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PERFORMANCE OF ELEVEN VARIETIES OF DRY BEANS (Phaseolus vulgaris) OVER TWO SUCCESSIVE SEASONS OF THE HILLSIDES OF JAMAICA

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ABSTRACT

Eleven bean cultivars (Phaseolus vulgaris) were evalueted in the hilly interior of Jamaica for grain yield and yield components during two successive growing seasons of 1980, viz., May - August and September - December.

Grain yields were highest in the Spring planted crop ranging from 1.2 to 3.0 t/ha of excellent quality seeds. Seed yields declined considerably in the second planting and ranged from 0.55 to 1.32 t/ha. Black seeded cultivars produced the highest grain yield in both plantings. The impressive yield figures obtained in the first trial could be attributed to favourable 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 Fall planted crop. Bean Rust and Anthracnose constituted important diseases. Positive linear correlations were observed btween the number of pods per plant and: a) seeds per pod; b) see yield; and c) plant height whereas number of seeds per pod were negatively correlated with seed size. This suggests that small seedes varieties tend to produce more seeds per pod and a greater number of pods per plant than large seeded varieties.

In view of the superior performance of the black seeded varieties over the red-seeded ones in the trial plots, it is recommended that these findings be commercially validated with the ultimate objective of producing black bean for the export market thereby earning vitally needed foreign exchange.

INTRODUCTION

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

Dry beans (red peas) are the most popular food legume in Jamaica. It is produced almost exclusively by small hillside farmers on plots varying from 0.04 to 0.4 hectare, under conditions of rain-fed agriculture. Despite this, most of the research work to date has been carried out under irrigation on the plains of Kingston and St. Catherine. Further, recommendations arising out of these studies are applied to the hillsides as well as on the coastal plains where agro-climatic conditions are strikingly dissimilar.

In 1978, 5,148 hectares produced 4,067 short tons of dry beans. Although demand is always greater than supply production has not shown any marked increase over the last 10 years (2,4). The Government is presently seeking to narrow the existing gap between demand and supply. To this end it is proposed to expand the hectarage under grain legume production, as well as to increase the productivity of the crops. At present farmers obtain an average yield of 500 kg/hectare yet up to 2,000 kg/hectare have been obtained under experimental conditions (1,5).

Some of the major problems contributing to the low yields of farmers, are poor agronomic practices, high incidence of pest and disease as well as poor quality planting material. At present there is no source of good quality, disease free seed material. Consequently, farmers resort to replanting seeds from

the previous crop. This has over the years resulted in seed material that consist essentially of a mixture of varieties. Also this level of technology results in diseases which are carried over to successive crops.

The study reported here was designed to assess the yield potential of eleven 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. Ultimately it is planned to produce a limited supply of high quality seeds of the most promising varieties for distribution to farmers of the area.

MATERIALS AND METHODS

The Olive River demonstration site lies at 750 meters above sea level. The soil is classified locally as Wait-a-Bit Clay, Map No. 95. It is strongly acidic (pH 4.8), contains medium levels of Nitrogen (.18 ppm), medium to low levels of available Phosphorus (32 ppm P_2O_5) and medium levels of Potash (280 ppm K_2O).

The experiments (Trials I and II) were established on the 15th and 11th of May and September 1980, respectively on a site which had been cultivated to banana for many years. Land preparation consisted of manual ploughing to a fine tilth using agricultural forks. The trial design was that of a completely randomised block having three replicates and eleven treatments (varieties). Plots were 25 meters square and consisted of 5 rows, spaced 0.5m apart and 10m long. Plants were spaced 8 cm intra-row to give an expected density of 250,000 plants per hectare.

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

Insects and diseases were controlled by using sevin, malathion, dithane and karathane at recommended rates. Plants affected by bean mosiac virus were rogued as the symptom appeared.

