African Crop Science Journal, Vol. 19, No. 4, pp. 387 - 392
ISSN 1021-9730/2011 $4.00


# SUSCEPTIBILITY OF SOUTH AFRICAN DRY BEAN CULTIVARS TO BACTERIAL DISEASES

D. FOURIE
Agricultural Research Council-Grain Crops Institute, Private Bag X1251, Potchefstroom, 2520, South Africa
**Corresponding author:** FourieD@arc.agric.za

## ABSTRACT

Dry beans are an important crop in South Africa with the annual bean consumption being approximately 120 000 t. The crop is annually subjected to a number of biotic constraints such as bacterial diseases that can cause serious yield losses especially when the climate is conducive to diseases. The use of resistant varieties is an effective way of reducing the risk of crop failure and deployment of resistance requires knowledge on the susceptibility of cultivars. Twenty-one locally grown commercial dry bean cultivars were evaluated at Potchefstroom in South Africa to evaluate the resistance to common bacterial blight, halo blight and bacterial brown spot. Results indicated that South African cultivars differed in susceptibility to bacterial diseases. Cultivars Teebus, Cerillos, PAN 146 and PAN 159 were most susceptible to common bacterial blight with Monati and OPS-RS2 having low levels of resistance. Negative correlations (r=-0.44)(P<0.001) between disease ratings and yields were obtained in the common bacterial blight trial. Levels of resistance to halo blight were observed with small seeded cultivars generally being more resistant than large seeded types. A negative correlation (r=-0.35)(P=0.001) was obtained between halo blight rating and yield. Cultivars differed regarding susceptibility to bacterial brown spot with the majority having adequate resistance. Teebus, Cerillos, Bonus and PAN 159 were most susceptible, with Mkuzi exhibiting highest levels of resistance. No correlation was obtained between disease rating and yield. Although a number of cultivars exhibited field resistance to halo blight and bacterial brown spot, all cultivars were more or less susceptible to common bacterial blight. Common bacterial blight can be considered the most important bean bacterial disease in South Africa. Improvement of common bacterial blight resistance in South African cultivars is necessary for yield stability.

*Key Words:* Common bacterial blight, bacterial brown spot, halo blight, resistance

## RÉSUMÉ

Les haricots secs constituent une culture importante en Afrique du Sud avec une consommation annuelle d'environ 120 000 t. Par ailleurs, cette culture est annuellement sujet à un bon nombre de contraintes biotiques dont les maladies bactériennes responsables de pertes considérables de rendement, spécialement lorsque le climat est favorable aux maladies. L'utilisation des variétés résistantes est un moyen efficace de réduction du risque d'échec des cultures, ce qui demande la connaissance sur la susceptibilité des cultivars pour la préparation de traits de résistance. Vingt et un cultivars de haricots secs commerciaux localement cultivés étaient évalués au Potchefstroom en Afrique du Sud face à la résistance à la bactérie commune de flétrissement, le flétrissement auréolaire et la bactérie de la tâche brune. Les résultats ont indiqué que les cultivars sud africains présentaient une différence quant à la susceptibilité aux maladies bactériennes. Les cultivars Teebus, Cerillos, PAN 146 et PAN 159 étaient les plus susceptibles à la bactérie commune de flétrissement, les cultivars Monati et OPS-RS2 présentant des niveaux bas de résiatance. Des collélations négatives (r=-0.44)(P<0.001) entre les taux d'incidence maladie et rendements étaient obtenues dans des essais de bactéries communes de flétrissement. Des niveaux de résistance au flétrissement auréolaire étaient observés, les cultivars à petit grains étant les plus résistants que ceux à grains larges. Une corrélation négative (r=-0.35)(P=0.001) était obtenue entre le taux de flétrissement auréolaire et le rendement. Les cultivars différaient en leur susceptibilité à la bactérie de la tâche brune, la majorité ayant une résistance adequate. Teebus, Cerillos, Bonus et PAN 159 étaient les plus susceptibles, le cultivar Mkuzi présentant les plus hauts niveaux de résistance. Aucune corrélation n'était obtenue entre le taux de maladie et le rendement. Bien qu'un bon nombre de cultivars avaient montré une résistance sur terrain au flétrissment auréolaire et à la bacteria de la tâche brune, tous les cultivars étaient plus ou moins susceptibles à la bactérie commune de flétrissement. Par conséquent, cette dernière peut être considérée comme la plus importante maladie bactérienne du haricot en Afrique du Sud. L'amélioration de la résistance à la bactérie commune de flétrissement dans les cultivars sud africain est pour ce faire nécessaire pour la stabilité de rendement.

