Performance of Eleven Dry Bean Cultivars (*Phaseolus vulgaris*) Over Two Successive Seasons on the Hillsides of Jamaica[1]

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ABSTRACT

Eleven bean cultivars (*Phaseolus vulgaris*) were evaluated on the hillsides of Jamaica for grain yield and yield components during two sccessive growing seasons, viz., May-August and September-December, 1980.

Grain yields were highest in the May planted crop ranging from 1.2 to 3.0 t/ha of excellent quality seed. Yields were considerably lower in the second planting ranging from 0.55 to 1.32 t/ha. Black seeded cultivars produced the highest grain yield in both plantings. The greater yields obtained in the first trial could be attributed to favorable weather conditions. However, a serious constraint to high yields is poor rainfall distribution which could lead to moisture stress and disease conditions as evidenced in the September crop. Bean rust and anthracnose adversely affected the crop. Positive linear correlations were observed between the number of pods/plant; seeds/pod; yield; and plant height. Number of seeds/pod were negatively correlated with seed size. This suggests that small seeded varieties tend to produce more seeds/pod and a greater number of pods/plant than large seeded varieties.

INTRODUCTION

Food legumes are major sources of relatively inexpensive protein in many countries. They are essential in complementing and supplementing protein-deficient diets. Unfortunately, their scarcity and high cost in recent times in Jamaica do not permit as wide a usage as is desirable.

Dry beans are the most popular food legume in Jamaica. They are produced almost exclusively by small hillside farmers in plots varying from 0.04 to 0.4 ha under conditions of rainfed agriculture. Despite this, most of the research work to date has been conducted under irrigation on the plains of Kingston and St. Catherine. Recommendations based on these studies are used in the hillsides as well as on the coastal plains where agroclimatic conditions are strikingly different.

In 1978, 5,148 hectares produced 4,067 short tons of dry beans. Although demand is always greater then supply, production has not shown any marked increase over the past 10 years.[3,4] The Government is

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[3] Priorities for Crop Research and Development over the Next Five Years, 5 Year Development Plan, Ministry of Agriculture, 1980.

[4] Wahab, A. H., Position Paper of the Inter-American Institute of Agricultural Sciences/

presently seeking to narrow the gap between demand and supply. At present farmers obtain an average yield of 500 kg/ha although yields up to 2,000 kg/ha have been obtained under experimental conditions.[5,6]

Some of the major problems contributing to the low yields are poor agronomic practices, high incidence of pests and diseases as well as the use of poor quality planting material. At present, there is no source of good quality, disease-free seed. Consequently, farmers resort to replanting seed from previous crops. This has over the years resulted in seed material that consists essentially of a mixture of varieties; and an increase in seed borne diseases.

The study herein reported was designed to assess the yield potential of 11 cultivars of dry beans during the periods of May to August and September to December at Olive River, a hillside demonstration site in Southern Trelawny.

MATERIALS AND METHODS

The Olive River demonstration site lies at 750 meters above sea level. The soil is an Ultisol classified locally as Wait-a-Bit clay. It is strongly acidic (pH 4.8), contains medium levels of N (0.18 p/m), medium to low levels of available P (32 p/m P_2O_5) and medium levels of K (280 p/m K_2O).

Experiments I and II were established May 15 and September 15, 1980, respectively, on a site which had been in bananas for many years. Land preparation consisted of forking to a fine tilth. The design followed a complete block with three replicates and 11 cultivars as treatments. Plots were 25 m^2 and consisted of 5 rows, spaced 0.5 m apart and 10 m long. Plants were spaced 8 cm intrarow for an expected density of 250,000 plants/ha.

At planting 365 kg/ha of a commercial mixture of N, P_2O_5, K_2O (12-24-12) was applied in the furrows about 5 cm below the seeds. This was followed at the flowering stage by 20 kg/ha of N, as ammonium sulphate, banded about 15 cm from the rows.

Insects and diseases were controlled with Sevin,[7] malathion, dithane

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Jamaica (IICA/JA) on Legumes, Proc. Seminar on Legumes, held under the auspices of Research and Development Department, Ministry of Agriculture, Jamaica, held on February 28, 1980 at Twickenham Park, Jamaica, pp. 61–5.

[5] Pierre, R. E., Yield Potential and Disease Resistance of Dry Bean (*Phaseolus vulgaris* L.) varieties in Jamaica. pp. 165–9, Proc. Caribbean Food Crops Soc. 12: 1974.