Daily records of rainfall were maintained for both trial periods. The varieties tested were:

Variety Designation	Origin	Seed Colour
Miss Kelly	Local	Red striated
Cockstone	Local	Red striated
Round red	Local	Red
Portland red	Local	Red
ICA Duva	Introduced	Red
Bolita-42	Introduced	Black
Cueto-C-25-9	Introduced	Black
M1	Local (a selection from Cockstone/Miss Kelly mixture)	Red striated
M2	Local (a selection from Miss Kelly/ Cockstone mixture)	Red mottled
M3	Local (a selection from Portland red)	Red
M4	Local (a selection from the Miss Kelly/ Cockstone mixture)	Red striated

The trials were intensively managed. During crop growth and development measurements were taken of: (1) germination; (2) plant vigour; (3) nodulation score; (4) time to flowering; (5) plant height; (6) growth habit at maturity; (7) lodging score; (8) pods per plant; (9) seeds per pod at harvest; (10) time to maturity; (11) seed yield; (12) 100-seed weight; and (13) seed quality.

Germination was recorded at two weeks from sowing. Plant vigour was measured at 4 and 5 weeks after planting on a scale of 1 - 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, 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.

Time to flowering (days) was recorded when 50% of the plants in a plot had at least one open flower. The date on which 90% of the pods had changed completely from green to an intermediate colour was considered time of maturity.

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 - 5 scale, with 1 signifying that almost all plants are erect, 2 = all plants leaning slightly or a few down, 3 = all plants leaning moderately (45°) with 25 - 50% of the plants down, 5 = all plants leaning heavily or 80 - 100% of plants down.

Pods were counted on 10 plants chosen at random from the experimental rows. The number of seeds in 5 pods were counted from each of the 10 plants. Seed yield was determined from two central rows(10 square meters) of each plot and expressed 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

Trial No. 1 (May - August, 1980)

A total of 431 mm of rain fell from planting to harvest of the crop. Between planting and flowering 294.9 mm of rain was recorded. This kept the soil moist and promoted vigorous crop growth. However, a drought period prevailed during the critical period beginning with the onset of flowering and continuing for three weeks thereafter. This could have had some adverse effects on seed yields through abortion of flowers and young pods. Rainfall over the next three weeks amounted to 136.9 mm. This favoured pod and seed development. This was followed by another dry period which facilitated drying of the pods and reaping.

Grain yield data are presented in Table 1. Mean yields were relatively high and differed significantly between varieties at the 1% level of probability. The differences between blocks were significant at the 5% level. Both black seeded varieties performed well. Bolita - 42 yielded highest producing 3 tonnes of grains per hectare. The variety Cockstone constitutes a major portion of the mixture of varieties which the area's farmers grow. This variety yielded 2.1 t/ha which was significantly better than the 1.9 tonnes per hectare produced by the variety Miss Kelly - the other major component of the farmers planting material. Miss Kelly is generally regarded as the best local cultivar.

The variety Round Red is grown only to a small extent in this area. It was severely affected by rust which could have resulted in the depressed yield of 1.5 t/ha. 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 gave relatively low yields of 1.6 and 1.3 tonnes per hectare respectively.

Lowest grain yield (1.2 t/ha), was produced by the variety ICA Duva, which following its development in Colombia was released in Jamaica in 1974 for commercial production. However, this variety is still not widely grown in Jamaica. 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 per plot for Cockstone to 327 for Bolita. The theoritical density should have been 250 test plants/plot. As presented in Table 1 density differences between varieties were significant. Seed yield per plant varied significantly between cultivars. Ranking of varieties 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 in yield per hectare, and first in yield per plant; and M1 which ranked second in yield per hectare and fifth in yield per plant (Table 1). Population 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, while seeds per pod showed some correlation with yield ($r = 0.6$). On the other hand, seeds per pod and seed size was 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 varieties with small seeds tended to have more seeds in each pod and bore more pods per plant.

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

Lodging scores and plant growth habit are presented in Table 2. Seed quality was very good for all varieties except for ICA Duva which was characterized by a large amount of seed discolouration.