*Mots Cles:* Bactérie commune de flétrissement, Bactérie de la tâche brune, flétrissement auréolaire, résistance

## INTRODUCTION

Dry beans (*Phaseolus vulgaris* L.) represent an important leguminous food crop grown in South Africa, with approximately 50 000 tons being produced annually by commercial and small scale farmers. Bacterial diseases, e.g. common bacterial blight (*Xanthomonas axonopodis* pv. *phaseoli,* Xap) (Smith) Vauterin et al. 1995 halo blight (*Pseudomonas savastanoi* pv. *phaseolicola,* Psp) (Burkholder) Gardan et al. 1992 and bacterial brown spot (*Pseudomonas syringae* pv. *syringae*, Pss), van Hall, limit dry bean production in many international bean producing areas (CIAT, 1985). Pathogens responsible are all seed-borne infecting beans at different stages of maturity. Their relative importance varies annually depending on biological and climatic factors and management practices.

Common bacterial blight (CBB) is widespread throughout the South African bean producing areas (Fourie, 2002). It can also be highly destructive during extended periods of warm, humid weather, resulting in yield and seed quality loss (Saettler, 1991). Typical blight symptoms are visible during the crop's reproductive stage. Yield losses have been poorly documented, but vary from 22 to 45% (Wallen and Jackson, 1975; Yoshii 1980).

Halo blight (HB) is restricted to cooler production areas at higher altitudes and typical symptoms are visible from seedling stage to crop maturity. Serious yield losses have been observed, particularly where farmers grow their own seed for a number of seasons (D. Fourie: unpublished data). Yield losses of 43% have been obtained under experimental conditions (Allen *et al*. 1998). Pathogenic variation within Psp isolates exist, with seven (races 1, 2, 4, 6, 7, 8 and 9) of the described nine races (Taylor *et al*., 1996) occurring in South Africa (Fourie, 1998).

Bacterial brown spot (BBS), the most widespread bacterial disease in South Africa, occurs in all seed and commercial production areas (Fourie, 2002). Sporadic losses occur in moderate to hot climatic areas, particularly where plants have been damaged by heavy rain or hail (Serfontein, 1994). Yield reduction, as high as 55%, were reported (Serfontein, 1994).

Bacterial bean pathogens are seed-borne and this is the primary inoculum source (Allen *et al*., 1998). Planting of pathogen-free seed is the most important primary control method (Gilbertson *et al*., 1990). Use of pathogen-free seed, however, does not guarantee disease control, as other inoculum sources exist (Allen *et al*., 1998). Additional cultural practices, such as removing, destroying or deep ploughing of debris, effective weed control, crop rotation and minimising movement within fields when foliage is wet, may be also effective in controlling the disease (Allen *et al*., 1998, Schwartz and Otto, 2000).

The most effective and economic bacterial control strategy in dry beans, is this use of cultivars with stable resistance (Rands and Brotherton, 1925). The aim of the study was to determine susceptibility of local commercial cultivars to CBB, HB and BBS and, thus, to direct breeding strategies towards resistance against important bacterial diseases in South Africa.

## MATERIALS AND METHODS

Twenty-one South African dry bean cultivars (Table 1) were evaluated for resistance to CBB, HB and BBS. Three field trials, one for each disease, were conducted at Potchefstroom during the 1998/1999 and 1999/2000 rainy seasons. Cultivars were planted in 2 row plots, 5 m in length with 750 mm inter-row and 75 mm intra-row spacing. Trials were planted in a randomised complete block design with three replications,

TABLE 1. Characteristics of 21 commercial South African dry bean cultivars screened for resistance to bacterial diseases

| CV name | Bean type | Growth habit* | Mean growing season (No. of days from plant to harvest) | Seed size (g 100 seeds$^{-1}$) |
|---|---|---|---|---|
| Teebus | Small white canning | III | 92 | 127 |
| Helderberg | Small white canning | II | 99 | 180 |
| OPS-KW1 | Small white canning | II | 96 | 156 |
| PAN 182 | Small white canning | II | 90 | 183 |
| PAN 185 | Small white canning | II | 96 | 183 |
| Cerillos | Alubia | I | 91 | 57 |
| Kranskop | Red speckled sugar | II | 97 | 63 |
| OPS-RS1 | Red speckled sugar | II | 96 | 63 |
| OPS-RS2 | Red speckled sugar | I | 100 | 61 |
| OPS-RS3 | Red speckled sugar | II | 97 | 65 |
| Jenny | Red speckled sugar | II | 96 | 57 |
| Bonus | Red speckled sugar | III | 97 | 69 |
| Monati | Red speckled sugar | II III | 97 | 55 |
| PAN 146 | Red speckled sugar | I | 86 | 70 |
| PAN 148 | Red speckled sugar | II | 96 | 72 |
| PAN 159 | Red speckled sugar | I | 85 | 74 |
| PAN 178 | Red speckled sugar | II | 97 | 76 |
| Stormberg | Red speckled sugar | III | 97 | 70 |
| Leeukop | Red speckled sugar | III | 99 | 69 |
| PAN 150 | Carioca | II | 95 | 123 |
| Mkuzi | Carioca | II | 96 | 143 |