[6] Wright, A. L., Wahab, A. H., Murray, H. and Lugo-López, M. A., Performance of Six Cultivars of Red Beans (*Phaseolus vulgaris* L.) on a Newly Terraced Ultisol in Jamaica, J. Agric. Univ. P.R.

[7] Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

and karathane at recommended rates. Plants affected by bean mosaic virus were rogued as the symptom appeared.

Daily records of rainfall were maintained for both trial periods. The following tabulation indicates the cultivars tested.

Cultivar	*Seed characteristics*
Miss Kelly	Red striated
Cockstone	Red striated
Round red	Red
Portland red	Red
ICA Duva	Red
Bolita-42	Black
Cueto-C-25-9	Black
M1	Red Striated
M2	Red Mottled
M3	Red
M4	Red striated

Germination was recorded at 2 weeks from sowing. Plant vigor was measured at 4 and 5 weeks after planting, on a scale of 1 to 4 with 1 indicating Excellent, i.e. inter- and intra-row spaces covered; 2, Good, i.e. intra-row covered, inter-row partially covered; 3, Fair, i.e. intra-row not covered; and 4, Poor, i.e. intra- and inter-row not covered. Nodulation was assessed by counting the nodules on the roots of 10 plants randomly chosen from the two border rows of each plot at the 50% flowering stage.

Days to flowering were recorded when 50% of the plants in a plot had at least one open flower and harvest date was noted when 90% of the pods had changed completely from green to an intermediate color.

Plant height was recorded on 10 plants from each plot and was considered the distance from the soil surface to the top of the main stem. Growth habit was rated on a scale of 1 to 4 with 1 considered determinate; 2, semi-determinate, short, medium guide; 3, indeterminate non-climbing, long guide; and 4, indeterminate, climbing.

Lodging was scored on a 1 to 5 scale, with 1, almost all plants erect; 2, all plants leaning slightly or a few down; 3, all plants leaning moderately (45°) with 25 to 50% of plants down; 5, all plants leaning heavily or 80 to 100% of plants down.

Pods were counted on 10 plants chosen at random from the experiment rows. The number of seeds in 5 pods were counted from each of the 10 plants. Seed yield was determined from the two central rows (10 m^2) of each plot and expressed as grams at 14% moisture. The weight of 100 randomly selected seeds at 14% moisture was recorded.

Diseases observed were scored as mild, intermediate and severe and plots were rated as good, fair or poor based on the overall appearance due to diseases.

RESULTS AND DISCUSSION

FIRST CROP

A total of 431 mm of rain fell during the growing season from May to August. Between planting and flowering 295 mm of rain were recorded. This kept the soil moist and promoted vigorous growth. However, a drought period prevailed during the critical season beginning with the onset of flowering and continuing for 3 weeks thereafter. This could have had some adverse effects on seed yields through abortion of flowers and young pods. Rainfall over the next 3 weeks amounted to 137 mm. This favored pod and seed development. However, the wet period was followed by another dry period which facilitated drying of the pods and harvesting.

TABLE 1.—*Yield and yield components of 11 cultivars of* **Phaseolus vulgaris** *tested at Olive River, Trelawny, May–August, 1980 (Experiment 1)*

Cultivar	Yield at 14% moisture	Pods/plant	Seeds/pod	100-seed weight at 14% moisture	Mean yield/plant at 48% moisture
	t/ha	no.	no.	g	g
Miss Kelly	1.927	9.1	4.7	30.25	6.332
Cockstone	2.124	11.3	4.0	39.37	9.911
Round Red	1.486	9.4	3.6	28.58	5.190
ICA Duva	1.208	4.6	3.1	44.27	3.768
Portland Red	1.592	11.7	4.9	20.52	6.025
Cueto-C-25-9	2.232	13.5	5.5	21.55	9.633
Bolita-42	3.006	10.6	6.0	21.66	9.192
M1	2.356	8.5	4.3	34.10	7.569
M2	1.683	9.5	3.8	25.84	5.984
M3	1.263	10.5	5.3	19.68	4.384
M4	1.991	11.3	4.8	35.79	7.688
Coefficient of variation (%)	9.78	16.2	7.04	27.38	15.23
LSD—1%	0.43 t/ha	3.756	0.74	3.91	2.45

Table 1 shows grain yield data. Mean yields were relatively high and differed significantly between varieties at the 1% level. Both black-seeded cultivars performed well. Bolita-42 yielded highest; it produced 3 t/ha. Cultivar Cockstone, a major component of the mixture of cultivars the area farmers grow, yielded 2.1 t/ha, which was significantly better than the 1.9 t/ha produced by cultivar Miss Kelly, the other major component of the farmers planting material. Miss Kelly is generally regarded as the best local cultivar.