Catalogued in Table 3 are the diseases which were identified. Rust, anthracnose, alternaria and mildew were observed on some varieties. 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.

Trial #2 - September to December 1980

A total of 212.2 mm or about one-half the amount of precipitation for the 1st crop, occurred during the second planting. Of this total 69.3 mm fell between sowing and flowering, and 81.8 mm fell in the first week following the onset of flowering. During this period many flowers were shed and there was a rapid spread of fungal disease throughout the crop. The severity of the diseases probably resulted inter alia from planting the second crop on 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 one week's 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 further facilitated the spread of diseases which had a marked effect on grain yield and seed quality.

Grain yield data are presented in Table 4. Yields were relatively low, ranging from 0.39 t/ha for M3 to 1.32 t/ha for Cueto. Differences between yields were significant at the 5% level of probability. Both black seeded varieties, Cueto and Bolita performed best producing in excess of 1 t/ha. Lines M1 and M2 performed relatively well (0.99 and 0.82 t/ha, respectively), whereas Cockstone and Miss Kelly gave yields of 0.68 and 0.55 tonne

per hectare, respectively. The lowest yield (0.39 t/ha) was obtained from line M3.

In the second trial population at harvest ranged from 287 test plants per plot for Round red to 338 for M2. Differences were not significant between blocks and varieties. Varieties ranked similarly on the bases of yield per hectare and yield per plant (Table 4). There was no significant correlation between yield and population at harvest.

Varieties differed significantly in number of pods per plant, seeds per pod and weight of 100 seeds (Table 4). 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 ($r = 0.69$) and between seed size and seeds per pod ($r = -0.86$). The negative relationship between these two yield characters is well known. Similar results were obtained in the first trial.

Data relating to seed germination and plant height are presented in Table 5. Percent germination and plant height at maturity differed significantly between varieties. 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 the varieties Cockstone and Miss Kelly were erect to slightly leaning at harvest whereas large numbers of the better performing black seeded plants (Cueto and Bolita) had lodged at maturity.

Lodging and growth habit data are presented in Table 5. Seed quality was affected by rainfall during drying of the pods. A large amount of moldy and discoloured seeds were obtained in most varieties. The seed quality rating is shown in Table 5.

Incidence of diseases in the second trial was severe and most plots were rated as poor. Major diseases were alternaria, Mildew, Rust, Angular Leaf Spot and Bacterial Blight. The results are shown in Table 5. Many plants were rogued because of the virus disease, Bean Golden Mosiac.

CONCLUSION

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 the seeds, early growth, production of flowers 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 cause damage to the seeds.

While very good yields were obtained from the Spring planted crops ($\geq$ 3 t/ha), drastic reductions (mean 59.9%) occurred in the Fall planted crop. This was attributed chiefly to: (1) the diseases remaining from the previous crop; and (2) an unfavourable rainfall pattern. There was also mean reductions of 25.5%, 8.2% and 12.4% in pods per plant, seeds per pod and 100-seed weight, respectively from the previous crop. Also seed quality was poor compared to the previous crop. Table 7 shows the percentage reduction in yields for this trial.

Linear correlation studies (Table 8) for both trials reveal a significant positive relationship between number of pods per plant and number of seeds per pod ($r = 0.67$ in the first trial and $r = 0.69$ in the second trial). A significant negative relationship existed 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 varieties 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 effect 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 accompanied by an increase in node number, contribute to a higher number of pods per plant and should also be considered. Plant height was positively correlated with yield (r = 0.77) in the second trial but not in the first trial (r = 0.5). Plant height was also positively correlated with pods per plant, (r = 0.86 in the second trial whereas in the first trial the linear correlation coefficient was not significant (r = 0.49).

