Evaluation of Winged Bean in Okinawa

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Introduction

Winged bean (*Psophocarpus tetragonolobus* (L.) D.C.), a tropical multipurpose legume, whose traditional cultivation is mainly distributed in the equatorial Asia, is basically adapted to warm climate with short day-length[9]. Then it is of interest to see how winged bean accessions react to subtropical environments where two climatic factors influencing plant growth, that is, temperature and daylength, show greater seasonal variations than in the tropics.

The objectives of this study were to assess the genetical variation in seed and tuber productivity as well as flowering behavior under such subtropical conditions, using widely different accessions obtained from eight countries. This study constitutes a part of the TARC's research program, "The Winged Bean Introduction"[1,14].

Materials and methods

We conducted winged bean evaluation using 44 accessions from 8 countries in 1983 (see Appendix).

Fifteen seeds of each accession were sown without replication in the field of TARC at Ishigaki Island (24°N, lat.) on May 25, 1983. The planting density was 1.5 m between rows and 1 m between plants. The plants received neither fertilizer nor support for entwining. The data were collected from 41 accessions except three feeble ones (see Appendix). The characters in regard to seed and pod size were measured for 10 pods sampled at random. The tuber yield was examined on March 1, 1984.

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Results

1) Growth and morphology

The seeds germinated eight to ten days after sowing, indicating that winged bean is one of slow-germinating plants (Fig. 1). The very early-flowering group consisting of four accessions showed the first flower opened at the end of August about three months after sowing. Most of the accessions, 60% of the total, began to flower in October. The Indonesian accessions began to flower late after the second half of October and three of them flowered in November, contrary to the very earlyflowering Papua New Guinea accessions in spite of their native places at the similar latitude near the equator.

There was much variation in morphological characters as well. The color of the flower (corolla) was light blue to blue, but white flowers were shown in Pyimana and Florida 2. The leaflet shape of most of accessions was obate, while lanceolate types were observed in MHS-14, Indonesia-1, -2, Tpt-6, -8, -15, -16, -17, -29 and -33. Their length along the mid-rib varied from 6 cm (Tpt-15) to 16 cm (Tpt-6), with 20% of the coefficient of variation. Winged bean is well known to have rectangular pods in cross section, but semi-flat shape was shown in Pyimana, Tpt-12 and -15. Pod length, which relates to the number of seeds per pod ($r=0.66$, $p<0.001$), ranged from 11 (Tpt-9) to 25 cm (6035 A). Pod width varied independently of pod length ($r=-0.03$), with 9.2 mm in the average. The coefficients of variation of pod length and width were 13.9 and 9.4%, respectively. Pods gen-

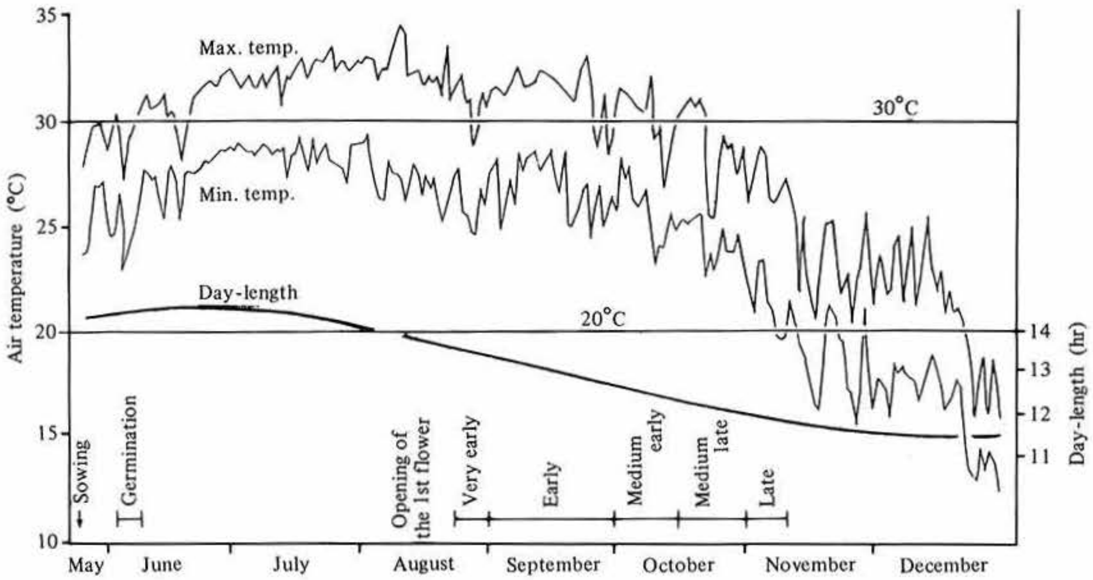

Fig. 1. Air temperatures and day-length (including twilight) during the period of the experiment at Ishigaki Island

erally colored pale green to green, while the pods of 6035 A were purple.

