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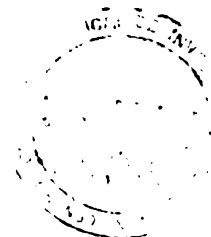
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WINGED BEAN VARIETAL RESPONSE TO WET ENVIRONMENTAL
CONDITIONS AT TURRIALBA, COSTA RICA

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INTRODUCTION

After the conference of winged bean in the Philippines, in January 1978, much interest was placed on this plant at CATIE, because it was considered to be a suitable crop for small farmers in the American humid tropics.

Most of the protein consumed in the world (70%) is of vegetable origin (8). Less is obtained from expensive animal products.

A good selection of winged bean could be richer in grain protein than soya or cowpea (2), enabling small farmers to have more protein in his farm with less effort. If one considers that other parts of the plant are rich in different nutritive elements (8, 2, 3, 4, 5, 10), the plant becomes attractive to small farmers.

The root is characteristically much more richest in nutrients than of any other known plant. The young pods are appetizing for many people, and are high in protein content. Other edible parts of the plant are also rich in protein, mineral elements and vitamins (2).

In the humid tropics, the winged bean could replace the common bean (Phaseolus vulgaris L.) (7, 9) because of its better adaptation and growth habits.

The winged bean is one of the neglected tropical legumes with good potential, that recently has been introduced into Latin America (11), where Phaseolus and Vigna are genera more commonly used (in the region). Much work would be required to substitute the winged bean for the usual legumes in the market, as people of these latitudes normally have well established food habits.

CATIE has studied the adaptation of this bean since 1970. Genetic materials from different parts of the world are being introduced for

testing. International trials were made in two different locations. One did not work out. The other, planted at the Turrialba Experimental Station with the cooperation of the Genetic Resources Program, permitted certain conclusions. Unfortunately the recommendations of the International Board were not followed and only yield data were registered.

These were analyzed and the best selections planted in the field in 1980. Data obtained are presented here.

One of the best selections is a variety introduced early in the seventies, and was planted under different shade conditions in order to study its response to light gradients.

MATERIAL AND METHODS

The first cooperative international experiment included 14 new varieties and a check variety, '6307-A', that previously had been grown locally. The experiment was planted November 15, 1979 at Turrialba (602 m, 22.2° C mean annual temperature, 17.6-27°C average temperature range, 2673 mm precipitation, 1667 hours sunshine).

Number of pods per plant, number of seeds per pod and dry weight of seeds were recorded at harvest and data were analyzed. The varieties are listed in the tables of results.

The best plants from the five best varieties were selected for further comparison. Four replications of two 5-m-long rows were planted with 0.25 m between plants and 0.5 m between rows, with 1 m between plots, on May 24, 1980. The plants are still producing, thus harvest data are not final.

From all varieties tested in the first experiment during 1979, 83

plants, that were considered superior, were selected from each plot by choosing plants that produced more than two times the value of the standard deviation above the mean. Number of plants selected differed with variety and are listed below. This material was planted June 2, 1980 in one 5-m-long rows per variety, with 0.25 m between plants and 1 m between rows.

Six repetitions with 5 shade treatments were planted with variety '6307-A' to study the effect of shade on the winged bean, when intercropped. As shade, the plantain, 'Pelipita' variety was used.

The plantains were planted at a 3 x 4 m spacing, with 1, 2, 3 and 4 plants per locations, including a treatment without shade. Three replications were oriented NS and three EW. NS oriented plots were 8 x 4 m and EW plots 8 x 3 m. The cropping cycle was from April to December 1979.

RESULTS

Mean yield per plot, analysis of variance, and estimations of kg/ha yield based on theoretical plant population, if no plants were lost, are presented in Table 1.

Yields from the three best varieties ('LBN-C-1, '6307-A' and 'LBN-C-3') were over 2000 kg/ha and not significantly different, indicating similar behaviour under conditions at Turrialba. Varieties with yields less than 1000 kg are considered unacceptable under the conditions tested.

Mean plant survival (Table 1) of more than 30 plants per plot indicates good adaptation. Only the varieties 'UPS-62', 'UPS-31', and 'UPS-122' were below this limit.

Table 1. Yield in g/plot. Analysis of variance, Duncan's test, estimation on kg/ha*. Winged bean experiment 1979.