* Type I: Determinate growth habit: flowers at end of branches stop stem growth
Type II: Intermediate growth habit: few short and upright branches, grow after flowering
Type III: Intermediate growth habit: long and low trailing branches

each surrounded by two border rows. Herbicide (flumetsulam/sulfonanilide, 1 l ha$^{-1}$) was applied directly after planting.

Two Xap isolates (X6 and Xf105) were used, in a mixture to inoculate the common blight trial. A mixture of Psp isolates representing local races (races 1, 2, 6, 7, 8 and 9) was used to inoculate the halo blight trial. Race 4 isolates were not included as this race has only been identified locally from greenhouse grown seedlings. A highly aggressive Pss isolate (BV100) was used for the bacterial brown spot inoculum.

Inoculum was prepared from 48 hr cultures grown on King's B medium (Psp and Pss) and yeast-extract-dextrose-calcium-carbonate agar (YDC) medium (Xap), respectively. Bacterial cells were suspended in tap water and adjusted to $10^8$ CFU ml$^{-1}$ water. Trials were irrigated prior to inoculation and repeated weekly to enhance disease development. Each trial was inoculated in the late afternoon using a motorised backpack sprayer at 21, 29 and 36 days after planting. First disease evaluations were done 10-14 days after the first inoculations on a 1-9 scale (Van Schoonhoven and Pastor-Corrales, 1987) with 1 being resistant and 9 susceptible. Evaluations were repeated at flowering and at full pod set. At maturity, two row plots of all cultivars were harvested manually and yield data recorded.

Data were analysed using a factorial analysis of variance (Statgraphics Plus 5.0) with disease ratings and yield as variables. Correlation coefficients were used to determine the relationships between the measured variables.

## RESULTS

Susceptibility of South African cultivars to CBB, HB and BB is shown in Tables 2 - 4, respectively. All cultivars were susceptible to CBB (Table 2). Cultivars, Teebus, Cerillos, PAN 146 and PAN 159 were susceptible and differed from the other cultivars, with ratings of 7 and higher. Cultivars Monati and OPS-RS2 had the lowest CBB score

TABLE 2. Common bacterial blight reaction and yield of 21 South African dry bean cultivars in artificially inoculated field trials at Potchefstroom

| Cultivar | Mean disease rating (1-9) | Yield (kg ha$^{-1}$) |
|---|---|---|
| Teebus | 7.8 | 702 |
| Helderberg | 6.0 | 645 |
| OPS-KW1 | 5.8 | 752 |
| PAN 182 | 6.5 | 696 |
| PAN 185 | 6.0 | 983 |
| Cerillos | 7.8 | 477 |
| Kranskop | 5.8 | 905 |
| OPS-RS1 | 5.8 | 930 |
| OPS-RS2 | 4.8 | 1096 |
| OPS-RS3 | 5.3 | 1283 |
| Jenny | 5.2 | 1009 |
| Bonus | 5.7 | 1077 |
| Monati | 4.7 | 1000 |
| PAN 146 | 7.5 | 567 |
| PAN 148 | 5.2 | 1001 |
| PAN 159 | 7.3 | 504 |
| PAN 178 | 5.3 | 1053 |
| Stormberg | 5.3 | 1080 |
| Leeukop | 5.8 | 843 |
| PAN 150 | 5.8 | 1008 |
| Mkuzi | 5.7 | 1081 |
| LSD (0.05) | 0.58 | 440 |