2) Seed yield

As the plants were allowed to creep on the field without receiving any support for the purpose of preventing serious typhoon damage, their seed yield was lower than that of plants supported with stakes[6,8].

Very early-flowering, UPS-132 and UPS-122 gave the highest yield, 152 g and 133 g/plant, respectively. This seems to be due to their long duration of pod production in addition to genetic ability (Table 1). This was confirmed by the evidence that any accessions whose first flowers opened after mid-October, did not yield more than 100 g per plant and the latest accession, 902-01, produced only one dry pod per plant. The yields of three fourths of the total accessions ranged 40 g to 130 g per plant.

As to the yield components, the number of pods per plant was the only character showing significant positive relation with seed yield (r=0.86). This result is consistent with other results[3,7-9]. Detailed examination of the result showed that the seed yields are also related to other components. For example, of four accessions showing the pod number greater than 31.8, UPS-132 (with 31.8 of pod number) gave the highest yield than others due to the number of seeds/pod was the greatest among them. As a whole, however, the yield components other than the number of pods per plant showed no significant relation with seed yield (r=0.10−0.12).

3) Tuber yield

The tuber of winged bean functions as a storage and reproductive organ, on which shoot regrowth for the second year depends in relatively high altitude regions[2]. Thus, winged bean has at least two sorts of sinks for the assimilate.

The very early-flowering UPS-132 and UPS-122 which flowered under the condition of long day-length combined with high air temperature, did not produce any tuber at all (Table 2). This may not be genetical, because they are known as good tuber producers[9]. On the contrary, the late-flowering accessions which began to flower in November when the daily maximum air temperature lowered below 30°C and day-length decreased less than 12 hr gave the highest tuber yield, by taking advantage of such favorable conditions for

Table 1. Seed yield and yield components of winged bean accessions

	Earliness of maturity (classified by flowering earliness)					
	VE	E	ME	ML	L	Total
Number of seeds/pod						
7 — 8	1	0	1	0	0	2
9 — 10	1	4	0	1	0	6
11 — 12	1	2	8	7	1	19
13 — 14	1	2	4	3	3	13
15 — 16	0	0	0	1	0	1
average	10.7	10.9	11.7	12.2	13.0	11.4
100-seed weight (g)						
21 — 25	0	0	1	0	0	1
26 — 30	0	3	2	0	1	6
31 — 35	4	1	3	6	1	15
36 — 40	0	2	5	3	2	12
41 — 45	0	2	2	3	0	7
average	32.5	34.9	34.8	36.1	34.5	35.0
Number of dry pods/plant						
1 — 9	0	1	0	4	2	7
10 — 19	0	2	3	4	2	11
20 — 29	1	4	8	4	0	17
30 — 39	2	1	0	0	0	3
40 — 49	1	0	2	0	0	3
average	31.5	19.7	25.3	14.0	9.8	20.0
Seed yield/plant (g)						
11 — 40	0	1	0	3	2	6
41 — 70	1	3	0	4	1	9
71 — 100	1	3	6	5	1	16
101 — 130	0	1	7	0	0	8
131 — 60	2	0	0	0	0	2
average	109.3	72.8	98.8	60.8	43.8	78.2

Table 2. Tuber yield and yield components of winged bean accessions

	Earliness of maturity (classified by flowering earliness)					
	VE	E	ME	ML	L	Total
Number of tubers/plant						
none	4	0	1	3	0	8
0.1 — 1.5	0	3	3	4	0	10
1.6 — 3.0	0	2	4	3	0	9
3.1 — 4.5	0	2	4	0	1	7
4.6 —	0	1	1	1	3	6
average*	—	2.4	2.5	1.7	5.1	2.8
Tuber weight (g)						
1 — 10	0	1	1	1	0	3
11 — 20	0	4	3	2	0	9
21 — 30	0	3	3	1	2	9
31 — 40	0	0	4	2	2	8
41 —	0	0	1	2	0	3
average*	—	19.3	26.7	27.7	27.6	25.2
Tuber yield/plant (g)						
none	4	0	1	3	0	8
1 — 50	0	5	6	6	0	17
51 — 100	0	2	2	1	1	6
101 — 150	0	1	2	0	2	5
151 — 200	0	0	2	1	0	3
201 —	0	0	0	1	1	2
average*	—	49.1	73.3	75.7	144.3	76.7

* Excluding non-tuber accessions.

tuber formation[9].