Variety	\bar{X} /plot g	Duncan's test	\bar{X} of plants per plot	kg/ha estimated
UPS-122	368	d	29.7	467
UPS-31	468	d	28.2	594
LBN-C-3	1.909	a	37.0	2.151
UPS-53	596	c d	36.0	757
6307-A (control)	1.960	a	37.7	2.489
UPS-102	440	d	30.2	559
UPS-121	683	c d	32.0	867
UPS-62	288	d	27.2	366
UPS-45	419	d	35.7	532
UPS-32	424	d	34.7	538
Thailand	983	b c	38.0	1.248
UPS-99	285	d	32.2	362
TPT-1	1.240	b	34.2	1.575
UPS-47	258	d	32.7	328
LBN-C-1	2.000	a	37.5	2.540

* Plot area 8.8 m²

Varieties with best survival rate were '6307-A' and 'Thailand' with means of 37.7 and 38.0 plants per plot (Table A-4).

Mean yield per plant, range of yield per plant, range of standard deviation and total plant survival per plot are presented in Table 2. Variations in per plant and mean per plant yields are indicated. The best mean yields were produced by 'LBN-C-1', '6307-A' and 'LBN-C-3'. 'UPS-47' had the lowest mean yield. Data for individual plots are presented in Table A-1.

Per plant production for all lines varied widely, as reflected by the high standard deviation values (Table A-1), which sometimes were greater than the mean, i.e. 'TPT-1' replication two and 'UPS-31' first and second replications.

Mean number of pods per plant, ranges of pods per plant, and standard deviation ranges are presented in Table 3. 'LBN-C-1' had both, the highest yield and the largest average number of pods per plant. There was a wide range of variability. All lines had some plants with few pods. This explains the lack of adaptability of some plants, both within and between lines. This production component perhaps has the narrowest standard deviation range. Original data on pods per plant can be found in Table A-2.

The mean number of seeds per plant, range of seeds per plant, and standard deviation ranges are presented in Table 4. The best mean seed production was observed with '6307-A' and the lowest with 'UPS-99'. Considering only the high side of the ranges, '6307-A' had the plant

Table 2. Mean yield/plant, range of yield, range of the standard deviation and total number of plants per plot. Winged bean experiment 1979.

Variety	\bar{X} yield/ plant g	Range of yield/plant g	Range of σ	Total N° of plants
UPS-122	12.4	0.3- 48.6	6-13	119
UPS-31	16.6	0.5-280.0	5-46	113
LBN-C-3	51.6	1.3-126.9	24-27	148
UPS-53	16.5	1.2- 99.3	7-21	144
6307-A (C)	51.9	3.5-171.5	31-35	151
UPS-102	14.5	0.9- 99.0	6-21	121
UPS-121	21.3	1.2- 81.1	8-18	128
UPS-62	10.6	0.5- 45.8	4- 9	109
UPS-45	11.2	0.5- 45.0	5- 9	150
UPS-32	12.2	0.9- 98.9	5-16	139
Thailand	25.9	4.6- 98.0	11-18	152
UPS-99	8.8	0.4- 41.7	4-10	129
TPT-1	36.2	1.1-316.0	25-53	137
UPS-47	7.8	0.1- 25.3	3- 6	131
LBN-C-1	53.3	4.1-172.2	23-39	150



Table 3. Mean number of pods per plant, its range and range of standard deviation. Winged bean experiment 1979.

Variety	\bar{x} of pods/plant	Range pods/plant	Range of σ
UPS-122	4.3	1-17	1.7- 3.4
UPS-31	8.0	1-31	3.1- 3.8
LBN-C-3	12.6	1-30	6.3-12.0
UPS-53	6.9	1-30	3.0- 5.3
6307-A(control)	12.6	1-37	5.0- 8.5
UPS-102	9.2	1-33	3.9- 8.0
UPS-121	7.2	1-26	2.6- 5.9
UPS-62	5.4	1-21	1.8- 4.5
UPS-45	4.9	1-18	1.9- 3.8
UPS-32	5.1	1-22	2.6- 4.4
Thailand	11.1	3-38	3.6-10.2
UPS-99	4.2	1-15	2.0- 3.8
TPT-1	11.6	1-43	5.6- 8.8
UPS-47	4.6	1-31	2.1- 4.9
LBN-C-1	14.0	2-38	7.4- 9.9

Table 4. Mean number of seeds per plant and it's range, the range of the standard deviation, the estimated mean number of seeds per pod.

