Inheritance of tolerance to low soil P availability

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INTRODUCTION

Soil P is the most frequently deficient nutrient and supply is low in 65 % and 80% of the bean production areas of eastern and Southern Africa (Wortmann et al 1998). In this region, most bean-growing farmers are resource poor; generally women and can not afford chemical fertilizers to attain acceptable fertility levels in their fields. With increasing population pressure and intensive land use, bean cultivation is being pushed into marginal and low productive lands where soil fertility is becoming increasingly important. Cultivars that are efficient in uptake and use of available nutrients are needed to give good performance and thus offer the farmers a source of income. There is considerable evidence for genetic variation for ability to utilize soil phosphorous in bean (Wortmann et al, 1999). Often desirable variation has been reported in germplasm without preferred seed types. Transfer of such tolerance to low soil P in breeding programs would be facilitated by an understanding of the mode of inheritance of this trait. In Eastern Africa, the BILFA working group has been screening germplasm for tolerance to low soil P (Wortmann et al 1995). Several lines were identified as tolerant to low soil P in the third cycle of screening (BILFA III nursery) in 1999. We studied the inheritance of low P tolerance in three of these lines.

MATERIALS AND METHODS

Eight parents were crossed in diallel producing 28 F_1 progenies. Crosses were made during 1999 in a greenhouse at the Dept of Crop Science, University of Nairobi. In addition, self-pollinated seeds were produced on each of the 8 parental stocks, making a total of 36 diallel progenies. Three of the parents (CAL 143, CIM 9314-36 and AFR 708) had confirmed tolerance to low phosphorous and low soil pH. The other five were susceptible but well adapted cultivars. These were E5 and E8, which are pre-release advanced generation breeding lines selected for multiple disease resistance. E5 is a large seeded sugar. E8 is large seeded, red mottled line. GLP-2 is a red mottled popular cultivar released by Grain Legume Project at National Horticultural Research Station, Thika; SCAM 80-CM/15 (KK8) is a medium-sized, red mottled cultivar resistant to bean stem maggot and root rots released in Kenya, and CAL 96 (K132), a large seeded and red mottled type cultivar released in Uganda. The 36-diallel progenies were planted out in a randomized complete block design at Kabete (1860 masl) and Thika (1500 masl) under no stress and high-P stress conditions. These were achieved by application 100 and 0 kg P ha-^{1}, respectively. Soil analyses at Thika site were: pH 4.6($CaCl_2$), P- 10.3 ppm (Mehlich) and 2.2% C. At Kabete, soil P was 19.5 ppm. Soils at both locations are considered low (20-45 ppm) to deficient (<20 ppm) in P (FURP, 1994). In both locations, supplemental irrigation, pest and weed control were provided as needed. Analysis of variance and combining ability analysis (Griffins Method II, model 1) was performed using MSTAT-C software. The GCA: SCA ratio was calculated as suggested by Baker (1978). Wortmann et al (1999) concluded that the best selection criterion for bean performance under P limiting conditions was grain yield.

RESULTS AND DISCUSSION

There were highly significant differences for grain yield among the genotypes. Mean yield was 1154.4 and 1458.2 kg ha-^{1} for P stressed and non-stressed plots at Kabete. At Thika mean yield was 1014.9 kg ha-^{1} in low P plots and 1325.1 kg ha-^{1} high P plots. This indicated that P level was a yield limiting factor at both sites. Combining analysis showed that the both general combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant (Table 1). GCA: SCA ratios were 0.78 and 0.77 under low P, and 0.73 and 0.72 under high P levels. Table 2 shows that the general combing ability effects for SCAM 80-

CM/15, CIM 9314-36 and CAL 143 were positive and significant under low P fertility at the two locations. This indicates that they would be expected to transmit low P tolerance to their progenies. Positive GCA effects for AFR 708, CIM 9314-36 and CAL 143 in high P fertility conditions at Thika indicate that these lines would transmit genes for increased P utilization. These would be expected to respond to increasing soil P levels.

CONCLUSION

The occurrence of GCA: SCA ratio of greater than 0.7 is a strong indication that the low P tolerance is to a great extent controlled by additive genes (main effects). Highly significant combining ability effects means that breeding for this trait is possible when parents with known tolerance are included. However, it would be more difficult to exploit the non-additive effects in

Table 1. General combining ability mean squares for grain yield for stress and non stress phosphorous conditions at Kabete and Thika.

		Mean squares			
		'-P		+P	
Source	df	Kabete	Thika	Kabete	Thika
GCA	7	2017232.14**	2184286.4122**	575686.45**	1752806.36**
SCA	28	1099393.03**	1240806.8115**	425360.67**	1371345.83**
Error	70	1207.81	1898.5396	9858.45	1307.14
GCA/SCA ratio		0.78	0.77	0.73	0.72
Mean yield kg ha-[1]		1154.4	1014.9	1458.2	1325.1

Table 2. The general combining ability effects for grain yield under stress and non stress phosphorous condition for the two locations.

	Phosphorous stress level			
	-P		+P	
Parents	Kabete	Thika	Kabete	Thika
E5	-474.765**	-491.976**	-4.207	-59.71**
KK8	271.462**	272.137**	-291.55**	17.79
K132	42.025*	36.592**	-70.995	-210.86**
E8	-100.627**	-99.149**	36.673	-346.52**
GLP 2	-191.668**	-209.582**	9.651	-95.98**
AFR 708	-7.988	-0.893	116.055*	95.67**
CIM9314-36	321.281**	338.669**	167.29**	154.13**
CAL 143	140.28**	154.202**	37.081	445.47**

* '** Significantly different from 0 at 0.05 and 0.01 probability levels respectively.
-P= low and, '+P= high phosphorous fertility levels.

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