32 ***	0.09 NS	0.02 NS	0.31 ***
N-percent		1	0.33***	-0.31 ***	-0.26 ***	0.21 ***	-0.47 ***	0.08 NS	0.61 ***	0.09 NS	-0.1 NS	-0.19 **	0.18 **
N-content			1	0.78 ***	0.67 ***	0.27 ***	0.6 ***	0.66 ***	0.04 NS	0.29 ***	0.26 ***	0.13NS	0.38 ***
Total biomass				1	0.85 ***	0.14 *	0.92 ***	0.62 ***	-0.36 ***	0.26 ***	0.34 ***	0.24 ***	0.28 ***
Stem wt.					1	-0.32 ***	0.78 ***	0.72 ***	-0.09 NS	0.15 *	0.3 ***	0.53 ***	0.28 ***
Reproductive wt.						1	-0.08 NS	-0.26 ***	-0.18 **	0.17 *	0.07 NS	-0.49 ***	0.01 NS
Leaf wt.							1	0.59 ***	-0.48 ***	0.22 ***	0.3 ***	0.23 ***	0.23 ***
Leaf area								1	0.41 ***	0.11 NS	0.15 *	0.45 ***	0.24 ***
SLA									1	-0.11 NS	-0.16 *	0.24 ***	0 NS
Node number										1	0.43 ***	-0.32 ***	0.32 ***
Height											1	-0.22 ***	0.18 **
Branch number												1	-0.17 **

****, **, & * denotes statistical significance at $P < 0.001$, $P < 0.01$ and $P < 0.05$ levels, respectively. NS = No significant at $P > 0.05$.*

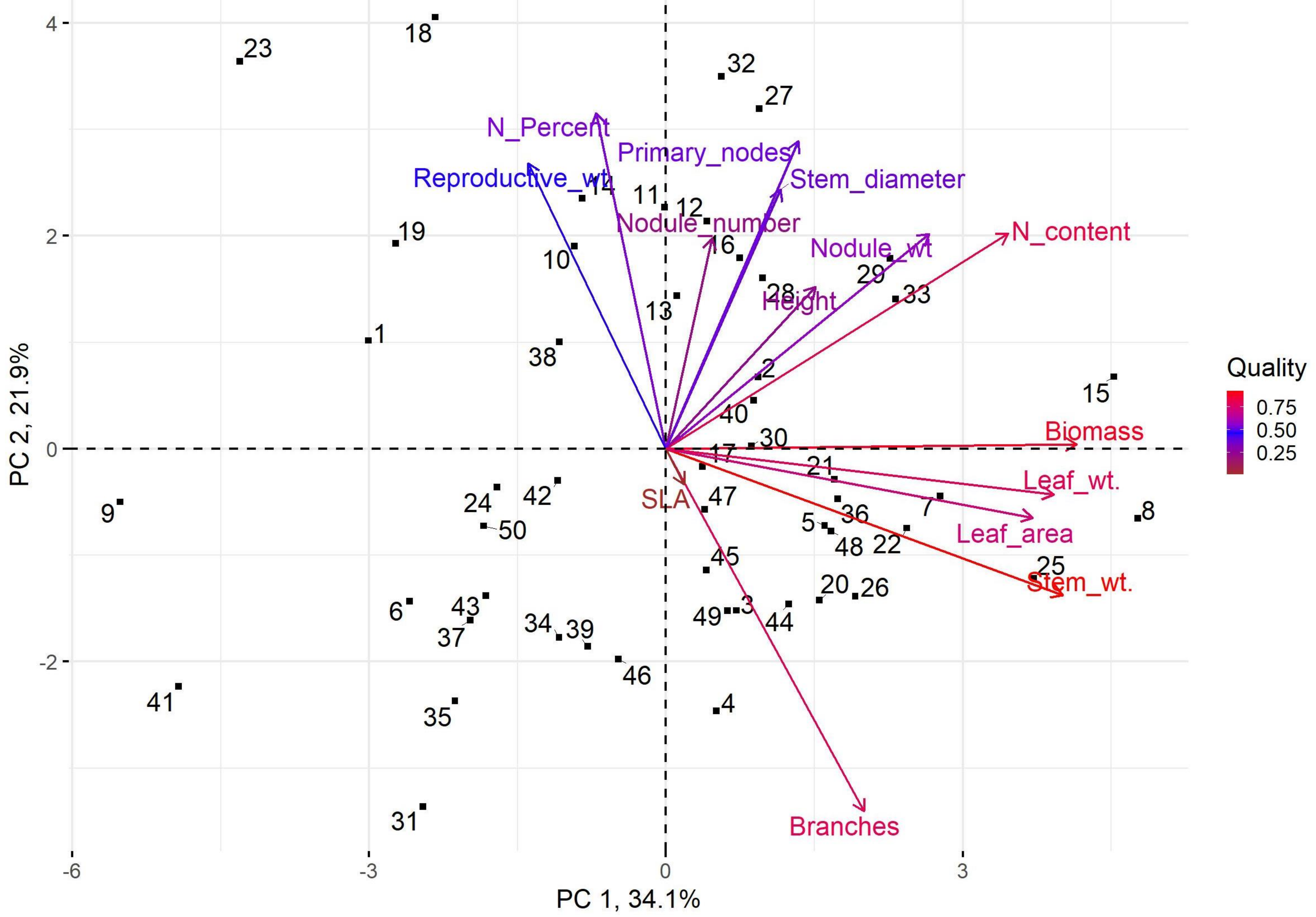

Figure 2. Biplot of the first two principal components. Each of the lines representing variables are respective trait vectors. The vector length of a trait estimates the magnitude of its effect (positive or negative), also shown as quality of variables. The numbers are genotype ID labels.

- Plant N-content was correlated to nodule weight and biomass/biomass components indicating high N-fixation and N-accumulation in genotypes with a greater biomass and nodule productivity.
- Interestingly, both the nodule number and weight were positively related to stem diameter, which suggests a relationship between stem and root system sizes, including the ability to support nodulation.
- Number of branches was positively related to most biomass production parameters, excluding reproductive biomass, but this relationship is likely reflecting varietal differences in maturity (reproductive development) due to short growing period.
- Specific leaf area (SLA) varied by > 49 cm^2/g leaf mass and was negatively related to biomass. This variation may be exploited by plant breeders to optimize potential SLA tradeoffs in leaf area production efficiency (relating to photosynthetic light interception) and leaf thickness (relating to drought tolerance trait)

Conclusion

There is substantial phenotypic and genotypic variation exploitable for improving guar germplasm in relation to drought tolerance, N-fixation, and plant productivity traits.

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