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Anthracnose Disease in Common Bean (*Phaseolus vulgaris* L.) in Shambat, Sudan
II. Disease Incidence, Severity and Effect on Yield*

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Abstract: A field experiment was conducted for two seasons (1999/2000 and 2000/2001), at Shambat Research Station, to investigate the effect of anthracnose disease incited by *Colletotrichum lindemuthianum* (Sacc. and Magn.) Bri. and Cavi. in three common bean (*Phaseolus vulgaris* L.**)** cultivars. Mean disease incidence of 15.70% was recorded in 1999/2000 season and 13.79% in 2000/2001. Mean disease severity of 0.39 and 0.47 were recorded in seasons 1999/2000 and 2000/2001, respectively. Mean pod infection in season 1999/2000 was 19.59% and mean seed infection in the same season was 15.77%. The corresponding results for season 2000/2001 were 49.62% and 20.98%, respectively. Mean seed weigh reduction was 24.72% in season 1999/2000 and 26.33% in season 2000/2001. The introduced cultivar Cranberry out-yielded the two local cultivars in both seasons. The increase in mean yield was 21.13% in season 1999/2000 and 54.04% in season 2000/2001.

Key words: Anthracnose disease*; Phaseolu*s *vulgaris*; incidence; severity; yield

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INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is one of the major cheap sources of vegetable proteins for the middle-and low-income populations. The crop is generally characterized, by unstable yield resulting from biological and climatic factors which affect plant growth and productivity (Van Schoohoven and Pastor-Corrales 1987).

In Sudan, common bean comes second to faba bean in acreage, production and consumption. Ninety percent of the common bean is produced in the northern part of the Sudan on an average of 30000 feddans (1fed. = 0.42 ha) and with average productivity of 0.5-1.2 ton/feddan in recent years (Khalifa *et al*. 2002). The major producing centres in northern Sudan are Berber, Shendi and EI-Damer, where bushy types with small medium (about 20-25g/100 seeds) white seeds are the common types (Khalifa *et al*. 2002).

The crop is grown successfully during winter for export to European and other markets, but its yield and quality are low due to many factors. Among these are excessively high temperature, salinity, cultural practices and diseases (El Amin 1998).

Anthracnose, *Colletotrichum lindemuthianum* (Sacc. and Magn.) Bri. and Cavi., is the most serious disease attacking bean in cool weathers in Latin America and Africa. Field losses in these regions, due to seedling, leaf, stem and pod infections, are up to 90% under climatic condition favourable to the disease. The infected seeds are the most important means of dissemination of this pathogen, which explains its worldwide distribution. In developed countries, the disease is mainly controlled by resistant cultivars. In developing countries, cultivation of resistant cultivars is not the absolute solution due to high pathogenic variability of the fungus (Allen 1986; Nyvall 1989).

In recent years, the occurrence of anthracnose on common bean has been observed in Shambat area, Sudan (Mudawi *et al*. 2008.) The objective of this study was to determine the incidence and severity of this disease and its effect on yield of common bean.

MATERIALS AND METHODS

A field experiment was conducted at Shambat Research Station during the 1999/2000 and 2000/2001 winter seasons. Two local common bean cultivars Grade A and Grade B and Cranberry, obtained from CIAT (CIAT 1990) were used in this study.

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The bean seeds were planted in plots 3 m long with 5 rows, spaced 70 cm apart. Seeding rate was 45.72 seeds /m^2 giving a plant population of 15.29 plants /m^2 after thinning. Fertilizers, irrigation and weed control practices were applied as recommended.

The experimental design in both seasons was randomized complete block design with four replications. Starting from the emergence of the trifoliate leaves, the number of infected plants with characteristic symptoms on leaves, stems and pods were recorded. Disease incidence and severity were assessed under natural field infections, every two weeks.

Disease severity was scored on a 0-4 scale, as described by Barrus (1918), Van Schoohoven and Pastor-Corales (1987) and CIAT (1990), where, 0 = no visible disease symptoms, 1= very few small lesions on leave veins, ridges of stems and pods, covering approximately 15% of plant surface area, 2 = presence of numerous small lesions on the leaves, stems and pods (< 2 mm in diameter) covering approximately 25% of plant surface

area, 3 = presences of many enlarged lesions (> 2 mm diameter) covering approximately 50% of plant surface area , 4 = severe necrosis on 75% or more of the plant tissues in leaves, petioles ,stems and pods.

