Original Research Article

Evaluation of Selected French Bean (*Phaseolus vulgaris L.)* Genotypes for Resistance to Angular Leaf Spot (*Pseudocercospora griseola*) in Western Kenya

ABSTRACT

French bean, a sub-group of the common bean (*Phaseolus vulgaris* L.), is grown for its tender green pods. It is a major export crop in Kenya but production levels are constrained by both biotic and abiotic stresses. Angular leaf spot (ALS) disease, caused by *Pseudocercospora griseola*, can cause major reductions in yield. The pathogen is highly variable and endemic in various agro-ecological zones. Genetic resistance against ALS is a high breeding priority, as effective cultural control is difficult. The main objective of this study was to evaluate French bean germplasm for ALS resistance in western Kenya. A set of 26 commercial varieties, three breeding lines, three landraces and two checks (resistant and susceptible dry bean cultivars) were planted in a randomized complete block design with three replicates at three sites in Kenya (Eldoret, Kisii and Kakamega) in 2014. Disease assessment was done using a 1-9 CIAT scale. There were significant ($P \leq 0.05$) differences in disease severity between the three sites: the Kakamega site experienced the greatest disease pressure (mean severity of 6.2), followed by the Kisii site (5.7) and the Eldoret site (5.3). Only one out of the 34 entries (not a French bean variety) showed field resistance to ALS. Most exhibited either an intermediate or a susceptible reaction at all three sites. The resistant control Mexico 54 (a dry bean variety) remained clear of ALS infection, so could represent a useful donor of resistance in a French bean breeding program. There remains a need to identify further donors of resistance, preferably within the French bean genepool.

Keywords: French beans, Pathogen variability; Resistance; Yield reduction.

1. INTRODUCTION

The French bean (*Phaseolus vulgaris L*.) is an important export product from Kenya. The crop is cultivated mainly by contracted small- to medium-scale farmers, along with a few large-scale growers, and is produced mostly for European Union countries [1]. The crop is largely produced to supply the fresh vegetable market and the canning and freezing industry [2]. The annual world production of French beans is estimated to be 18 Mt, with China, India, Brazil and Spain being the biggest producers [3]. The major production areas in Kenya are in the Central, Rift valley, Eastern and Western Provinces [4]. French bean pods are consumed as a green vegetable [5] and therefore consumers prefer unblemished pods, which are not a consideration for dry beans, where the seed is consumed. The production of French bean is constrained by a number of diseases, notably angular leaf spot (ALS) (*Pseudocercospora griseola* (Sacc) Ferraris; bean rust (*Uromyces appendiculatus* (Pers.pers.) Unger), common bacterial blight (*Xanthomonas campestris* pv. *phaseoli* (Erw. smith) and anthracnose (*Colletotrichum lindemuthianum*), [6, 7]. These diseases affect common bean production worldwide [8]. ALS is a major constraint in common bean production in both the tropics and sub-tropics, causing an estimated annual loss of 0.39 MT [9, 10]. The disease is prevalent in western Kenya [11]; a high disease incidence and severity is common particularly in Kakamega. The causative pathogen is *Pseudocercospora griseola* (Sacc) Ferraris, an imperfect fungus belonging to family Stibaceae, class Hyphomycete and order Moniliales [12]. At the onset of the disease, the lesions appear tannish gray in color, and later turn dark brown or black, coalescing, given favorable conditions, to induce chlorosis [13]. During humid weather, the under-surface of the leaves may take on a black felt-like appearance, reflecting the formation of spore masses, which is typically followed by leaf drop. Diseased pods exhibit circular spots with reddish brown centers. Severely diseased plants are non-vigorous and yield poorly [14]. Several disease control strategies have been employed to manage ALS, including crop rotation, planting pathogen-free seed in well drained soils and the use of fungicides [10]. However, the effectiveness and cost of these methods is variable and as a result, there remains a priority to breed in broad and durable host resistance. The French bean varieties

grown commercially in Kenya have largely been bred in Europe, so suffer a number of adaptability challenges and express susceptibility to various pathogens [15]. The aim of this study was to screen a set of French bean germplasm in a search for sources of resistance against ALS which would be effective in western Kenya.

2. MATERIALS AND METHODS

2.1 Plant Materials

The germplasm panel comprised a set of 34 common bean genotypes: of these, 26 were varieties commercially grown in Kenya, three were advanced French bean breeding lines and three were landraces provided by the National Gene Bank of Kenya (NGBK). Two dry bean entries (Mexico 54 and GLP X92) were included as a resistant and susceptible check, respectively.