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TABLE 1. - Grain Yields and Yield Components for 11 Varieties of Phaseolus vulgaris tested at Olive River, Trelawny, during the Period May - August, 1980 (Trial #I)

Variety Designation	Grain Yields (t/ha) at 14% Moisture	Pods/ Plant	Seeds/ Pod	100-seed weight at 14% Moisture (gm)	Popu-lation at harvest	Avg. yield per plant at 14% Moisture (gm)
Miss Kelly	1.927	9.1	4.7	30.25	304.3	6.332
Cockstone	2.124	11.3	4.0	39.37	214.3	9.911
Round Red	1.486	9.4	3.6	28.58	286.3	5.190
ICA Duva	1.208	4.6	3.1	44.27	320.7	3.768
Portland Red	1.592	11.7	4.9	20.52	264.3	6.025
Cueto-C-25-9	2.232	13.5	5.5	21.55	231.7	9.633
Bolita - 42	3.006	10.6	6.0	21.66	327	9.192
M1	2.356	8.5	4.3	34.10	311.3	7.569
M2	1.683	9.5	3.8	25.84	281.3	5.984
M3	1.263	10.5	5.3	19.68	288.0	4.384
M4	1.991	11.3	4.8	35.79	259.0	7.688
Coefficient of variation (%)	9.78	16.2	7.04	27.38	11.47	15.23
LSD - 5%	0.32 t/ha	2.75	0.54	2.87	54.85	1.79
- 1%	0.43 t/ha	3.756	0.74	3.91	74.81	2.45
Standard error of the difference between 2 means	0.151 kg/ha	1.32	0.26 seed/ pod	1.38 gm/ 100-seed	26.3	0.86

TABLE 2. - Percent germination, days to flowering, days to maturity, plant height at maturity, lodging and growth habit for 11 varieties of *Phaseolus vulgaris* tested at Olive River, Trelawny, during the period May - August, 1980 (Trial #I)

Variety Designation	Germination (%)	Plant Vigour	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Lodging Score 1/	Growth Habit 2/
Miss Kelly	81.3	G	35	67.7	73.80	1	2
Cockstone	60.1	G	35	68.3	38.87	1	1
Round Red	78.6	G	33	62.0	37.30	1	1
Portland Red	71.6	G	39	62.0	72.20	1	3
ICA Duva	67.7	F	34	72.3	37.53	1	1
Cueto-C-29-9	70.3	F	42	76.7	74.73	3	3
Bolita-42	82.7	E	42	70.0	76.57	1	3
M1	83.4	E	35	68.7	45.80	1	1
M2	77.0	G-E	39	67.7	44.77	2	3
M3	74.1	G	39	61.7	42.50	1	2
M4	64.4	G	33	70.3	51.07	1	1
Coefficient of variation %	11.67		1.66	2.12	8.8		
LSD - 5%	14.67		1.04	2.44	8.8		
- 1%	20.00		1.42	3.39	12.04		
Standard error of the difference between 2 means	7.02		0.50	1.17	4.23		

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

TABLE 3. - Disease rating of 11 varieties of *Phaseolus vulgaris* tested at Olive River, Trelawny, during the period May - August, 1980 (Trial #I)

Variety Designation	DISEASES [1/]				
	Alternaria	Rust	Anthracnae	Mildew	Overall Plot Rating
Miss Kelly	-	-	M		
Cockstone	M	M	-	I	G
Round Red	M	S	-	I	G
ICA Duva	-	M	-	I	G
Portland Red	-	S	S		F
Cueto-C-29-9	-	-	-		G
Bolita-42	-	M	-		G
M1	M			I	G
M2		I			G
M3	-	S	S	-	F
M4	M	-	-	M	G

1/ M = mild; G = good; I = intermediate; F = fair; S = severe

TABLE 4. - Grain yields and yield components for 11 varieties of *Phaseolus vulgaris* tested at Olive River, Trelawny, during the period September - December, 1980 (Trial #II)

Variety Designation	Mean Seed Yields at 14% Moisture (t/ha)	Pods/ Plant	Seeds/ Pod	100-seed wt. at 14% Moisture (gm)	Popu- lation at harvest	Avg. Yield/ plant at 14% Moisture (gm)
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 - 5%	0.46	2.09	0.41	15.25	NS	
- 1%	0.63	2.85	0.56	20.80	NS	
Standard error of the difference between 2 means	0.221	1.4	0.19	7.31	33.45	