Cultivar Round Red is grown only to a small extent in the area. It was severely affected by rust, to which the depressed yield of 1.5 t/ha could be attributed. Both Portland Red, which is grown mainly in the Parishes of Portland and St. Thomas, and its related line M3 were also affected

by rust. They produced the relatively low yields of 1.6 and 1.3 t/ha, respectively.

Lowest grain yield (1.2 t/ha), was produced by cultivar ICA Duva, developed in Colombia and released in Jamaica in 1974 for commercial production. However, this cultivar is not widely grown in Jamaica yet. Good yields were obtained from M1 (2.4 t/ha), and M4 (2.0 t/ha). Both of these lines have Cockstone as one of their parents.

Population at harvest ranged from 214 test plants/plot for Cockstone to 327 for Bolita. Table 1 shows significant density differences between cultivars. Yield per plant varied significantly between cultivars. Ranking of cultivars according to yield per plant differed slightly from the order of ranking derived on the basis of yield per hectare. The major differences involved Cockstone, which ranked fourth as to yield per hectare and first as to yield per plant; and M1, which ranked second as to yield per hectare and fifth as to yield per plant (table 1). Plant density at harvest showed no significant correlation with yield ($r = 0.03$).

Significant differences between varieties were observed for yield components such as pods per plant, seeds per pod and 100-seed weight (table 1). Pods per plant and 100-seed weight showed no significant linear correlation with yield, but seeds per pod showed some significant correlation with yield ($r = 0.60$). On the other hand, seeds per pod and seed size were negatively correlated ($r = -0.69$), while the number of pods per plant was positively correlated with seeds per pod ($r = +0.67$). This suggests that those cultivars with small seeds tend to have more seeds in each pod and bear more pods/plant, a relationship which is well known.

Percentage germination, days to 50% flowering, days to maturity and plant height differed significantly between cultivars (table 2). None of these parameters appeared to be correlated with seed yield. Furthermore, days to flowering and days to maturity were not correlated with number of pods per plant.

Table 2 shows lodging scores and plant growth habit. Seed quality was very good for all cultivars except for ICA Duva which was characterized by a large amount of seed discoloration.

The diseases identified on some cultivars were rust, anthracnose, alternaria leaf spot and mildew. The most serious were rust and anthracnose. Rust appeared on Portland Red, M3 and Round Red, Cockstone, M2, ICA Duva and Bolita, whereas anthracnose was observed on M3, Portland Red and Miss Kelly.

SECOND CROP

A rainfall of 212.2 mm, or about one-half that of the first crop, occurred during the growing season of the second crop from September to Decem-

ber. Of this total, 69.3 mm fell between sowing and flowering, and 81.8 mm in the first week following the onset of flowering. During this period, many flowers were shed and there was a rapid spread of fungal diseases throughout the plots. The severity of the diseases probably resulted, among other reasons, from planting the second crop in the same plot as the first. This practice is followed by farmers who often establish two consecutive crops of beans on the same plot of land. A short dry period of 1 week duration followed the rainy period which accompanied flowering, after which 61.1 mm fell over the remaining 6-week period to crop maturity and harvest. The intermittent showers which fell up to reaping,

TABLE 2.—*Percentage of germination, days to flowering, days to maturity, plant height at maturity, lodging and growth habit of 11 cultivars of* **Phaseolus vulgaris** *tested at Olive River, Trelawny, May–August, 1980 (Experiment 1)*

Cultivar	Germination	Days to 50% flowering	Days to maturity	Plant height	Lodging score[1]	Growth habit[2]
	%	no.	no.	cm		
Miss Kelly	81.3	35	67.7	73.80	1	2
Cockstone	60.1	35	68.3	38.87	1	1
Round Red	78.6	33	62.0	37.30	1	1
Portland Red	71.6	39	62.0	72.20	1	3
ICA Duva	67.7	34	72.3	37.53	1	1
Cueto-C-25-9	70.3	42	76.7	74.73	3	3
Bolita-42	82.7	42	70.0	76.57	1	3
M1	83.4	35	68.7	45.80	1	1
M2	77.0	39	67.7	44.77	2	3
M3	74.1	39	61.7	42.50	1	2
M4	64.4	33	70.3	51.07	1	1
Coefficient of variation %	11.67	1.66	2.12	8.8		
LSD—1%	20.00	1.42	3.39	12.04		

[1] For lodging: 1 = all plants erect; 5 = 80–100% of plants down.

