GLADSTONE ROAD AGRICULTURAL CENTRE
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EVALUATION OF FOUR GREEN BEAN VARIETIES (*PHASEOLUS VULGARIS* L.) FOR PEST AND DISEASE TOLERANCE

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ABSTRACT

Four green bean varieties (Phaseolus vulgaris L.) were evaluated in a replicated small plot trial at the Gladstone Road Agricultural Centre during 2012. After 50-70 days of growth, the varieties were assessed for pest and disease tolerance and for pod quality and yield. One of the varieties succumbed to pest and disease problems. There were significant differences among the three surviving varieties with respect to the total number of pods per plant, weight of pods per plant and pod length. Poor harvest quality was observed and this contributed to the low yields recorded for the green bean varieties in this study. The inferior performance of the bean varieties could be attributed to the prevalence of pest and disease problems in the field. Results indicated that green bean cultivation is possible under local conditions, but with proper pest and disease management and the use of varieties resistant to important diseases such as brown rust.

Green bean (*Phaseolus vulgaris* L.) variety 'Gold Dust' at the Gladstone Road Agricultural Centre, 2012

Introduction:

Legume crops grown for human consumption belong to the Fabaceae (formerly Leguminosae) family. They are important foods in most tropical and subtropical countries of the world and are second only to cereals as a food source for humans and animals (Graham and Vance, 2003). The common bean (*Phaseolus vulgaris* L) provides one of the most important sources of protein (Boudoin and Maquet, 1999; Arulbalachandran and Mullainathan, 2009) and is rich in vitamins,

minerals and dietary fibre (Kelly and Scott, 1992; Ndegwa *et al*., 2006). The immature pods of these beans are also an important food source in many locations around the world, where they are known as green beans, snap beans, French beans or string beans.

Green beans have a short growing season of between 50 and 60 days. Many of the green bean varieties grown in developing countries are introduced from cooler regions and may not be suitably adapted to tropical conditions (Janssen, 1988; CIAT, 1992). High temperatures during the summer may restrict cultivation in The Bahamas to the cooler months of October through to March, as green beans show a substantial reduction in yield when nighttime temperatures exceed 27°C (80°F) (Rainey and Griffiths, 2005). Green beans are not widely cultivated in The Bahamas but, as research conducted at the Gladstone Road Agricultural Centre during 2011 has shown (Richardson, 2011), this crop has great potential for the fresh market.

Legume crops are also important for their nitrogen fixing capabilities (Piha and Munns, 1987; Keyser and Li, 1992; Amanuel *et al*., 2000), and can be used in crop rotation systems to improve soil conditions. Nitrogen fixation by legume crops offers an alternative to nitrogen fertilisers which may present a serious environmental problem (Nason and Myrold, 1992; Brentrup *et al*., 2001). In addition, with increasing interest in organic farming, which requires minimum or zero use of chemical pesticides, bean varieties highly resistant to pests and diseases are in growing demand.

Green bean (*Phaseolus vulgaris* L.) variety 'Burgundy' at the Gladstone Road Agricultural Centre, 2012

Leguminous plant species are susceptible to many biotic stresses, including attacks by many different insect pests and diseases. Pest and disease problems present major constraints to agricultural productivity of the common bean, particularly in the tropics (Graham and Vance, 2003). Worldwide, yield losses due to insect pests alone have been estimated to be from 35% to 100% annually (Singh and Schwartz, 2011). Pest problems prohibiting more extensive production of legume crops include such diseases as brown rust, powdery mildew and insect pests such as aphids, caterpillars, leafhoppers and whiteflies. These pest and disease problems can be controlled through proper management. The use of resistant varieties provides a practical and less costly method of pest and disease control in the green bean. The introduction and evaluation of high

yielding legume crops resistant to pests and diseases is essential to the exploitation of this crop's potential.

The best approach to controlling pest problems in beans is through an integrated pest management system, combining several techniques known to be effective in keeping pest problems to a minimum. These techniques include the use of resistant varieties, natural predators, organic pesticides, biopesticides, crop rotation, and other cultural practices, such as the removal of debris from the field. This study is necessary as attempts are made to identify high yielding bean varieties with good tolerance to pests and diseases.

Objective:

The purpose of this study was to evaluate the pest and disease tolerance of four green bean varieties and to assess their pod quality and yield under these biotic stress conditions.

