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GENOTYPIC VARIATION IN BIOMASS ACCUMULATION AND PARTITIONING AMONG MESOAMERICAN DRY BEAN GENOTYPES UNDER DROUGHT STRESS CONDITIONS

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Introduction

Partitioning of shoot dry matter to pods and remobilisation from pod wall to the developing grain is an important mechanism of adaptation to drought stress among dry bean genotypes (Rao et al., 2007). Yield under stress is enhanced through efficient assimilate redistribution in favour of grain production (Beebe et al., 2008). Drought tolerance genes have been incorporated into many small seeded bean genotypes through intensive breeding (Beebe et al., 2008), but the mechanisms of adaptation to drought stress have not adequately been addressed. Infact, such studies have not been reported in East and Central Africa. It is therefore important to understand these mechanisms and identify or develop bean varieties that have the ability to efficiently accumulate dry matter, partition and channel these photosynthates to the grain. This will result into increased yield of dry bean under stress and enhanced productivity of beans as droughts will continue due to projected climate change and variability (Jarvis, 2009).

Objective

To evaluate genotypic variation in dry matter accumulation and partitioning among Mesoamerican dry bean genotypes under drought stress

Materials and Methods

This study was conducted for two seasons at the University of Nairobi's Upper Kabete Field Station. Eighty four lines of Mesoamerican dry beans comprising drought navy beans (DNB), drought mixed colours (DMC) drought small reds (DSR), local and international checks were used. The design used was a randomized complete block design arranged as a split plot with three replications. Main plots were either irrigated (NS) or rainfed (DS) while subplots consisted of the 84 lines and checks. The plot size was 3 m long planted with two rows each consisting of 30 plants at a spacing of 50 cm x 10 cm. Both DS and NS plots were initially grown under irrigation at 80% field capacity. Stress was induced at pre flowering to maturity for DS treatment. Among the parameters measured were shoot, stem, leaf and pod biomass at mid pod filling and stem, seed, pod wall and pod biomass at physiological maturity. This was done through destructive sampling of a 0.5 m row of plants. Sampled plants were separated into respective plant parts, oven dried at 60ºC for 48 hours and dry weights recorded. Yield was measured by counting and harvesting the rest of the plants when fully dry and taking the seed weights. Also, soil moisture was monitored from the time of stress induction to maturity using the gravimetric method in order to determine moisture differences between the treatments.

Data analysis

The measurements recorded on various parameters were subjected to analysis of variance using Genstat version 13 at 95% and 99% confidence intervals. Sigma plots were also developed to show correlations among various parameters.

Results

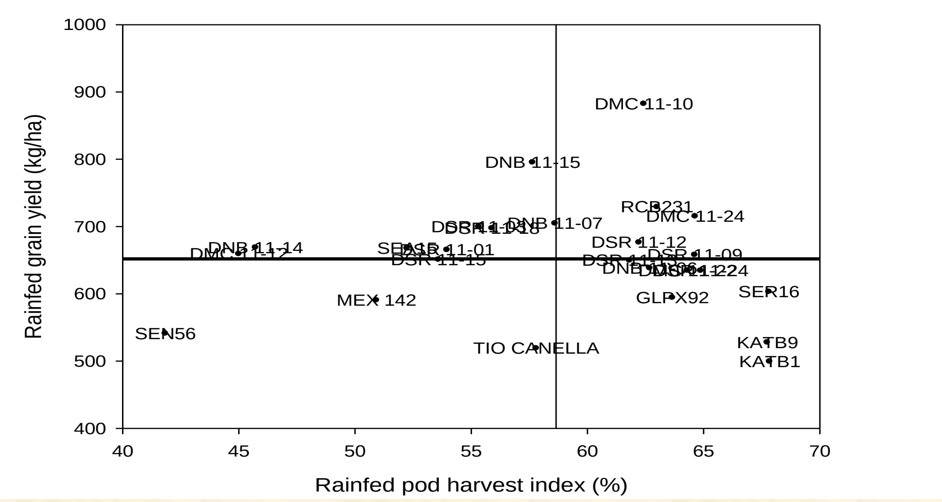
Pod partitioning index (PPI) was high under stress compared to non stress treatment. However, harvest index (HI)pod harvest index (PHI) and pod wall biomass proportion (PWBP) were high under irrigated treatment. There was a positive stem biomass reduction (SBR) among genotypes under rainfed treatment. Lower grain yields were obtained under rainfed conditions among most genotypes (Table 1). A strong correlation was observed between grain yield and pod harvest index under rainfed treatment (Figure 1)

Table 1: Plant attributes measured on 23 genotypes grown under irrigated (IRR) and rainfed conditions