Disease severity was calculated according to the formula of Nigam *et al*. (1989) and Gabur *et al*. (1998) as follows:

$$\text{Disease severity} = \sum \frac{\text{Numerical value x number of infected pods}}{\text{Total number of plants}}$$

The three central ridges of each plot were harvested, and the number of infected pods, the number of seeds/plot, and the weight of 100 healthy seeds and 100 infected seeds were recorded. The data were transformed to Arc Sin and square root transformation and subjected to analysis of variance.

RESULTS

The incidence of anthracnose disease in the three tested cultivars (Grade A, Grade B and Cranberry), during the two successive growing seasons (1999/2000 and 2000/2001), increased with time from week two onwards, with slight decrease in week eight. It ranged from 3.12% to 50.40% in 1999/2000 and from 1.93% to 53.77% in 2000/2001 (Table 1). In season 1999/2000, the local cultivars were significantly different but not in 2000/2001. The introduced cultivar Cranberry, displayed significantly ($P \leq 0.05$) less disease incidence during the two seasons (Table1)

The development of disease severity in the two seasons displayed similar pattern as that of the disease incidence, i.e., increase with time from week two onwards (Fig.1a and 1b). Disease severity in the range of 0.03 to 1.56

and 0.05 to 2.61 was recorded during 1999/2000 and 2000/2001, respectively. The highest disease severity of 2.61 was recorded on the local cultivar Grade A. The introduced cultivar gave significantly ($P \leq 0.05$) less disease severity than the local cultivars, in both seasons. Generally, the rate of disease incidence and severity increased in the three cultivars exponentially from week 8 (i.e., pod formation) to week 12 for the two seasons.

The range of pod infection was 16.30%-24.34% in season 1999/2000 and 45.60%-55.95% in season 2000/2001. A range of seed infection of 10.38%-22.02% and 16.43%-27.15% was recorded for seasons 1999/2000 and 2000/2001, respectively. The reduction in seed weight of the three cultivars was 20.55% - 30.86% for 1999/2000 and 27.74% - 33.94% for 2000/2001. The highest seed and pod infection, in the two growing seasons, was recorded for cultivar Grade a (Table 2).

There was no significant ($P \leq 0.05$) difference between the three cultivars in pod infection in the two seasons. The seeds of the local cultivar Grade A was highly significantly infected in 1999/2000, and no significant differences were detected between the three cultivars in 2000/2001. No significant difference in the reduction of seed weight was detected between the three cultivars in the two growing seasons.

The yield of Cranberry was 103.37 kg/ha in 1999/2000 and 97.71kg/ha in 2000/2001, i.e., higher than the yield of the two local cultivars. Grade A ranked second to Cranberry in the two growing seasons. In 1999/2000, no significant differences in the yields of the three cultivars were detected, but the yield of cultivar Cranberry was significantly ($P \leq 0.05$) higher than the yield of the two local cultivars in the next season.

Table 1. Mean percentages* of anthracnose disease incidence on three bean cultivars, during the 12 weeks of observation, after the emergence of the trifoliate leaves in 1999/2000 and 2000/2001 seasons

Cultivar	Weeks after the emergence of trifoliate leaves					
	2^{nd} †	4^{th} †	6^{th} †	8^{th} †	10^{th} ψ	12^{th} ψ
			1999/2000			
Cranberry	2.18	2.34	2.55	1.49	26.72	39.07
	(1.46)	(1.88)	(2.49)	(2.28)	(2037)	(39.90)
Grade A	2.79	3.05	4.08	3.00	35.53	5.60
	(3.33)	(2.84)	(9.84)	(9.10)	(34.05)	(59.30)
Grade B	3.59	3.17	3.51	2.49	29.69	52.34
	(4.57)	(4.84)	(6.38)	(6.28)	(24.57)	(52.01)
Mean	2.96	2.85	3.38	2.33	30.68	47.34
	(3.12)	(3.19)	(5.28)	(5.89)	(26.33)	(50.40)
LSD(0.05)	0.36	0.48	0.58	0.74	17.49	11.44
			2000/2001			
Cranberry	2.28	2.21	3.65	2.47	5.55	37.25
	(1.52)	(1.52)	(7.56)	(6.18)	(21.65)	(36.98)
Grade A	2.28	2.20	4.55	2.42	5.66	36.11
	(1.92)	(1.77)	(12.65)	(6.47)	(21.81)	(35.00)
Grade B	2.28	2.55	4.10	2.63	6.24	40.76
	(1.89)	(2.63)	(6.80)	(6.95)	(28.31)	(42.67)
Mean	2.30	2.32	4.10	2.51	5.82	38.04
	(1.93)	(1.97)	(10.06)	(6.53)	(23.96)	(38.27)
LSD(0.05	1.62	2.43	2.26	0.93	2.85	17.78

*Means of four replicates

† Figures are square root transformed.