Tuber yield exhibited a higher positive correlation with the number of tubers per plant ($r=0.91$) than with the average tuber weight ($r=0.57$, $p<0.01$). Tpt-11 and BBG (1), which showed the highest tuber yield (more than 200 g) had the greatest number of tubers (7–8 tubers/plant) with moderate size (32–37 g/tuber). The dual-purpose type of plants was observed: Tpt-11, -15, -33 and -48 yielded more than 100 g/plant of both seed and tuber, although both organs compete with each other for the assimilate[5].

Discussion

Although small differences were observed, the range and mean value of several important characters such as pod length, 100-seed weight, and the number of seeds per pod were similar to those reported earlier, except the maximum pod-length[3,4,7-9]. Our collection of Indonesian genotypes did not include the long pod type (about 40 cm long) shown in reports. According to the coefficient of variation, the characters are grouped as follows; seed size (5%)<100-seed weight, pod length and number of seeds/pod (13–14%)<seed yield/plant and number of pods/plant (42–43%)<number of tubers/plant and tuber yield/plant, both calculated with tuber producing accessions (65–88%). The values suggest the degree of sensibility to environmental conditions.

In spite of that winged bean is considered a short-day plant[9], six accessions flowered under long daylength before the autumnal equinox. The existence of such day-neutral genotypes was predicted by earlier experiments in the subtropics[10] or in the temperate zone[12]. In fact, we also found in 1982 that a new cultivar, Urizun, developed at Okinawa Branch of TARC[11], was day-neutral. On the other hand, the Indonesian accessions, the other extreme, did not begin to flower until the end of October. This character of late-flowering seems to show that they must require a longer period of short day-length rather than the degree of shortness of day-length enough for flower induction, because the day-length becomes shorter in the subtropics than in the tropics after the autumnal equinox.

In Okinawa, the pod production of winged bean is restricted to a few months from October to December. The critical climatic values for flowering and pod setting are ca. 12 hr of day-length[9] and ca. 20°C of mean air temperature[11]. Although air temperature permits pod setting in most seasons except winter, most warm seasons have not enough short day-length for flower induction. To overcome such a barrier to pod production, we must find day-neutral genotypes. A newly-developed day-neutral cultivar, Urizun is expected to produce green pods during the long warm season in Okinawa[11]. It enables farmers there to get dry seeds for producing tofu or miso[13] before plowing the plants into the soil as green manure for preparing sugar cane fields in late autumn.

Summary

Genetical variation in morphological characters, flowering behavior, and seed and tuber productivity of 41 winged bean accessions collected from eight countries were assessed in Ishigaki Island (24°N lat.).

The range and mean value of morphological characters such as pod-length, 100-seed weight and the number of seeds per pod were similar to those reported earlier except the maximum pod length. There was much difference in earliness of flowering ranging from very early-flowering in August to late-flowering in November, although most accessions began to flower in October. The highest seed yield was shown in two very early-flowering accessions from Papua New Guinea, while late-flowering accessions from Indonesia gave very poor yield. The seed yield was dependent on different length of podproducing period with more than 20°C of mean air temperature. On the contrary, the very early-flowering accessions did not produce any tuber at all, but the late-flowering ones gave good tuber yields. The possibility of productive winged bean culture in Okinawa will be materialized by solving the climatic disadvantage such as long day-length in the warm season of Okinawa with the use of day-neutral cultivars.