TABLE 3. Halo blight reaction and yield of 21 South African dry bean cultivars in artificially inoculated field trials at Potchefstroom

| Cultivar | Mean disease rating (1-9) | Yield (kg ha$^{-1}$) |
|---|---|---|
| Teebus | 3.0 | 2747 |
| Helderberg | 3.5 | 2716 |
| OPS-KW1 | 3.2 | 2620 |
| PAN 182 | 5.3 | 1931 |
| PAN 185 | 4.0 | 2718 |
| Cerillos | 5.0 | 1944 |
| Kranskop | 4.8 | 2833 |
| OPS-RS1 | 5.0 | 2020 |
| OPS-RS2 | 4.7 | 2644 |
| OPS-RS3 | 5.0 | 2311 |
| Jenny | 5.0 | 2829 |
| Bonus | 5.0 | 2726 |
| Monati | 5.0 | 2496 |
| PAN 146 | 5.2 | 1936 |
| PAN 148 | 5.0 | 2651 |
| PAN 159 | 4.8 | 1778 |
| PAN 178 | 5.0 | 2729 |
| Stormberg | 4.8 | 2251 |
| Leeukop | 5.0 | 2122 |
| PAN 150 | 3.0 | 3540 |
| Mkuzi | 3.0 | 3193 |
| LSD (0.05) | 0.39 | 786 |

with mean ratings of 4.7 and 4.8, respectively. Small seeded cultivars were generally more susceptible to CBB than large seeded red speckled sugars. Lowest yields were recorded on Cerillos, and PAN 159, while OPS-RS3 was the highest yielding cultivar (Table 2).

Cultivars exhibited higher levels of resistance to HB than to CBB (Table 3). Teebus, PAN 150 and Mkuzi were the most resistant cultivars with PAN 182 most susceptible. Large seeded cultivars were more susceptible to HB than small seeded cultivars, with mean disease ratings averaging 4 and 5. Yields in the HB trial were generally higher than those in the CBB and BBS trials (Table 3). The lowest yielding cultivars were OPS-RS1 and PAN 159 while PAN 150 was the highest yielding cultivar.

Cultivars differed in susceptibility to BBS (Table 4). Teebus, Cerillos, Bonus and PAN 159 were most susceptible, with Mkuzi exhibiting highest levels of resistance. The majority of cultivars had acceptable levels of resistance to BBS. Significant yield differences were obtained for cultivars in the BBS trial (Table 4). Kranskop was the lowest yielding cultivar with highest yields recorded for PAN 178.

## DISCUSSION

Results indicated significant differences in susceptibility of South African cultivars to the economically important bacterial diseases (Tables 2-4). All cultivars were susceptible to CBB, with Teebus, Cerillos, PAN 146 and PAN 159 being most susceptible. Teebus is an important small white canning bean variety that is preferred by the canning industry for its excellent canning quality (Liebenberg *et al*., 2008). Improvement of resistance within this cultivar is, therefore, important.

Yields recorded for PAN 146 and PAN 159 were significantly lower than the majority of red

TABLE 4. Bacterial brown spot reaction and yield of 21 South African dry bean cultivars in artificially inoculated field trials at Potchefstroom

| Cultivar | Mean disease rating (1-9) | Yield (kg ha$^{-1}$) |
|---|---|---|
| Teebus | 6.3 | 816 |
| Helderberg | 3.0 | 1013 |
| OPS-KW1 | 3.0 | 782 |
| PAN 182 | 2.8 | 863 |
| PAN 185 | 2.8 | 934 |
| Cerillos | 5.7 | 1030 |
| Kranskop | 3.7 | 1036 |
| OPS-RS1 | 3.2 | 1261 |
| OPS-RS2 | 2.7 | 1000 |
| OPS-RS3 | 3.5 | 1019 |
| Jenny | 3.3 | 1061 |
| Bonus | 5.5 | 1012 |
| Monati | 2.8 | 1205 |
| PAN 146 | 3.5 | 885 |
| PAN 148 | 3.2 | 1471 |
| PAN 159 | 5.7 | 1079 |
| PAN 178 | 3.3 | 1804 |
| Stormberg | 3.0 | 1119 |
| Leeukop | 2.8 | 902 |
| PAN 150 | 2.8 | 1124 |
| Mkuzi | 2.7 | 977 |
| LSD (0.05) | 0.62 | 436 |

speckled sugar cultivars (Table 2).Yield reduction could be attributed to high susceptibility. Lowest yield was recorded in Cerillos, which was highly susceptible to CBB. High levels of susceptibility to CBB in Teebus, could have contributed to the reduction in yield. Negative correlations (r=-0.44)(P,0.001) between disease ratings and yields indicate yield reduction due to CBB. Acceptable levels of resistance to HB were identified in commercial cultivars (Table 3). Large seeded cultivars were generally more susceptible than small seeded cultivars. Thus, attempts should be made to improve HB resistance in these cultivars.