TABLE 5. - Percent germination, plant height at maturity, lodging and growth habit for 11 varieties of Phaseolus vulgaris tested at Olive River during the period September - December, 1980 (Trial #II)

Variety Designation	Germination (%)	Plant Height (cm)	Vigour 1/	Lodging 2/	Growth Habit 3/	Seed Quality 1/
Miss Kelly	90.5	51.3	F	2	2	G
Cockstone	67.9	32.5	F	1	1	P
Round Red	83.4	26.0	G	1	1	P
Portland Red	88.6	51.0	F	4	3	VP
ICA Duva	87.1	31.5	F	1	1	VP
Cueto-C-29-9	82.1	123.2	F	4	3	G
Bolita-42	85.8	123.0	F	3	3	G
M1	86.0	32.6	G	1	1	P
M2	14.8	79.1	F	4	2	F
M3	87.3	39.3	F	1	2	F
M4	80.2	35.8	G	1	1	P
Coefficient of variation %	4.9	26.49				
LSD - 5%	6.88	34.85				
- 1%	9.39	25.64				
Standard error of the difference between 2 means	3.3	12.29				

1/ For Vigour and Seed Quality: F = fair; G = good; P = poor; VP = very poor.

2/ For Lodging: 1 = all plants erect; 5 = 80-100% of plants down.

3/ For Growth Habit: 1 = determinate; 2 = semi-determinate;
3 = indeterminate non climbing; and
4 = indeterminate climbing.

TABLE 6. - Disease rating for 11 varieties of *Phaseolus vulgaris* tested at Olive River during the period September - December, 1980 (Trial #II)

Variety Designation	DISEASES 1/				Overall Plot Rating
	Anguiar Leaf Spot	Bacterial Blight	Rust	Anthracnose	
Miss Kelly	I	I	-	I	P
Cockstone	M	I	M	I	P
Round Red	I	I	I	I	P
Portland Red	I	S	S	I	P
ICA Duva	S	I	I	I	P
Cueto-C-29-9	M	M	-	-	G
Bolita-42	-	M	-	-	G
M1	I	M	M	M	F
M2	M	-	I	I	P
M3	S	I	S	I	P
M4	S	S	-	S	VP

1/ M = mild; I = intermediate; S = severe; G = good; F = fair; P = poor; VP = very poor.

TABLE 7. - Yield (kg/ha) of 11 varieties of Phaseolus vulgaris tested at Olive River during the periods May - August and September - December (Trial #II) and percent yield reduction from the previous trial

Variety Designation	SEED YIELD		
	Trial #I (kg/ha)	Trial #II (kg/ha)	Yield Reduction from Trial No. I (%)
Miss Kelly	1927	551	71.4
Cockstone	2124	682	67.9
Round Red	1486	691	53.5
ICA Duva	1208	572	52.6
Portland Red	1592	616	61.3
Cueto-C-29-9	2232	1319	37.7
Bolita-42	3006	1135	62.2
M1	2356	999	57.6
M2	1683	824	51.0
M3	1263	395	68.7
M4	1991	514	74.2
Mean	1897	761	59.9

TABLE 8. - Correlation coefficients (r) of five variables contributing to yield for 11 varieties of Phaseolus vulgaris tested at Olive River during the periods May - August and September - December, 1980

Variable	Trial #I (r)	Trial #II (r)
pods/plant versus yield	0.39	0.89*
seeds/pod versus yield	0.60	0.43
seed size versus yield	-0.14	-0.25
plant height versus yield	0.50	0.77*
population at harvest versus yield	0.03	0.04
pods per plant versus seeds/pod	0.67*	0.69*
seed/pod versus seed/size	-0.69*	-0.86*
Plant height versus pods/ plant	0.49	0.86*

* Significant at P = 0.05