[2] For growth habit: 1 = determinate; 2 = semi-determinate; 3 = indeterminate non-climbing; and 4 = indeterminate climbing.

further facilitated the spread of diseases which had a marked effect on seed yield and quality.

Table 3 shows grain yield data. Yields were low, ranging from 0.39 t/ha for M3 to 1.32 t/ha for Cueto. Differences in yields between cultivars were significant at the 5% level. Both black-seeded varieties, Cueto C-25-9 and Bolita-42, performed best, producing more than 1 t/ha. Lines M1 and M2 performed relatively well (0.99 and 0.82 t/ha, respectively), whereas Cockstone and Miss Kelly had yields of 0.68 and 0.55 t/ha, respectively. The lowest yield (0.39 t/ha) was obtained from line M3.

Plant density at harvest ranged from 287 plants/plot for Round Red to 344 for ICA Duva. Differences between cultivars were not significant

TABLE 3.—*Yield and yield components of 11 cultivars of* **Phasoelus vulgaris** *tested at Olive River, Trelawny, September–December, 1980 (Experiment 2)*

Cultivar	Mean seed yield at 14% moisture	Pods/plant	Seeds/pod	100-seed weight at 14% moisture	Population at harvest	Mean yield/plant at 14% moisture
	t/ha	no.		g	no.	g
Miss Kelly	0.5512	5.7	4.8	21.58	302	1.8
Cockstone	0.6818	6.9	3.8	30.91	292	2.3
Round Red	0.6911	6.7	3.0	25.84	287	2.4
ICA Duva	0.5717	4.1	2.4	45.36	344	1.5
Portland Red	0.6155	6.8	4.6	19.45	311	2.0
Cueto-C-25-9	1.3190	13.8	5.4	18.12	314	4.1
Bolita-42	1.1351	12.6	5.6	19.61	297	3.7
M1	0.9994	7.1	3.4	33.91	330	3.0
M2	0.8235	6.3	4.4	22.04	338	2.5
M3	0.3948	5.9	4.6	18.08	302	1.3
M4	0.5143	4.9	3.8	27.60	317	1.6
Coefficient of variation %	35.9	23.45	11.74	34.9	13.11	
LSD—1%	0.63	2.85	0.56	20.80	NS	

(table 3). They ranked similarly on the basis of yield per ha and yield per plant. There was no significant correlation between yield and plant density at harvest.

Cultivars differed significantly in pods per plant, seeds per pod and weight of 100 seeds (table 3). Seeds per pod and weight of 100 seeds showed no significant linear correlation with yield ($r = 0.43$ and $r = -0.25$, respectively). However, pods per plant showed a significant positive linear correlation with yield ($r = 0.89$). Significant linear correlations were also observed between number of pods per plant and seeds per pod

TABLE 4.—*Percentage germination, plant height at maturity, lodging and growth habit for 11 cultivars of* **Phaseolus vulgaris** *tested at Olive River September–December, 1980 (Experiment 2)*

Cultivar	Germination	Plant height	Lodging[1]	Growth habit[2]	Seed quality[3]
	%	cm			
Miss Kelly	90.5	51.3	2	2	G
Cockstone	67.9	32.5	1	1	P
Round Red	83.4	26.0	1	1	P
Portland Red	88.6	51.0	4	3	VP
ICA Duva	87.1	31.5	1	1	VP
Cueto-C-25-9	82.1	123.2	4	3	G
Bolita-42	85.8	123.0	3	3	C
M1	86.0	32.6	1	1	P
M2	14.8	79.1	4	2	P
M3	87.3	39.3	1	2	P
M4	80.2	35.8	1	1	P
Coefficient of variation	4.9	26.49			
LDS—1%	9.39	25.64			
Standard error of the difference between 2 means	3.3	12.29			

[1] For lodging: 1 = all plants erect; 5 = 80–100% of plants down.

[2] For growth habit: 1 = determinate; 2 = semi-determinate; 3 = indeterminate non climbing; and 4 = indeterminate climbing.

[3] For seed quality: F = fair; G = good; P = poor; VP = very poor.

($r = 0.69$), and between seed size and seeds per pod ($r = -0.86$). The negative relationship between these two yield characters is well known.

Table 4 shows data on seed germination and plant height. Percent germination and plant height at maturity differed significantly among cultivars. There was no significant linear correlation between germination and yield ($r = 0.13$). Plant height at maturity was, however, significantly correlated with yield ($r = 0.77$) and with pods per plant ($r = 0.86$).