Materials and Methods:

The green bean trial was conducted at the Gladstone Road Agricultural Centre from November 2011 to January 2012. The four varieties were evaluated in a completely randomised design with four replications. The varieties included four common bean varieties, 'Burgundy', 'Crocket', 'Gold Dust' and 'Supremo'. These beans are short, bush type plants that do not require support. They are early maturing varieties that produce all of their pods within a short period of time, after which production ceases. The pods of 'Burgundy', 'Crocket' and 'Gold Dust' are round and thin, while those of 'Supremo' are broad and flat. Three of the green bean varieties, 'Crocket', 'Gold Dust' and 'Supremo', are products of the Seedway Seed Company and are developed for the fresh market. The variety 'Supremo' is a dual crop, used for its young, tender pods as well as its mature dried beans. The fourth variety, 'Burgundy', is a purple coloured heirloom variety of unknown origin.

The varieties were planted in 3.0 m (10 ft) long plots in double rows with spacing of 20 cm (8 in) between plants within the row. The rows were 1.5 m (5 ft) apart. The usual cultural practices were observed to ensure that an even stand of plants was established in the field plots. The plants were side dressed with 8-18-8 fertiliser, applied in one application at a rate of 30 g (1.0 oz) per plant, at the flowering stage. The rows were irrigated with a drip irrigation system which supplied water throughout the growing season.

The plants were not treated with insecticides or fungicides, in order to determine their resistance or susceptibility to insect pests and diseases. They were evaluated on the basis of the level of tolerance displayed by their performance in the field. Insect pests and diseases observed on the plants were photographed. These photographs were then compared to photographs located through an internet search of the literature on pests and diseases of the green bean. Observations were made on the number of days to 50% flowering and the number of days to harvest.

Upon maturity of the green pods, the beans were harvested by hand. For this study, all observations and measurements were made on the initial harvest of marketable pods. Fifteen plants were harvested at random from each of the four plots, for each variety. The pods were graded,

then weighed and measured. The total number of pods per plant was recorded. Pod length (cm) was measured with a ruler. Fifteen pods were selected randomly from the total batch of harvested pods from each variety to assess their post-harvest quality characteristics. They were examined for disease levels and visible signs of chlorosis. Colour and shape were determined by visual examination. The fibre content was determined by breaking the pod and determining whether it snapped cleanly or did not snap, due to excessive string and seediness.

The mean daily maximum and minimum temperatures for the trial period were 27.1^{o}C (80.7^{o}F) and 19.7^{o}C (67.5^{o}F), respectively. The total rainfall for the period was 16.5 mm (0.65 in). Weather information was obtained from the Meteorological Department of The Bahamas.

Table 1. Weather data on rainfall, hours of sunshine and mean maximum and minimum temperatures for New Providence for the period of November 2011 to January 2012, courtesy of the Meteorological Department of The Bahamas.

Month	**Total rainfall (mm/**inches**)**	**Mean monthly radiation (h)**	**Mean maximum temperature (°C/**°F**)**	**Mean minimum temperature (°C/**°F**)**
November 2011	**20.1**/0.79	**8.1**	**28.2**/82.7	**21.6**/70.8
December 2011	**22.9**/0.9	**7.0**	**26.9**/80.4	**19.8**/67.6
January 2012	**6.6**/0.26	**8.0**	**26.1**/78.9	**17.8**/64.0

Note: Monthly mean values have been rounded up to the nearest tenth

Statistical Analyses:

All experimental results were analysed using Instat+™ and ASSISTAT. Instat is an interactive statistical package, copyright © 1999-2005, Statistical Services Centre, University of Reading, UK. All rights reserved. ASSISTAT, Version 7.5 beta (2008), website – http://www.assistat.com, by Fransisco de Assis Santos e Silva, Federal University of Campina-Grande City, Campina Grande, Brazil.

Results:

(a) Insect pest and disease evaluation

The bean varieties evaluated in the present study all manifested severe pest and disease problems, with the exception of 'Burgundy' which was moderately affected by diseases. Plant stand was very low for the variety 'Crocket' resulting in no yield data being collected on any of its plants. Photos 1-12 illustrate the various insect pest and disease problems encountered in the trial plots and fields surrounding those plots at the Gladstone Road Agricultural Centre. The bean varieties were evaluated based on appearance and by comparing to literature downloaded from various internet websites.