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Appendix

Accession (origin)	Earli-ness*	Leaflet length (cm)	Pod size		No. of pods**	Seed weight (mg)	No. of seeds /pod	Seed size		Seed yield** (g)	No. of tubres**	Tuber yield** (g)
			Length (cm)	Width (mm)				Length (mm)	Breadth (mm)			
Ishigaki local 1 (Japan)	ML	11	19	8.2	19.6	385	13.0	9.6	8.2	98	—	70
Ishigaki local 2 (Japan)	E	10	18	9.9	18.0	408	13.4	9.6	8.6	103	3.2	52
M-13-1 (Malaysia)	E	7	18	9.7	19.6	280	12.0	9.4	8.4	66	1.3	21
MHS-14 (Thailand)	ML	7	17	9.4	4.5	326	11.3	9.4	8.5	16	0.8	6
Pyimana (Burma)	ME	7	19	9.8	39.7	233	13.2	9.1	8.5	119	2.0	17
Indonesia 1 (Indonesia)	L	14	20	7.5	6.7	322	13.8	9.1	8.3	28	4.6	140
Indonesia 2 (Indonesia)	L	13	19	8.7	12.1	297	11.8	9.6	8.6	43	3.3	78
902-01 (Indonesia)	L	9	20	7.8	1.3	367	13.4	10.0	8.7	6	5.8	142
1126-a (Indonesia)	ML	13	23	10.1	10.4	358	11.4	9.6	8.7	41	1.2	14
1126-b (Indonesia)	ML	12	19	9.3	8.7	328	12.9	9.1	8.4	37	0.8	26
BBG (1) (Indonesia)	ML	11	22	7.7	6.0	323	13.6	10.5	9.1	27	8.0	293
BBG (2) (Indonesia)	ML	13	22	10.1	13.4	410	11.9	10.4	9.8	66	2.0	47
UPS-122 (Papua New Guinea)	VE	11	19	9.2	39.9	307	10.7	9.7	9.1	133	0	0
UPS-132 (Papua New Guinea)	VE	11	21	9.6	31.8	341	14.4	9.6	8.8	152	0	0
Florida 1 (U.S.A.)	ME	12	21	9.1	18.7	286	13.8	8.5	8.2	75	0.8	17
Florida 2 (U.S.A.)	E	12	23	7.6	9.5	415	13.3	10.0	8.5	51	5.0	137
Tpt-1 (Nigeria)	ML	11	21	8.4	21.6	324	11.6	9.9	8.6	84	3.0	153
Tpt-3 (Nigeria)	ML	11	20	9.1	16.2	427	12.4	10.0	9.0	83	2.3	24
Tpt-4 (Nigeria)	ME	12	22	8.3	23.4	331	12.0	10.4	9.2	93	2.7	34
Tpt-6 (Nigeria)	ME	16	17	8.8	26.7	354	11.0	9.4	8.6	104	0	0
Tpt-8 (Nigeria)	ME	9	18	9.7	20.6	300	12.3	9.4	8.7	74	2.2	25
Tpt-9 (Nigeria)	VE	11	11	7.9	32.8	316	7.5	8.3	7.5	82	0	0
Tpt-10 (Nigeria)	E	13	16	9.5	26.7	296	9.0	8.7	8.2	71	1.7	48
Tpt-11 (Nigeria)	L	9	21	8.4	19.1	394	13.0	10.2	9.5	98	6.8	217

Appendix (continued)

Accession (origin)	Earliness*	Leaflet length (cm)	Pod size		No. of pods**	Seed weight (mg)	No. of seeds /pod	Seed size		Seed yield** (g)	No. of tubres**	Tuber yield** (g)
			Length (cm)	Width (mm)				Length (mm)	Breadth (mm)			
Tpt-12 (Nigeria)	E	8	17	9.9	24.6	363	10.3	10.1	9.1	98	1.2	11
Tpt-14 (Nigeria)	ME	11	23	10.3	28.2	344	12.6	9.9	9.4	126	1.2	42
Tpt-15 (Nigeria)	ME	6	17	10.2	26.0	357	10.9	9.6	8.8	102	4.2	106
Tpt-16 (Nigeria)	ML	14	21	7.7	22.3	366	11.8	9.5	9.1	98	1.0	48
Tpt-17 (Nigeria)	E	10	18	9.6	8.9	301	11.6	9.2	8.9	32	1.2	23
Tpt-18 (Nigeria)	ME	10	16	9.0	40.5	380	8.1	10.5	9.2	123	1.0	39
Tpt-19 (Nigeria)	ME	11	24	9.7	17.1	368	12.9	10.8	9.6	82	2.0	76
Tpt-22 (Nigeria)	E	10	19	9.8	30.0	328	8.6	9.6	9.1	91	3.3	48
Tpt-26 (Nigeria)	ML	9	18	10.2	22.3	337	9.5	9.3	9.4	75	0	0
Tpt-29 (Nigeria)	ML	10	18	9.7	13.6	314	11.1	8.9	8.8	47	0	0
Tpt-29-1 (Nigeria)	VE	9	17	10.4	21.3	328	10.3	9.3	9.1	70	0	0
Tpt-30 (Nigeria)	E	8	16	9.5	20.1	386	9.1	9.9	9.0	70	2.3	53
Tpt-31 (Nigeria)	ME	12	16	9.3	17.6	393	11.1	9.6	8.7	76	5.6	162
Tpt-32 (Nigeria)	ME	11	18	9.5	27.2	357	11.0	9.5	8.7	107	3.3	65
Tpt-33 (Nigeria)	ME	14	20	8.3	20.9	405	11.4	9.2	8.4	93	3.5	115
Tpt-48 (Nigeria)	ME	10	19	10.1	21.8	419	11.5	10.5	9.5	110	3.8	182
6035 A (unknown)	ML	11	25	10.5	9.1	419	15.4	10.0	8.7	57	0	0
Average		10.7	19.2	9.2	20.0	350	11.4	9.6	8.8	78.2	2.8***	76.7***
Coefficient of variation (%)		20.1	13.9	9.4	47.7	12.5	14.3	5.7	5.2	42.2	65.4	88.8

* The time of the 1st flower opening; VE: August, E: September, ME: early half of October, ML: latter half of October, L: November.
** Values per plant.
*** Excluding non-tuber accessions.