2.2 Site Description

The experiments were conducted at three sites in western Kenya (Eldoret, Kisii and Kakamega), representing a diversity of agro-ecological zones, cultural practices and intensity of common bean cultivation. Eldoret is a high altitude region, Kisii a mid-high altitude region and Kakamega a mid-altitude region. The plants were exposed to natural infection, and were sown during the long rains of March-June, 2014, at the University of Eldoret (0°34' N,35°18'E), a small-holder farmer's field in Kisii (0°48'S,34°58'E) and at the Kenya Agricultural Resea rch and Livestock Organization (KALRO), Kakamega (0°16'N, 34°45'E). The Eldoret site (2153 m.a.s.l) is classified as a Lower Highland Agro Ecological Zone (AEZ); it typically experiences one rainfall season between March and September. The annual average rainfall is 1085 mm and the mean temperature ranges from 11-24°C. The soils are *rhodic ferralsol* [16]. The Kisii site (1936 m.a.s.l) lies within the Upper Midland AEZ and experiences a bimodal rainfall with long rains occurring between March and May and short rains in September to November. The annual average rainfall is 1900 mm, and means temperature ranges from 16-26°C. The predominant soil type is *luvic phaoezem*. The Kakamega site (1585 m.a.s.l.) lies within Upper Midland AEZ. The predominant soil type is *sandy loam*. The site experiences a mean annual rainfall of 1700 mm and the temperature ranges from 12-24°C [16].

2.3 Experimental Procedures

The experiment was set out in a randomized complete block design with three replicates. Each experimental unit consisted of a 3 m long single row separated from its adjacent row by 30 cm. Diammonium phosphate fertilizer was applied at sowing at a rate of 80 kg ha^{-1}. Weeding was done thrice at each site: the first time two weeks after emergence, the second before flowering and the final time at podding. The crop was protected from insect pests by spraying with Imidacloprid.

2.4 Disease Assessment

Disease severity data were collected starting from the trifoliate leaf stage through to pod formation. The 1-9 CIAT scale for ALS assessment was used (Table 1), where scores of ≤3 were considered as resistant, 4-6 as intermediate and 7-9 as susceptible [17].

2.5 Statistical Equation

$X_{ijklm} = \mu + B_i + G_j + E_k + EG_{jk} + BEG_{ijk} + £_{ijkl}$ Where: μ=Mean; B_i = Effect due to the ith Block; G_j=Effect due to the jth genotype; E_k = Effect due to the kth environment; G_{Ejk} =Interaction between the jth genotype and k^{th} environment; $£_{ijkl}$ =Residual effect.

2.6 Statistical Analysis

The disease severity scores data for each site was subjected to an analysis of variance using the PROC ANOVA procedure implemented in the SAS package (SAS Institute Inc, Release 9, Cary, NC, USA). The following general linear model was used:

$Xi_{jklm} = \mu + B_i + G_j + E_k + EG_{jk} + £_{ijkl}$

Where μ = mean; B_i = effect due to the ith block; G_j = effect due to the jth entry; E_k = effect due to the kth site; EG_{jk} = interaction between the jth entry and the kth site; $£_{ijkl}$ = residual effect.
Tukey's test was used to separate the means ($P \leq 0.05$).

Table 1. CIAT scale (1-9) of Angular Leaf Spot disease assessment scale

Reaction rating	Category	Description
1	Resistant	No visible symptom
2	Resistant	Lesions on up to 3% of leaf area
3	Resistant	Lesions on up to 5% of leaf area
4	Intermediate	Lesions and sporulation on up to 10% of leaf area
5	Intermediate	Lesions and sporulation with 2–3 mm in diameter on 11–15% of leaf area
6	Intermediate	Lesions and sporulation >3 mm in diameter on 16–20% of leaf area
7	Susceptible	Lesions and sporulation >3 mm in diameter on 21–25% of leaf area
8	Susceptible	Lesions and sporulation >3 mm in diameter on 26–30% of leaf area
9	Susceptible	Lesions, frequently associated with early loss of leaves and plant

3. RESULTS AND DISCUSSION

Significant differences ($P \leq 0.05$) were revealed between entries with respect to disease severity, and also between sites. The highest mean disease severity was recorded at Kakamega (6.2), followed by Kisii (5.7) and Eldoret 5.3 GBK032921 all showed an intermediate level of disease severity at Eldoret which was considerably lower as compared to the other two sites. Of the 34 entries, only Mexico 54 was considered to be resistant to ALS in western Kenya.