Variety	\bar{X} Seeds/plant	Range Seeds/plant	Range of σ	N° of seeds per pod
UPS-122	42	2-141	18-36	9.8
UPS-31	64	3-246	28-59	8.0
LBN-C-3	111	2-259	46-59	8.8
UPS-53	62	7-349	29-60	9.0
6307-A (C)	118	7-377	72-83	9.4
UPS-102	62	6-249	27-49	6.7
UPS-121	72	9-218	27-55	10.0
UPS-62	43	4-195	18-35	8.0
UPS-45	44	3-174	17-31	9.0
UPS-32	48	6-257	22-42	9.4
Thailand	89	16-236	36-49	8.0
UPS-99	32	3-121	17-30	7.6
TPT-1	102	7-322	54-77	8.8
UPS-47	37	3-115	16-27	8.0
LBN-C-1	108	12-318	57-77	7.7

with the most seed, and 'UPS-47' had the plant with least seed. Standard deviation variation indicates high variability within this character.

'UPS-121' had the highest average number of seeds, 10 per pod, and 'UPS-102' the lowest with 6.7. All varieties had a relatively uniform number of seeds.

Accumulated yield data from the trial with five varieties indicate good production potential, especially with '6307-A' (Table 5). This variety demonstrated an early production tendency, while 'LBN-C-1' showed a later production tendency. Some pods still remained in the field after the last harvest, January 6, 1981.

Days to flowering, number of pods per plant, number of seeds per pod, pod length and weight of 100 seeds are presented in Table 6. '6307-A' flowered first, also reflected as early production (Table 5). 'LBN-C-3' and 'Thailand' were the latest in flowering. Differences between the earliest and latest was small, less than three days.

The line '6307-A' had the most pods per plant but this may change when harvest is complete.

There were more seeds per pod and less variability between plants than in the previous cycle (Table 4). '6307-A' had 21% more seeds per pod than 'LBN-C-3'. Pod length and seed weight varied little. 'Thailand' had the shortest pods, 17.4 cm, and 'LBN-C-3' had the longest, 20.5 cm. Seed weight at 14% RH for 100 seeds varied 5.8 g between the heaviest, 'Thailand' (47.0 g), and the lightest, 'TPT-1' (41.2 g) (see also Table A-3).

Varietal origin of materials and number of days to flowering for the 83 selections planted in June, 1980 are presented in Table 7. Most

Table 5. Accumulated yield in kg/ha of five harvest of five varieties on winged bean in 1980.

Variety	----- 1981 ----- Harvest dates				1981
	27/10	12/11	5/12	23/12	6/1
6307-A	131	673	1294	1486	1506
LBN-C-1	20	117	625	1130	1504
TPT-1	88	396	919	1104	1124
LBN-C-3	35	236	604	901	986
Thailand	68	155	322	714	895

Table 6. Mean number of days to flowering, number of pods per plant, number of seeds per pod, length of pod, and weight of 100 seeds. 1980.

Variety	Days to first flowering	Pods per plant	Seeds per pod	\bar{x} length of pod	\bar{x} weight of 100 seeds
6307-A	72.0	13.2	11.8	20.1	43.4
LBN-C-1	73.8	9.6	10.5	19.4	46.2
TPT-1	73.5	10.2	11.6	19.9	41.2
LBN-C-3	74.5	8.3	10.2	20.5	43.2
Thailand	74.8	11.2	9.3	17.4	47.0

Table 7. Days to flowering for 83 selections planted in Turrialba in June 1980.

Parental variety	N° of selections	Days to flowering				
		55	56-65	66-75	76-85	86-95
UPS-99	4	4				
UPS-31	3	2	1			
UPS-32	8	7	1			
UPS-45	5	3	2			
UPS-47	5	4	1			
UPS-62	6	5	1			
UPS-122	5	1	4			
UPS-102	4	2	2			
UPS-53	6	1	4	1		
6307-A (C)	7		1	4	2	
Thailand	7			4	3	
UPS-121	4			2	2	
TPT-1	5			1	4	
LBN-C-1	8		1		4	3
LBN-C-3	6		1		3	2

selections from the UPS group flowered early, with the exception of 'UPS-121'. None of the other varieties flowered before 56 days, the majority between 66 and 85 days. Material from the LBN lines flowered latest, most after 86 days, 30 days after the earliest lines.