The common bean rust *Uromyces viciae-fabae* (Photos 1-2) is distributed worldwide and is one of the major constraints to green bean production (Monda *et al*., 2003). The bean rust fungus is spread by airborne spores and thrives best in cool to moderate temperatures with prolonged wet periods (Imhoff *et al*., 1981). Infections occurring before the flowering stage are usually more severe, resulting in higher yield losses (Ariyarathne and Pradeep Nuwan, 2001). Symptoms are most often seen on the leaves, but are also found on the pods and stems. In this study, bean rust symptoms were confined to the leaves of the affected varieties. This disease was particularly severe on the bean variety 'Crocket' which exhibited heavily infected leaves that turned brown and died.

Ascochyta leaf and pod spot (Photos 3-4), also known as Ascochyta blight, is a fungal disease that thrives under cool, humid temperature conditions (Hanson *et al*., 1993). This disease is caused by *Phoma exigua* var. *diversispora* (Bubák) Boerema and *Phoma exigua* var. *exigua* Sacc. Symptoms of *P. exigua* var. *diversispora* and *P. exigua* var. *exigua* are very similar. The earliest symptoms of this disease appear as black concentric lesions on the leaves (Photo 3). These lesions later spread to other parts of the plant, such as the stem and pods (Photo 4). Plants sometimes lose leaves and pods (Bardas *et al.,* 2008). The fungus can spread systemically throughout the plant and is seed borne (Schwartz, 1989). This disease manifested itself on both the leaves and pods of several of the bean varieties under evaluation.

Among other diseases was the powdery mildew (Photo 5), which infected most the green bean varieties. Powdery mildew, which is a fungus caused by *Erysiphe polygoni*, first attacks the older leaves of the bean plant and then spreads to the stems and pods. Powdery mildew was first observed on two pasture legumes, glycine (*Neonotonia wightii*) and siratro (*Macroptilium atropurpureum*), growing in the vicinity of the bean trial. The fungus then spread onto the field plots.

The leafhopper (*Empoasca fabae*) (Photo 6) is a sap-sucking insect that causes yellowing, deformation and drying up of the bean leaves. It is responsible for the transmission of viruses. Triangular yellowing of the leaf edge of bean plants are the result of leafhoppers, seen here in its early stages (Photo 7). Necrotic symptoms appear in the later stages (Photo 8), as the potato leafhopper sucks the sap of the bean leaves, which turn yellow and dry up.

Damage by aphids (Photo 9) was observed, especially on the varieties ‘Crocket’ and ‘Supremo’. Aphids suck the sap from the young bean plants and the excess sap left on the leaf and other plant parts, referred to as honeydew, attracts other insects, in particular, ants. The varieties ‘Burgundy’ and ‘Gold Dust’ appeared not to be as affected by aphids, possibly due to a resistance mechanism in those varieties. Epidermal hairs (trichomes) on the leaves of plants have been shown to provide resistance to insect pests by trapping or impaling them with these hairs, as reported by Johnson (1953) who demonstrated that the hooked trichomes on the growing shoots of French beans impaled aphids, resulting in reduced longevity and reproduction and high larval mortality.

One of the insect pests detected was the caterpillar (Photo 10) of the long-tailed skipper butterfly, *Urbanus proteus* (L.). This caterpillar is known as the bean leaf roller, because of its habit of folding the leaf around its body to protect itself from predators (Greene, 1971). It is a defoliating pest of several legumes, including cowpea, soy bean and the common bean. The bean leaf roller feeds voraciously on the leaf and may cause complete defoliation of the plant (Nava and Parra, 2002). The adult butterfly of the Long-tailed Skipper (*Urbanus proteus proteus* L), was captured, though barely visible, on the leaf of a bean plant within the green bean trial plot (Photo 11).

Whiteflies (Homoptera: Aleyrodidae) feed on the sap of plant tissues and are responsible for the transmission of viruses. It only takes a few of these insect vectors to spread the virus, so an effective pest management programme is essential for their control. Whiteflies feeding on the bean plant can result in stunting and complete defoliation. The bean variety trial was infested by whiteflies which migrated from a nearby plot of assorted vegetable crops (Photo 12).

Photos 1-12. Pest and disease problems encountered in the green bean trial plots at the Gladstone Road Agricultural Centre.

Photo 1. Bean rust on 'Supremo' bean variety, caused by the fungus *Uromyces viciae-fabae.*

Photo 2. More severe symptoms of bean rust on 'Gold Dust' bean variety, caused by the fungus *Uromyces viciae-fabae.*

Photo 3. Leaf symptom of Ascochyta leaf and pod spot on 'Crocket' bean variety. This disease is caused by *Phoma exigua* var. *diversispora* (Bubák) Boerema and *Phoma exigua* var. *exigua* Sacc.