ψ Figures are Arc Sin transformed according to Little and Hills (1978).

Figures in parenthesis are actual ones.

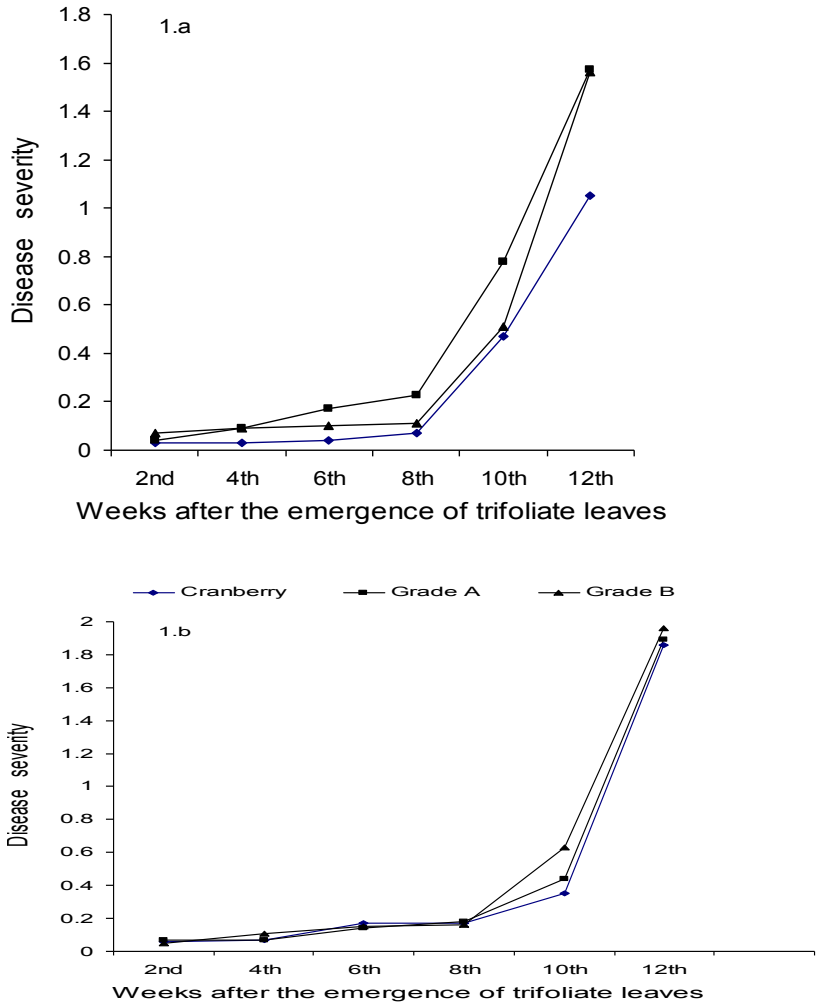

Fig.1. Mean anthracnose disease severity on 0-4 scale rating of the bean varieties, according to CIAT and Barrus scale, during 12 weeks of observation, season 1999/00 (1.a) and season 2000/01 (1.b)

Table 2. Mean seed yield and yield components of three bean cultivars infected by anthracnos

Cultivar	2000 / 2001 Season				1999 / 2000 Season			
	Mean pod Infection (%) †	Mean seed Infection (%) ψ	Seed weight reduction (%) ψ	Yield (kg/ha)	Mean pod infection (%) ψ	Mean seed Infection (%) ψ	Seed weight reduction (%) ψ	Yield (kg/ha)
Cranberry	5.18 (18.22)	4.21 (10.38)	26.91 (20.55)	(103.37)	6.71 (45.60)	5.04 (16.43)	27.74 (21.39)	(97.71)
Grade A	5.03 (16.30)	5.70 (22.02)	33.27 (30.86)	(90.34)	7.44 (55.95)	6.13 (27.15)	33.94 (31.33)	(71.12)
Grade B	5.91 (24.34)	4.85 (14.90)	28.17 (22.74)	(81.33)	6.88 (47.32)	5.30 (19.35)	30.80 (26.26)	(66.74)
Mean*	5.37 (19.59)	4.92 (15.77)	29.45 (24.72)	(91.68)	7.01 (49.62)	5.49 (20.98)	30.83 (26.33)	(78.52)
LSD(0.05)	1.16	0.48	5.52	25.5	1.19	2.60	6.61	11.80

* Means of 4 replicates

† Figures are square root transformed.