Yields recorded in the HB trial were generally higher than those obtained in the CBB and BBS trials (Table 4). A negative correlation (r=-0.35)(P=0.001) existed between HB disease rating and yield. This disease could seriously affect yield under conducive conditions, particularly when plants are systemically infected (D. Fourie: unpublished data). Although cultivars differed significantly in susceptibility to BBS, the majority of cultivars exhibited acceptable levels of resistance. Although field resistance to BBS exists, this disease is the most widespread bean bacterial disease (Fourie, 2002) and is a serious threat, particularly in the disease-free seed scheme. BBS is a relatively new disease in South Africa (Serfontein, 1994) and studies on pathogenic variation and epidemiology of Pss need to be conducted. This could influence future screening for resistance. No significant correlation (r=-0.15)(P=0.009) was, however, obtained between BBS rating and yield.

Although a number of cultivars exhibited field resistance to HB and BBS, all cultivars were moderately to highly susceptible to CBB. This disease is, therefore, considered the most important bean bacterial disease in South Africa. Improvement of CBB resistance in South African cultivars would largely contribute to obtain stable yields. Improving CBB resistance in Teebus should be a priority because of its high commercial value.

## ACKNOWLEDGEMENT

This work was partially supported by the Pan-Africa Bean Research Alliance (PABRA).

## REFERENCES

Allen, D.J., Buruchara, R.A. and Smithson, J.B. 1998. Diseases of common bean. pp. 179-235. In: Allen, D.J. and Lenné, J.M. (Eds.). The pathology of food and pasture legumes. CAB International, Wallingford.

CIAT. 1985. Bean Programme Annual Report for 1985. Centro Internacional de Agricultura Tropical, Cali, Colombia.

Fourie, D. 1998. Characterisation of halo blight races in South Africa. *Plant Disease* 82:307-310.

Fourie, D. 2002. Distribution and severity of bacterial diseases on dry beans (*Phaseolus vulgaris* L.) in South Africa. *Journal of Phytopathology* 150:220-226.

Gilbertson, R.L. and Hagedorn, D.J. 1990. Survival of *Xanthomonas campestris* pv. *phaseoli* and pectolytic strains of *X. campestris* in bean debris. *Plant Disease* 74:322-327.

Liebenberg, A.J., Heenop, H.W. and Fourie, M.C. 2008. Report on the national dry bean cultivar trials 2007/2008. South Africa.

Opio, A.F. 1990. Control of common bacterial blight of beans in Uganda. *Annual Report of the Bean Improvement Cooperative* 33: 41-42.

Oshima, N. and Dickens, L.E. 1971. Effects of copper sprays on secondary spread of common bacterial blight of beans. *Plant Disease Reporter* 55:609-610.

Rands, R.D. and Brotherton, W. 1925. Bean varietal tests for disease resistance. *Journal of Agricultural Research* 31:110-154.

Saettler, A.W. 1989. Common bacterial blight. pp. 261-283. In: Schwartz, H.F. and Pastor-Corrales, M.A. (Eds.). Bean Production Problems in the Tropics 2nd Edition. CIAT, Cali, Colombia.

Saettler, A.W. 1991. Diseases caused by bacteria. pp. 29-32. In: Hall, R. (Ed.). Compendium of bean diseases. APS-Press, St. Paul, Minnesota, USA.

Schwartz, H.F., Lienert, K. and Mcmillan, M.S. 1994. Timely and economical applications of pesticides to manage bean diseases. *Annual Report of the Bean Improvement Cooperative* 37:29-30.

Schwartz, H.F. and Otto, K.L. 2000. Enhanced bacterial disease management strategy. *Annual Report of the Bean Improvement Cooperative* 43:37-38.

Serfontein, J.J. 1994. Occurrence of bacterial brown spot of dry beans in the Transvaal province of South Africa. *Plant Pathology* 43:597-599.

Taylor, J.D., Teverson, D.M., Allen, M.A. and Pastor-Corrales, M.A. 1996. Identification and origin of races of *Pseudomonas syringae* pv. *phaseolicola* from Africa and other bean growing areas. *Plant Pathology* 45:469-478.

Van Schoonhoven, A. and Pastor-Corrales, M.A. 1987. Standard system for the evaluation of bean germplasm. CIAT, Cali, Colombia. 53pp.

Wallen, V.R. and Jackson, H.R. 1975. Model for yield loss determination of bacterial blight of field beans utilising aerial infrared photography combined with field plot studies. *Phytopathology* 65:942-948.

Weller, D.M. and Saettler, A.W. 1976. Chemical control of common and fuscous bacterial blights in Michigan navy (pea) beans. *Plant Disease Reporter* 60:793-797.

Yoshii, K. 1980. Common and fuscous blights. pp. 157-172. In: Schwartz, H.F. and Pastor-Coralles, M.A. (Eds). Bean production problems in the tropics. CIAT, Cali, Colombia.