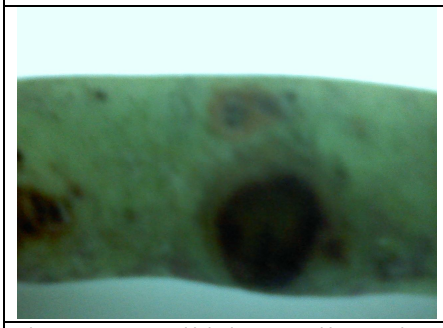
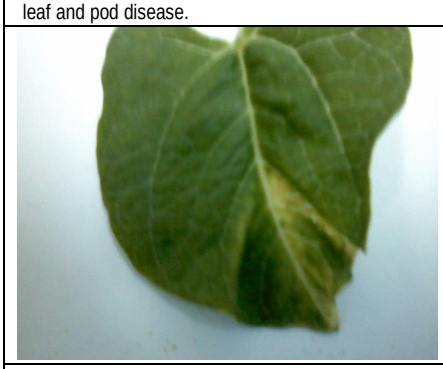


Photo 4. 'Supremo' with lesions caused by Ascochyta leaf and pod disease.

Photo 5. Powdery mildew on glycine (*Neonotonia wightii*) found growing near the bean trial.

Photo 6. Leafhopper (within circle) on bean leaf. Potato Leafhopper (*Empoasca fabae*).



. Photo 7. Characteristic triangular yellowing of leaf edge 'Gold Dust' bean leaf, the result of leafhoppers.

Photo 8. Necrotic symptoms in later stages, due to Leafhopper damage.

Photo 9. Aphids feeding on weed plant taken from bean trial plot.

Photo 10. Bean leaf roller, caterpillar of the Long-tailed Skipper (*Urbanus proteus proteus* L).

Photo 11. Barely visible photo of adult butterfly of the Long-tailed Skipper (*Urbanus proteus proteus* L).

Photo 12. Adult whiteflies (within circle) on backside of hot pepper leaf, growing in close proximity to the green bean trial.

(b) Pod quality and yield

Analysis of variance (Table 2) indicated that there was a significant difference in the number of pods per plant, pod length, total weight of pods per plant and plant height among the green beans evaluated. Seedling emergence averaged 7-10 days after planting. Stand establishment was very good for all varieties under study, until the pest and disease problems took its toll on the experimental plots. Flowers first appeared after about 35 days of growth, with 50% of them appearing after 42 days. Of the four varieties under study, only three gave measureable amounts of data. The variety 'Crocket' succumbed completely to pest and disease problems. All results are for the bean varieties 'Burgundy', 'Gold Dust' and 'Supremo'.

Table 2. Analysis of variance (ANOVA) for number of pods per plant, pod length, total weight of pods per plant and plant height among three varieties of green beans (*Phaseolus vulgaris* L.). Standard error is for each treatment mean. Error mean square has 44 df. *, ** and *** denote statistical significance at 5, 1 and 0.1% level of confidence, respectively. NS indicates differences between means not significant.

		----------Significance levels----------			
Source	df	Number of pods per plant	Pod length (cm)	Total weight of pods per plant (g)	Plant height (cm)
Varieties	2	**	**	**	**
Error	42				
Std. Err		0.6	0.4	2.6	0.5

The yield and yield contributing characteristics of the three surviving green bean varieties are shown in Table 3. The variety 'Gold Dust' outperformed the other two varieties in the number of pods per plant and the total weight of pods per plant. This variety was also significantly shorter in height than the varieties 'Burgundy' and 'Supremo'. There was much variation in pod length among the three varieties. 'Supremo', which is classified as a broad bean, rather than a string bean, had significantly larger pods than 'Burgundy' and 'Gold Dust'. The mean weight for each of the three varieties was expressed as g per plant. These figures were extrapolated to reveal the yield potential of the three varieties, expressed as tonnes per hectare (Table 3). The varieties 'Gold Dust' and 'Supremo' appeared to be similar in yield capability, while 'Burgundy' yielded the least of the three.

Table 3. Mean values of yield responses of three green bean varieties.

Variety	Number of pods per plant	Pod length (cm)	Total weight of pods per plant (g)	Plant height (cm)	Yield potential (tonnes/hectare)
Burgundy	2.4c	11.0c	6.5b	20.8a	0.2
Gold Dust	10.0a	13.0b	40.0a	16.1b	1.3
Supremo	5.0b	15.6a	33.1a	20.9a	1.1

The t-test at a level of 5% probability was applied. Means with different letters differ significantly.