The study has described the presence and severity of ALS in Kenyan-grown French bean. The outcome agrees with the suggestion that the disease is prevalent in the bean growing areas of western Kenya [11]. The lowest disease scores were recorded in Eldoret, which reflects the lower temperatures resulting from its high altitude, an environmental factor which is unfavourable for disease development. Previous studies have suggested that the ALS pathogen requires a relative humidity of 70-100% and a temperature range 18-22ºC to successfully infect and sporulate [10], and temperatures below 16ºC have been documented to retard fungal development [18]. At both Kakamega and Kisii, where the disease pressure was higher, some of the entries experienced premature leaf drop. These two sites are among the most important bean growing regions in Kenya, since their bimodal rainfall and moderate temperatures allow for continuous cropping. As a result, the inoculum load is high and the disease is endemic. Genotype by environment effect indicated minimal variable rate of ALS infection on the genotypes. The fungal population is also not significantly restricted by chemical intervention, because most of the common bean production is carried out by smallholder farmers who tend to use little fungicide. None of the French bean accessions tested exhibited full resistance, but some showed a moderate level of resistance against ALS; the moderate resistance to susceptibility presumably reflects a degree of selection pressure imposed by breeders for pod quality not focused to this biotic constraint.

Disease hotspot sites are useful for screening for field resistance to disease. On this basis both Kakamega and Kisii, appear to be favourable sites for ALS screening. A similar recommendation applies to bean rust and similar studies on ALS [15, 19]. The present study has demonstrated that commercial French bean germplasm lacks a source of robust resistance against ALS. However, the exotic variety Mexico 54 could be used to improve ALS susceptible elite varieties. Mexico 54 is an indeterminate dry bean variety, so an intensive backcross program would be needed to restore the necessary pod quality and determinacy. In the meantime, there is a need to identify other sources of resistance, preferably within the French bean genepool, both to increase the diversity of resistance and to simplify the improvement of current elite varieties.

Table 2. Table of means for Response of French beans to Angular Leaf Spot in each site during March –December 2014 cropping season in western Kenya

Genotype	Eldoret	Kakamega	Kisii	Mean
Manakely	5.0bdac	5.7ba	5.3ba	5.5bdc
Tana2	5.5bdac	6.1a	5.5ba	5.5bdac
Star2053	5.2bdac	6.3a	6.5ba	6.0bdac
Venda	4.5bdac	6.7a	6.6ba	5.9bdac
Julia	4.0dc	6.3a	6.1ba	5.5bdc
Monel	7.3ba	7.3a	6.5ba	7.0bac
Morgan	4.8bdac	5.8ba	5.5ba	5.3dc
Andete	4.3bdc	5.5ba	5.3ba	5.0d
Venadon	4.6bdac	5.6ba	6.1ba	5.5bdc
T19	4.6bdac	6.5a	6.1ba	5.7bdac
Paulista	4.6bdac	6.5a	6.1ba	5.7bdac
Konza	5.3bdac	5.8ba	5.6ba	5.6bdac
Strada	4.8bdac	5.8ba	5.6ba	5.4bdc
Kendo	5.8bdac	5.6ba	5.5ba	5.6bdac
Serengeti	5.3bdac	6.0ba	4.5ba	5.0d
Morlane	6.3bac	7.1a	6.3ba	6.6bdac
Organdia	7.3ba	6.3a	5.1ba	5.9bdac
Supervolet	5.8bdac	6.5a	5.6ba	6.0bdac
Mozelli	5.6bdac	6.0ba	5.5ba	5.7bdac
Castore	5.0bdac	6.8a	6.0ba	5.9bdac
Samantha	5.0bdac	5.6ba	4.5ba	5.0d
Teresa	6.0bdac	7.1a	6.5ba	6.5bdac
Ducato	5.0bdac	6.0ba	5.5ba	5.5bdc
Amy	5.5bdac	6.5a	5.5ba	5.8bdac
Tana	5.5bdac	6.0ba	5.3ba	5.6bdac
Bravo	6.3bac	6.3a	5.1ba	5.9bdac
French bean lines				
Mu#2	4.8bdac	6.1a	5.1ba	5.3dc
Mu#10	5.1bdac	6.5a	4.5ba	5.3dc
Mu#13	6.3bac	6.1a	6.0ba	6.0bdac
Landraces				
GBK032805	4.8bdac	5.8ba	5.6ba	5.4bdc
GBK032921	4.2dc	7.2a	6.1ba	5.8bdac
GBK032952	7.5a	7.5a	7.0a	7.3a
Checks				
Mwitemania	7.3ba	7.1a	7.5a	7.2ba
Mexico54	3.0d	3.3b	3.3b	3.2e
Mean	5.3c	6.2a	5.7b	5.7
CV%	18.0	13.8	18.5	17.2

Means followed by the same letter are not significantly different according to Tukey's test

4. CONCLUSION

This study identified promising intermediate genotypes across the test sites, i.e. Andate, Samantha, and outstanding genotypes at specific sites such as Julia in Eldoret**.** The study also revealed that angular leaf spot spans across the various agro ecological zones in western Kenya and the French bean genotypes currently available and grown by farmers are susceptible to the disease.