Plants of cultivars Cockstone and Miss Kelly were erect to slightly leaning at harvest, whereas large numbers of the better performing black

seeded plants (Cueto and Bolita) lodged at maturity. Seed quality was affected by rainfall during the drying of the pods. A large amount of moldy and discolored seeds were obtained in most cultivars.

Incidence of diseases in the second trial was severe and most plots were rated as poor. Major diseases were alternaria, leaf spot mildew, rust, angular leaf spot and bacterial blight. Many plants were rogued because of the bean golden mosaic virus.

COMPARISON OF THE TWO CROPS

Rainfall plays a critical role in determining the level of dry bean production and productivity for the majority of farmers in Jamaica. This is so because rainfall is their only source of moisture and dry bean is very sensitive to moisture stress. Importance is placed not only on the quantity of rainfall but also on its distribution during crop growth and development. Moisture is required for germination of seeds, early growth, flowering and development of pods. However, too much water can result in failure of the seeds to germinate or rapid spread of diseases on the plants. A dry period is needed for the drying of the pods and reaping. Rain during this time encourages diseases and damages the seeds.

TABLE 5.—*Correlation coefficients (r) of five variables contributing to yield for 11 cultivars of* **Phaseolus vulgaris** *tested at Olive River May–August and September–December, 1980*

Variable	Experiment 1	Experiment 2
	r	
Pods/plant vs. yield	0.39	0.89*[1]
Seeds/pod vs. yield	0.60	0.43
Seed size vs. yield	−0.14	−0.25
Plant height vs. yield	0.50	0.77*
Population at harvest vs. yield	0.03	0.04
Pods/plant vs. seeds/pod	0.67*	0.69*
Seed/pod vs. seed size	−0.69*	−0.86*
Plant height vs. pods/plant	0.49	0.86*

[1] Significant at P = 0.05.

While very good yields were obtained from the spring planted crops (more than 3 t/ha), drastic reductions (mean 59.9%) occurred in the fall planted crop. This was attributed chiefly to the diseases remaining from the previous crop; and an unfavorable rainfall pattern. There were mean reductions of 25.5%, 8.2% and 12.4% in pods per plant, seeds per pod and 100-seed weight, respectively, as compared to the previous crop. Also, seed quality was poorer than that of the first crop.

Linear correlation studies (table 5) for both trials reveal a positive relationships between pods per plant and seeds per pod ($r = 0.67$ in the

first trial and $r = 0.69$ in the second trial). A negative relationship exists between seeds per pod and seed size, ($r = -0.69$ in the first trial and $r = -0.86$ in the second trial). This suggests that cultivars with small seeds have more seeds per pod and more pods per plant than those with larger seeds. However, this increase in number of pods and seeds is associated with lower seed weight. Because of this interaction between the major yield characters, i.e., pods per plant, seeds per pod and seed weight, all three components should be considered together when assessing yield potential. Previous studies have shown that maximum yield is attained when a high seed weight and large number of seeds per pod are combined with a large number of pods per plant. Plant height and an increase in node number contribute to a higher number of pods per plant and should also be considered. Plant height was correlated with yield ($r = 0.77$) in the second trial but not in the first trial ($r = 0.5$). Plant height was also correlated with pods per plant, ($r = 0.86$) in the second trial but not in the first.

RESUMEN

Se evaluó el comportamiento de 11 cultivares de habichuelas (*Phaseolus vulgaris* L.) en áreas montañosas de Jamaica en cuanto al rendimiento y los componentes de rendimiento. Las cultivares se evaluaron en dos ciclos de producción consecutivos, esto es, de mayo a agosto y de septiembre a diciembre de 1980. Los rendimientos más altos se obtuvieron en la siembra de primavera y fluctuaron de 1.2 a 3.0 Tm/ha de semillas de excelente calidad. Los rendimientos disminuyeron substancialmente en la segunda siembra y fluctuaron de 0.55 a 1.32 Tm/ha. Las cultivares de semillas negras produjeron más en ambas siembras. Los altos rendimientos de la primera cosecha se atribuyen a las condiciones favorables del tiempo. En la segunda cosecha, la distribución de la lluvia fue errática. También las enfermedades afectaron esta cosecha. Se obtuvieron correlaciones lineales positivas entre el número de vainas por planta y semillas por vaina, rendimientos y altura de la planta. La correlación entre el número de semillas por vaina y el tamaño de la semilla fue negativa. Esto sugiere que las cultivares de semillas pequeñas tienen la tendencia a producir más semillas por vaina y en mayor número de vainas por planta que las de semilla grande.