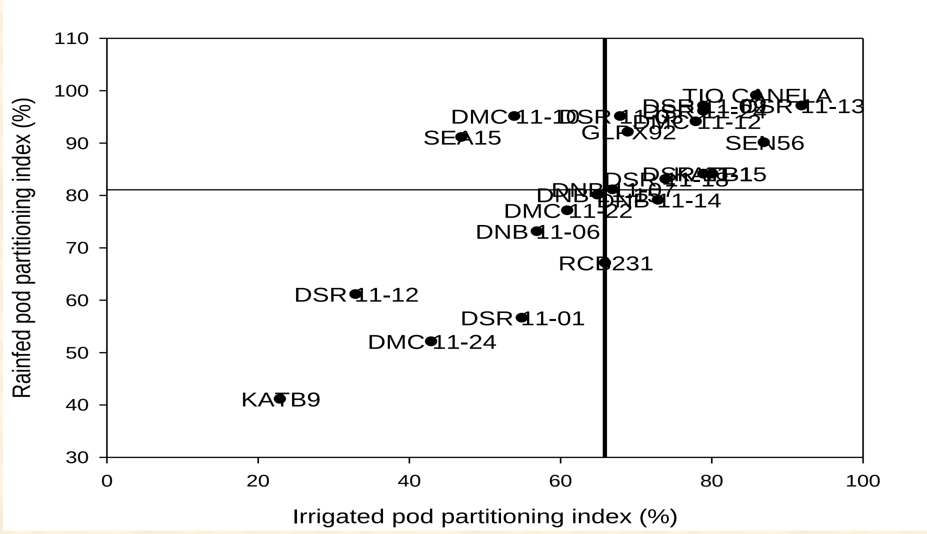
	PPI(%)		PHI(%)		HI(%)		SBR(%)		PWBP(%)		Yield in kg/ha	
GENOTYPE	IRR	RF	IRR	RF	IRR	RF	IRR	RF	IRR	RF	IRR	RF
DMC 11-10	54*	95*	69*	62*	38	33	-42*	65*	50*	37*	1302*	1005*
DMC 11-12	78*	94*	37*	45*	51*	40*	-24*	73*	62*	55*	841	716
DMC 11-22	61*	77*	64*	67*	58*	47*	-92	68	36*	33*	987*	652*
DMC 11-24	43*	52*	68*	64*	53*	37*	-80*	86*	35*	31*	1072	1027
DNB 11-06	57*	73*	65	63	40*	24*	-91	79	38	37	1213*	924*
DNB 11-07	67*	81*	68*	58*	49	45	-88	72	41*	32*	1508*	1218*
DNB 11-14	73	79	68*	45*	53*	43*	-33*	48*	54*	32*	952	894
DNB 11-15	65*	80*	67*	57*	47*	31*	-82	66	42*	32*	1286*	1043*
DSR 11-01	55	57	62*	53*	40*	30*	-36	34	48	46	876	810
DSR 11-03	68*	95*	66*	55*	50*	33*	-77	52	45*	33*	1281*	868*
DSR 11-09	79*	97*	71*	64*	52	47	-58*	64*	35*	39*	887*	704*
DSR 11-12	33*	61*	65*	62*	46*	33*	-29*	65*	44*	37*	1122*	920*
DSR 11-13	92	97	68*	61*	56*	47*	-12*	76*	58*	38*	1080*	857*
DSR 11-15	79	84	65*	53*	57	54	-84	72	54*	46*	978	880
DSR 11-18	74*	83*	61*	55*	56*	44*	-17*	88*	69*	44*	1029*	812*
DSR 11-24	79*	96*	68*	64*	38	32	-16*	54*	51*	35*	1040*	858*
GLPX92*	69*	92*	69*	63*	36*	25*	-72	70	40*	36*	811*	601*
KATB1*	80	84	69	68	33*	23*	-12*	30*	33	32	654	528
KATB9*	23*	41*	68	68	47*	31*	-23*	54*	32	32	730	687
SEA15*	47*	91*	67*	52*	25*	17*	-16*	79*	48*	32*	943	816
RCB231*	66	67	67*	63*	54*	43*	-13*	56*	37*	33*	899	788
SEN56*	87	90	62*	41*	37*	28*	-20*	36*	58*	38*	585	572
TIO CANELA*	86*	99*	54*	57*	55*	47*	-12*	47*	45*	42*	773	771
MEAN	**66***	**80***	**65***	**59***	**47***	**36***	**-46***	**64***	**46***	**37***	**938**	**770**
LSD(p<0.05)	**7.3**	**7.3**	**2.08**	**2.08**	**6.1**	**6.1**	**2.9**	**2.9**	**2.11**	**2.11**	**168**	**168**

*on genotype denotes checks. Measurements without * along irrigated and rainfed columns of a given plant attribute shows no significant difference at p≤0.05 between them. The LSD used is for interaction between genotype and treatment.

Correlation between Grain yield and pod harvest index under rainfed conditions



Correlation between irrigated and rainfed pod partitioning indices



Discussion

❖Partitioning of dry matter in favor of grain production is an important mechanism of adaptation to drought stress in common bean as it enhances seed production (Beebe et al., 2008).

❖Pod partitioning under stress was observed to be higher leading to a high harvest index. This may be due to greater mobilization of assimilates from pod wall to the grain (Beebe et al., 2008).

❖The positive stem reduction observed under stress may be due to channeling of assimilates to the developing seed (Rao et al., 2009).

❖ Low pod harvest index under stress may be attributed to higher rates of flower and pod abortion by the plants in order to deal with the stress thus resulting into reduced yields (Rosales-Serna et al., 2004).

Conclusion

From the above results, it is evident that drought stress is a serious abiotic constraint to dry bean production especially under the current climate change and variability. Therefore, efforts being made to develop drought resilient materials should have a basis of understanding important mechanisms enhancing drought adaptability such as the one discussed above. This will help sustain dry bean productivity in the face of the present and future challenging environmental conditions thus maintain food security.

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