5. RECOMMENDATIONS

This study recommends continued screening of French bean genotypes in other agro-ecological zones in Kenya and using races of *P. griseola* in order to broaden the findings on resistance, and also continued pyramiding and introgression of resistance genes to angular leaf spot in French beans grown in Kenya..

REFERENCES

1. Horticultural Crops Development Authority, HCDA French beans (*Phaseolus vulgaris*). Export Crop Bulletin Nairobi, Kenya 2013:01.
2. Horticultural Crops Development Authority (HCDA).Horticulture Validation Report 2008;01 Nairobi, Kenya.
3. Food and Agriculture Organization of the United Nations. Statistics Division 2010 .Accessed 09 January 2015. Available: http://Faostat.Fao.Org/Site/339.
4. Horticultural Crops Development Authority (HCDA).French Beans (*Phaseolus vulgaris L*.) Export Crop Bulletin 2009:01 Nairobi, Kenya.
5. Myers J R, Baggett J R. Improvement of Snap Beans In: S.P.Singh Common Bean Improvement for the 21st Century 1999:289-329.
6. Monda E O, Munene S, Ndegua A. French Bean Production Constraints in Kenya. African Crop Science Conference Proceedings 2003; 6:683-687.
7. Wahome S W, Kimani P M, Muthomi J W, Narla RD, Buruchara R. Multiple Disease Resistance in Snap Bean Genotypes in Kenya. African Crop Science Journal 2011; 19:289-302.
8. Pastor-Corrales M A, Jara C, Singh SP. Pathogenic Variation in, Source of, and Breeding for Resistance to *Phaeoisariopsis griseola* Causing Angular Leaf Spot in Common Bean.Euphytica1998;103:161-171
9. Wortmann CS, Kirkby RA, Elude C A, Allen D J. Atlas of Common Bean (*Phaseolus vulgaris L*.) Production in Africa.CIAT 1998;297.
10. Stenglein S, Ploper LD, Vizgarra O, Balatti P. Angular Leaf Spot: A Disease Caused by the Fungus *Phaeoisariopsis griseola* (Sacc.) Ferraris on *Phaseolus Vulgaris* L. Advances in Applied Microbiology 2003; 52:209- 243.
11. Wagara I N,Mwangombe A W, Kimenju J W,Buruchara R A.Virulence,Variability and Physiological Races of the Angular leaf spot Pathogen *Phaeoisariopsis griseola* in Kenya Afri.Plant prot.2005;11:23-31.
12. Liebenberg, M.M. and Pretorius, Z.A. A review of angular leaf spot of common bean (*Phaseolus vulgaris* L.). *African Plant Protection* 1997;3:81-106.
13. Allen, D.J., Dessert, M., Truman, P. and Voss, J. Common beans production in Africa and their constraints. In: Schwartz H.F. and Pastor-Corrales M.A. (Eds.). Bean Production Problems in the Tropics. CIAT, Cali, Colombia 1989;9-32.
14. Agricultural sector development support programme Kakamega county development profile 2013:Accessed 13 October2015 available:http://www.asdsp.co.ke/index.php/kakamega county.
15. Arunga E, Breeding for Rust Resistance in French beans (*Phaseolus Vulgaris* L.) in Kenya: Pathogen diversity and Host Resistance. Moi University PhD Thesis 2012:52-53.
16. Jaetzold R.Schmid.T TH, Hometz,B B, Shisanya C .Farm Management Handbook of Kenya Ministry of Agriculture.2006;11.
17. Van Schoonhoven, Pastor-Corrales M.A. Standard System for the Evaluation of Bean Germplasm,Calli:CIAT;1987.

18. Ddamulira G, Mukankusi C, Ochwo-Ssemakula M, Edema R, Sseruwagi P, Gepts P. Distribution and Variability of *Pseudocercospora griseola* in Uganda. Journal of Agricultural Science 2014; 6: 24-25.
19. Mwang'ombe AW, Wagara IN, Kimenju JW, Buruchara RA. Occurrence and Severity of Angular Leaf Spot of Common Bean in Kenya as Influenced by Geographical Location, Altitude and Agro-ecological Zones. J.Plant Pathology 2007; 6:235-241.