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Research Application Summary

Inheritance of resistance to Fusarium root rot in three common bean genotypes

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Abstract

Fusarium solani f. sp *phaseoli* (FSP) is an important disease in Uganda causing in some cases 100% yield losses in beans. The study established the nature of inheritance to *FSP* resistance in genotypes RWR 719, NABE 14 and NABE 13. A 5x5 full diallel design involving three resistant and two susceptible genotypes was used to develop F_1 and F_2 populations which were inoculated with *FSP* isolate. Crosses, GCA and SCA values were significant, suggesting importance of both additive and dominance variances but additive variance was larger. Chi-square test conformed to 2-3 gene models with dominance/ epistasis and heritability (h^2_{NS}) was estimated at 0.77.

Key words: Diallel crosses, fusarium root rot, griffings, *Phaseolus vulgaris*, resistance

Résumé

Fusarium solani f. sp *phaseoli* (FSP) est une maladie importante en Ouganda causant dans certains cas des pertes de rendement de 100% dans les haricots. L'étude a établi la nature de la transmission à la résistance de FSP dans les génotypes RWR 719, le NABE 14 et le NABE 13. Une pleine conception du diallële 5x5 impliquant trois génotypes résistants et deux genotypes sensibles a été employée pour développer les populations F_1 et F_2 qui ont été inoculées avec FSP isolé. Les valeurs de croisement, de GCA et de SCA étaient significatives, suggérant l'importance de la variance additive et celle de dominance mais la variance additive était plus grande. Le test de Chi-carré s'est conformé à 2 ou 3 modèles de gène avec la dominance/suppression d'un caractère héréditaire et l'héritabilité (h^2_{NS}) a été estimée à 0.77.

Mots clés: croisement des diallëles, putréfaction de racine de fusarium, *Phaseolus vulgaris*, résistance

Background

Root rot caused by *Fusarium solani* f. sp. *phaseoli* (*FSP*) is a major disease of common bean (*Phaseolus vulgaris* L.) in Uganda, causing often total yield losses to susceptible cultivars. Use of resistant materials is the most effective way of managing *FSP* for small-scale farmers. Resistant varieties have been identified but they are not of preferred market classes. The mode of inheritance of *FSP* resistance in the new genotypes is also not sufficiently known and this limits their use in breeding programmes. This study was initiated to determine the nature of inheritance of *FSP* resistance in bean genotypes RWR 719, NABE 13 and NABE 14.

Literature Summary

Resistance to *FSP* is quantitatively inherited and controlled by additive genes **(**Faria, 1983). Schneider *et al.* (2001), Roman-Aviles and Kelly (2005) and Mukankusi (2008) concluded that resistance to *FSP* is complex and strongly influenced by environment, explaining the slow progress in breeding for resistance to this pathogen.

Study Description

A five-parent full-diallel design involving 3 resistant genotypes (RWR 719, NABE 14 and NABE 13) and 2 susceptible (K132 and NABE 4) ones was used to generate F_1 and F_2 populations that, together with the parents, were artificially inoculated with the *FSP-3* isolate. Twenty eight days after inoculation, plants were scored using the CIAT 1–9 scale. The data were analyzed in GENSTAT, using model one, method one of Grifffing (1956). Frequency distributions and chi-square tests were used to elucidate the genetic models for resitance to *FSP*.

Findings

The crosses, GCA and SCA mean squares were significant (P d” 0.001), while reciprocal differences were not significant. The GCA variance was larger (2ó^{2}gca/ (2ó^{2}gca + ó^{2}sca) = 71%) than the SCA. Genotypes RWR 719 and NABE 14 had highly negative GCA effects, suggesting good transmission of *FSP* resistance to their progenies (Table 1).

A Chi-square test showed that the observed ratios in various crosses conformed best to genetic models with differing ratios: 9:7 and 27:37 (two and three complementary dominant genes, respectively); 49: 15 (one dominant and two recessive genes), and 13: 3 (two epistatic genes). The frequency distribution of the F_2 presented a wide and skewed distribution (Fig. 1), suggesting epistasis (Griffith *et al*., 1997).

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Both GCA and SCA variances were significant for *FSP* scores, indicating that both additive and dominance variances were