Yield data from the experiment with plantain shade indicate that variety '6307-A' is very sensitive to light gradients (Table 8). Winged bean production under one plantain stem was 572 kg/ha, only 23% of the 2,489 kg obtained without shade. This latter figure is from data of a previous experiment reported in Table 2. Both bean and plantain production should be considered in combination when judging total production of an area. The winged bean was used as an annual crop and eliminated at the end of the cycle.

DISCUSSION

Undoubtedly there are good prospects of adapting some varieties of winged bean to the American tropics, especially in Central America, where the bean has never been cultivated. The ability to produce 2,000 kg of seed per ha with good protein content that has a better balance of amino-acids than other species (8), offers many advantages over other legumes. In the first trial in 1979, three varieties demonstrated a production potential of over 2,000 kg/ha, providing more than can be obtained from other legumes and would be cheaper to produce than from other protein sources, especially from animals. Considering a production level of 2,000 kg/ha, the cost of protein from winged bean would be seven times less than from beef and six times less than from potatoes.

There was great variability between and within lines in the first trial, standard deviations of most of the data being greater than the means, especially in the UPS materials. This was favorable from the

Table 8. Yield in kg/ha of winged bean (variety '6307-A) grown under different intensities of plantain shade. 1979.

Treatment	Yield kg/ha	Plantain bunches***
0 shoots*	2.489	
1 shoot	572,2 a**	800
2 shoots	182,0 b	1.300
3 shoots	88,5 b	1.700
4 shoots	74,0 b	2.000

* Mean of 4 replications, not included in the analysis

** Means with the same letter are not statistically different at the 5% probability level.

*** Estimated number of racemes harvested

standpoint of selection opportunity for more uniform material with desirable characteristics.

Yield per plant was one of the most variable characteristics. Extremes like 'TPT-1' varied from 1.1 to 316 g per plant, with per plot standard deviations from 25 to 53. Some varieties, 'UPS-47' and 'UPS-62' (Table 2), were less variable, indicating that these are more uniform and stable. Unfortunately these characteristics cannot be compared between original lines and the selections, as the data from the selections are not yet complete.

Numbers of pods per plant also varied. All varieties had at least one plant with only one pod, except 'Thailand' and 'LBN-C-1', which had plants with 3 and 2 pods respectively (Table 3). Some plants had more than 40 pods.

Mean number of pods from the second generation in the 1980 experiment (Table 6) did not differ much from the original data (Table 3). The only means that were different occurred with LBN origin. These means were less and may change significantly after the last harvest.

Numbers of seeds per pod were slightly greater in the first trial, especially with 'LBN-C-1' and 'TPT-1' which had 2.8 seed per pod more than in the latter trial. 'Thailand' and 'LBN-C-3' had the least change with an increase of 1.3 and 1.4 seed per pod respectively. '6307-A' increased 2.4 seeds per pod.

Seed weight varied little with the cycles although 'Thailand' increased 16.4 g for 100 seeds. Seed weight for '6307-A' and 'LBN-C-1'

decreased slightly while weight for the other two varieties increased slightly.

Within the selections there is a large group of plants that flower early, especially in the UPS group (Table 7). This facilitates de possible selection of high yielding material that occupies the land for a shorter period. Plant size is being carefully studied with the objective of adapting to more intensive systems with more plants per ha and perhaps a dwarf semi-erect plant type.

The possibility of combining more than two crops plant in the same area at the same time has many advantages, especially for the dominant plant, since it does not have to compete with weeds that are controlled by the plant association. Preliminary data indicate that winged bean yields are low if shade is dense, indicating that lack of light strongly inhibits normal plant development.

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Table A-1: Mean field/plot, standard deviation and mean field/plant number of plant. Winged bean experiment 1979.

Variety	I		II		III		IV		g/plant	No. of plant
	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ		
UPS - 122	16	13	11	6	11	7	9	6	12.4	119
UPS - 31	25	46	14	15	18	10	6	5	16.6	113
LBN - C-3	72	24	55	27	47	26	31	26	51.6	148
UPS - 53	19	10	15	7	23	21	8	7	16.5	144
6307 - A (C)	83	34	35	28	52	31	36	31	51.9	151
UPS - 102	26	21	10	7	12	14	8	6	14.5	121
UPS - 121	32	18	17	8	19	11	16	9	21.3	128
UPS - 62	18	9	10	7	9	6	5	4	10.6	109
UPS - 45	10	5	11	5	12	7	11	9	11.2	150
PUS - 32	11	8	12	16	18	10	7	5	12.2	139
Thailand	31	18	22	11	27	12	23	12	25.9	152
UPS - 99	9	4	8	5	8	5	11	10	8.8	129
TPT - 1	42	24	38	53	39	25	26	25	36.2	137
UPS - 47	10	6	8	4	7	5	5	3	7.8	131
LBN - C-1	58	39	41	53	42	23	51	31	53.3	150

Table A-2: Number of pods per plant, standard deviation, mean number of pods per plant. Winged bean experiment 1979.