The three varieties evaluated had acceptable colour, pod length, appearance, and fibre content (Table 4). The varieties 'Burgundy' and 'Gold Dust' displayed colours different to the usual green pod. The pod of 'Burgundy' was deep purple in colour, while 'Gold Dust' had a pale yellow colour. 'Supremo' was green with red speckles. The actual number of days to maturity for the variety 'Supremo' was more than twenty days earlier than the stated number of days to maturity for that variety. 'Gold Dust' matured about seven days earlier, while the maturity date for 'Burgundy' was within range for that variety.

Table 4. Post-harvest quality characteristics of three green bean varieties evaluated at the Gladstone Road Agricultural Centre during 2011.

Variety	Stated number of days to maturity	Actual number of days to maturity	Pod colour	Pod curvature	Fibre/String content	Visible signs of insect damage, disease or chlorosis
Burgundy	50-55	50	Deep purple	Straight to slightly curved	absent	None
Gold Dust	58	51	yellow	Straight to slightly curved	absent	Some lesions observed on pods
Supremo	72	51	Green with red speckles	Slightly curved	absent	Some fungal/bacterial spots

Photo 13 (a-c) gives some indication of the appearance and quality of the three bean varieties. Pods were generally healthy in appearance, in spite of the prevalence of insect pests and diseases in the field. The variety 'Gold Dust' (13b), in particular, did not display any visible defects that would affect quality. The variety 'Supremo' did have a small number of harvested pods with visible signs of disease. Note that the red speckles on the pods of the variety 'Supremo' (Photo 13c) are characteristic of this variety. This variety was harvested much earlier than the stated number of days to maturity. This had no apparent negative effect on quality, taste or texture of the pods.

(a) **(b)** **(c)**

Photo 13. Pods of green bean varieties: (a) 'Burgundy', (b) 'Gold Dust', (c) 'Supremo'.

Discussion:

Pests in nearby fields contributed to the prevalence of pest and disease problems and low yields of the experimental plots. There was also the presence of at least two pasture legumes, siratro (*Macroptilium atropurpureum*) and glycine (*Neonotonia wightii*), that appeared to be reservoirs for the powdery mildew fungus, and other diseases and insect pests. Opportunistic aphids, caterpillars, whiteflies, leaf hoppers migrated from the nearby field that contained an earlier bean crop, along with cabbage and other leafy vegetable crops.

Poor harvest quality was observed and this contributed to the low yields recorded for the green bean varieties in this study. The inferior performance of the bean varieties could be attributed to the prevalence of pest and disease problems in the field. The three bean varieties evaluated had low pod numbers per plant, which are below values obtained in a previous green bean study (Richardson, 2011). The bean trial of 2011 yielded approximately 3.4 and 4.5 tonnes per hectare for the two bean varieties evaluated, while the three green beans of the present trial revealed a low yield potential for each of the three varieties: 0.2 tonnes per hectare ('Burgundy'), 1.3 tonnes per hectare ('Gold Dust') and 1.1 tonnes per hectare ('Supremo'). These yields are well below the world average (FAOSTAT, 2008) of 6.9 tonnes per hectare, and well below the acceptable range

for green beans for developing countries, which fluctuates between 2.4 and 4.3 tonnes per hectare (Soejono, 1992).

The three varieties were all harvested before the stated number of days to maturity, which, in addition to the pest and disease problems, may have contributed to the low yields experienced. A number of pods were not at a mature stage during this initial harvest. Nevertheless, the harvested beans were of reasonably good quality and met market standards for grades of green beans (USDA-AMS, 1997). The differences in the stated number of days to maturity and the actual number of days to maturity may be attributed to any number of factors, including climatic, environmental or growing conditions.

Efforts must be made to secure varieties of green beans resistant to insect pests and diseases. Due to the severity of the damage, caused by the insect pests and diseases, the cultivation of these green legumes cannot be recommended without putting in place an effective pest management strategy. Further studies are also needed to evaluate the performance of these varieties under a pesticide management programme to gauge the performance of the green bean varieties under optimal conditions. In this regard, a follow up trial was conducted, in which the green bean varieties were treated with chemical pesticides.

General Comments:

It would appear that in cultivating these leguminous crops, special attention must be paid to crop rotation, cropping history of the field, crop scheduling, to minimise the impact of pest and disease problems. For a successful cultivation of this crop, efforts must be made to ensure that pest management issues are dealt with properly.

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