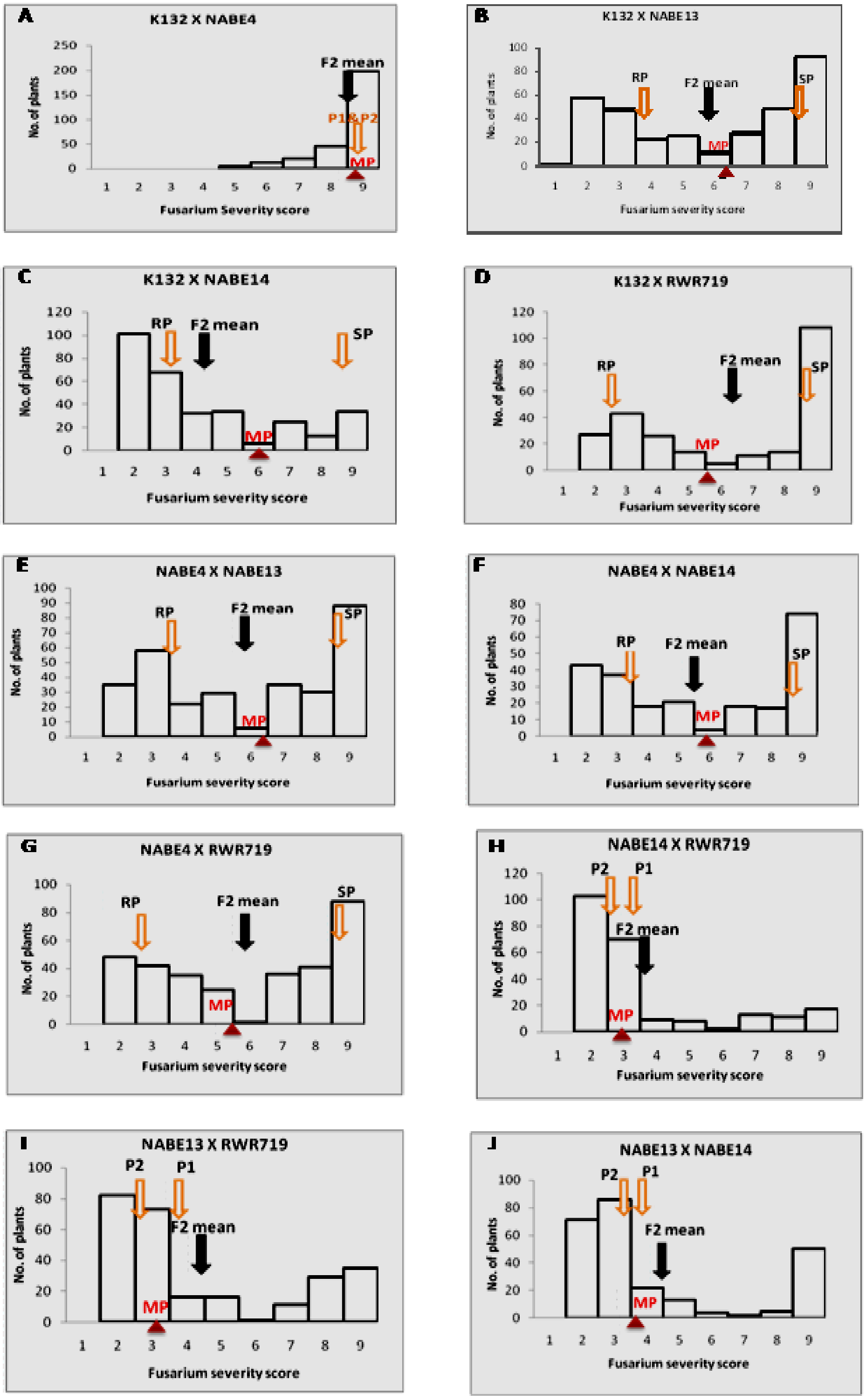

Figure 1. Histograms of FSP F_2 distribution for 10 crosses from the Diallel.
Key: MP = mid-parent, RP = resistant parent, SP = susceptible patent, P1 and P2 = parents involved in resistant by resistant crosses

Table 1. SCA (above diagonal), GCA (bold diagonal) and Reciprocal cross (below diagonal) effects for resistance to *F. solani* at F_1 generation.

Parents	1	2	3	4	5	Array mean
1	1.59***	1.1*	-0.7	-0.9	-0.5	6.2
2	-0.2	1.28***	-0.4	-1.3*	-0.9	6.0
3	0.3	0.1	-0.54^{ns}	0.5	0.4	4.0
4	-0.1	-0.3	0.3	-1.18***	0.6	3.3
5	0.7	-0.4	-0.1	-0.1	-1.15***	3.4
Mean						4.5

Key: *** Key: ***significant at P d• 0.001, **significant at P d• 0.01, *significant at P d• 0.O5. 1 = K132, 2 = NABE 4, 3 = NABE 13, 4 = NABE 14, 5 = RWR 719.

important in controlling the resistance to *FSP* in this set of dry beans. The additive variance being larger than dominance variance in this study implied that progeny performance could be predicted according to their parents' performance, and that line derivation and selection in later generations is effective. Generations also could be advanced by the single-seed-descent method or F_2-derived families harvested in bulk. Cytoplasmic gene effects were minor. *FSP* resistance was conditioned by two to three or more loci that displayed partial dominance and epistasis.

Recommendation

Because of the complex nature of inheritance, the genetic basis of resistance to *FSP* should be investigated in every new parental source before using it in breeding programmes.

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References

Mukankusi, C. 2008. Improving resistance to Fusarium root rot [*Fusariun solani* (mart) Sacc. f. sp. *phaseoli* (Burkholder) W.C Snyder and H.E Hans] in common beans (*Phaseolus vulgaris* L.). PhD. Thesis, University of KwaZulu-Natal, South Africa.

Román-Avilés, B. and Kelly, J.D. 2005. Identification of quantitative trait loci conditioning resistance to Fusarium root rot in common bean. *Crop Science* 45:1881-1890.

Schneider, K.A., Grafton, K.F. and Kelly, J.D. 2001. QTL analysis of resistance to Fusarium root rot in bean. *Crop Science* 41:535-542.