ψ Figures are Arc Sin transformed according to Little and Hills (1978).

Figures in parenthesis are actual ones

DISCUSSION

The anthracnose incidence and severity on the local cultivars were very high, in both seasons, compared to Cranberry. The local cultivars were highly susceptible, with a maximum disease incidence of 59.30%. In different locations in India, a disease incidence in the range of 5%-65% was reported by Sharma *et al*. (1994).

The disease incidence and severity of the tested cultivars increased with time, with a high increase at pod formation (i.e., after 8 weeks from trifoliate leaves emergence), which indicates that the disease increases with plant age, presence of a susceptibility reaction at pod formation and prevailness of favourable environmental conditions. This result agrees with those of Araujo *et.al* (1994) and Rajappan *et a*l. (2001). Wheeler (1978) stated that" when no heavy seedling infection is observed, another phase of marked susceptibility will be found at early stage of pod formation".

The susceptibility of the local cultivars was confirmed by high pod and seed infection. The range of pod infection was 45.60% – 55.95%. This finding is similar to that of Shyam and Chakraborty (1985) who reported pod infection ranging from 24% to 59% in four cultivars of beans. It was concluded that seed infection resulted in low seed yield and high seed discolouration, which lowered the marketability of the seed. Yield in the range of 97.71kg/ha -103.37kg/ha was recorded in the two successive seasons. This yield is far lower than that reported by Khalifa *et al*. (2002). This may be due to high inoculum contaminating the experimental site of this study and prevailness of conducive environmental conditions.

The average temperature and humidity records in 1999/2000-2000/2001 indicated that there are no differences in temperature between the two seasons. Thus, the high increase in susceptibility to anthracnose during the second season may be attributed to the assumption that the inoculum in the infected plant debris, embedded in the experimental site from the

first season, incited the primary infection in the second season. Ntahimpera *et al*. (1997) reported a significant correlation between the percentage of debris on the soil surface and subsequent disease incidence, which causes a random occurrence of the disease early in the season, while late in the season plant to plant spread results in cluster distribution of diseased plants. Young plants may be infected from spores carried on seeds or spores splashed from infected plants debris (Davis *et al*. 1999).

In conclusion, several perspectives appear to emerge from this study. The anthracnose disease is a real threat to common bean production in Shambat area. This is because the disease adversely affects the yield quantitatively and qualitatively. Removal and burning of infected plant debris and crop rotation may help in reducing the inoculum carried on the soil surface for the subsequent crop.

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مرض الأنثراكنوز في نبات الفاصوليا في السودان
II- حدوث و شدة المرض و تأثيره علي الأنتاجية *

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موجز البحث: أجريت تجربة حقلية خلال موسمي 2000/1999 و 2001/2000 فى محطة بحوث شمبات لدراسة تأثير مرض فطر الأنثراكنوز، الذى يسببه فطر *Colletotrichum lindemuthianum* (Sacc. and Magn.) Bri. and Cavi. ، على ثلاثة أصناف من الفاصوليا البيضاء. أظهرت النتائج أن متوسط حدوث الإصابة كان 15.7% و13.79% فى موسمي 2000/1999 و 2001/2000 على التوالي. أما متوسط شدة الإصابة فى موسم 2000/1999 فقد كان 0.39 و فى موسم 2001/2000 كان 0.47 . بلغ متوسط إصابة القرون و البذور بالمرض فى الموسم الأول 19.59% و 15.77% على التوالي، اما فى الموسم الذى تلاه فقد سُجل متوسط إصابة 49.62% على القرون و 20.98% على البذور. كان متوسط إنخفاض وزن البذور 24.72% فى موسم 2000/1999 و 26.33% فى موسم 2001/2000 . كما بيّنت النتائج أن إنتاجية صنف الفاصوليا Cranberry المستورد كان أعلى من إنتاجية الأصناف المحلية حيث أعطى زيادة فى الإنتاجية مقدارها 21.% و54.04% فى موسمي 2000/1999 و 2001/2000 علي التوالى.

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