Variety	REPETITIONS								\bar{x}
	I \bar{x}	σ	II \bar{x}	σ	III \bar{x}	σ	IV \bar{x}	σ	
UPS - 122	5.0	3.4	4.0	2.4	4.7	3.4	3.1	1.7	4.3
UPS - 31	11.6	7.6	7.7	3.8	13.0	6.8	5.3	3.9	8.0
LBN - C-3	16.8	12.0	12.9	6.5	11.8	6.3	8.0	6.3	12.6
UPS - 53	7.7	4.0	7.1	4.8	7.8	5.3	4.5	3.0	6.9
6307 - A (C)	17.9	7.7	8.1	5.0	13.5	7.7	10.6	8.5	12.6
UPS -102	14.6	8.0	6.7	3.9	7.6	4.8	7.3	4.3	9.2
UPS - 121	10.4	5.9	6.3	2.6	6.3	3.6	5.7	3.3	7.2
UPS - 62	7.7	4.5	4.9	2.6	5.1	2.8	3.3	1.8	5.4
UPS - 45	4.3	1.9	4.6	1.9	6.1	3.5	4.8	3.8	4.9
UPS - 32	4.4	2.6	4.9	4.4	7.6	3.7	3.3	2.5	5.1
Thailand	12.8	10.2	9.3	3.6	12.4	5.9	9.9	3.9	11.1
UPS - 99	4.3	2.0	3.9	2.2	3.8	2.0	5.2	3.8	4.2
TPT - 1	13.1	7.5	9.5	5.6	14.0	8.8	10.0	8.4	11.6
UPS - 47	6.0	4.9	4.3	2.1	4.1	2.7	3.6	2.1	4.6
LBN - C-1	14.6	8.0	12.4	9.9	13.3	7.4	15.4	9.8	14.0

Total mean (not mean of means).

Table A-3: Number of seeds per plant, standard deviation and mean number of seeds. Winged bean experiment 1979.

Variety	REPETITIONS								\bar{x}
	I		II		III		IV		
	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	
UPS - 122	53	36	39	19	41	25	29	18	42
UPS - 31	84	59	52	31	83	47	34	28	64
LBN - C-3	144	46	117	59	103	58	69	58	111
UPS - 53	75	38	56	30	77	60	37	29	62
6307 - A (C)	188	83	72	39	120	74	88	82	118
UPS -102	100	49	46	27	52	41	41	30	62
UPS - 121	102	55	62	27	67	41	57	30	72
UPS -62	64	35	39	23	41	27	22	18	43
UPS - 45	39	17	41	19	52	31	40	29	44
UPS - 32	43	28	46	42	73	36	29	22	48
Thailand	101	49	78	38	99	39	78	36	89
UPS - 99	34	17	30	18	29	20	36	30	32
TPT - 1	125	71	83	54	114	77	81	71	102
UPS - 47	46	27	40	20	33	16	27	17	37
LBN - C-1	125	77	99	62	94	57	112	69	108

Table A-4: Number of plants per plot. Winged bean experiment 1979 (harvested 40 plant per plot).

Variety	Replication				Total	\bar{x}
	I	II	III	IV		
UPS - 122	37	35	24	23	119	29.7
UPS - 31	36	33	21	23	113	28.2
LBN - C-3	40	39	37	32	148	37.0
UPS - 53	40	37	35	32	144	36.0
6307 - A (C)	40	38	38	35	151	37.7
UPS - 102	33	29	29	30	121	30.2
UPS - 121	33	36	27	32	128	32.0
UPS - 62	29	25	33	22	109	27.2
UPS - 45	39	38	34	39	150	37.5
UPS - 32	28	37	38	36	139	34.7
Thailand	40	38	36	38	152	38.0
UPS - 99	34	35	35	25	129	32.2
TPT - 1	38	34	31	34	137	34.2
UPS - 47	37	34	32	28	131	32.7
LBN - C-1	39	38	37	36	150	37.5