VARIATION IN WINGED BEANS-UNEXPLOITED FOOD CROP*)

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RINGKASAN

Lebih dari 140 nomer koleksi kecipir *(Psopocarpus tetragonolobus)* telah dikumpulkan di Departemen Agronomi Fakultas Pertanian Universitas Gadjah Mada. Lebih dari separonya berasal Indonesia yang merupakan pusat diversitas spesies.

Adanya keseragaman yang luas telah diamati pada sejumlah tanaman terhadap sifat-sifat daun bunga, biji dan polong, baik secara kualitatip maupun kuantitatipnya.

Pembuangannya adalah sangat responsip terhadap panjang hari. Kisaran keragaman menunjukkan adanya potensi protein, biomass, penambatan nitrogen dan komponen produksi (polong muda, biji dan ubi) dapat dikembangkan; begitu pula penggunaannya, meliputi daerah tropika basah.

Usaha seleksi dan pemuliaan sedang dalam pelaksanaan.

The winged bean might be called a "supermarket" since nearly every portion of the plant can be consumed or profitably utilized. Most current usage is made of the immature pods in countries where it is cultivated (Fig. 1). Recently when the winged bean has been tried in countries where it had not previously been grown, the acceptance and consumpson of the green pods as a vegetable has been very good. Pods are generally cooked in the immature pods in countries where it is cultivated (Fig. 1). Recently when the winged bean has been tried in countries where it had not previously been grown, the acceptance and consumption of the green pods as a vegetable has been very good. Pods are generally cooked in the immature stage and directly consumed in much the same manner as green pods of the garden bean, *Phaseolus vulgaris* , or the yard-long bean, *Vigna sesquipedalis*. Uncooked immature pods are used some in such Indonesian dishes as gado-gado salad.

The plants are usually vegetaively vigorous and leaves and stem tips are also eaten fresh, boiled, or stir fried. Even flowers, which are relatively large, are sometimes boiled lightly, fried or consumed fresh in salads.

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Seeds are consumed to a more or less minor degree either in the immature or fully dry stage. They may be prepared for eating by boiling after soaking overnight, fried, roasted or parched, and cooking techniques have been developed to promote usage (23). In Indonesia, some usage is made of the seed as a replacement for soybeans in the preparation, of tempe and tahu (tofu). Medicinal usage of the seed is very common. The root tuber is edible, but is currently not widely consumed except in Papua New Guinea and Burma, where it is apparently grown chiefly for the tubers. Many people in Indonesia who eat the green pods are unaware that the plant forms edible tuber. Tubers are generally eaten after boiling, frying, baking or roasting. We have made very tasty chips from the tubers, which have a desirable nutlike flavor. Stems and other plant parts make very acceptable livestock feed.

Many reports indicate that the winged bean nodulates readily and abundantly even without inoculation, and is highly efficient in fixing nitrogen (5, 8, 17, 18). The ability to fix nitrogen coupled with rapid vegetative growth would suggest potential usage as a cover and restorative crop. Natives in the Tanah Merah area of Madura told the authors that they formerly used the winged bean as a restorative crop in association with cassava and other food crops. This usage has sharply declined recently with the ready availability of relatively inexpensive. urea. We believe the plant has an important role to play in controlling soil erosion and restoring production on large tracts of hilly land in Java and elsewhere that have been denuded by slash and burn subsistence agriculture and overgrazing by animals.

What has really excited the imagination and attention of people all over the world is the extremely high protein content of most of the edible portions of this amazing plant (2,3,4,6,7,9,18,19,21).The dry seeds contain high levels of both protein and oil ranging from 26-45% and 13—20% respectively, closely approximating that of soybeans. The amino acid content is also similar to that of soybeans. The amino acid content is also similar to that of soybeans, and like soybeans and other lagume seeds is somewhat deficient in the essential sulfur amino acids methionine and cystine (3,4,7,12,18,19,21). However, the winged bean seed is relatively rich in lysine, which increases its potential value as a supplement for cereal diets. Little diversity was found in seed storage proteins among 80 lines from Papua New Guinea, which would significantly alter the nutritional value of the seed (2,7). It is unknown if the Indonesian and other Southeast Asian material contains significant variability in this regard.

The fatty acid content of the seed oil is reported to be over 70% unsaturated (3,4,18). The seeds are also rich in tocopherol (19), an antioxidant that enhances utilization of vitamin A in the human body; a very important feature since vitamin A deficiency is endemic and leads to blindness in children of many tropical countries, including Indonesia.

The protein content of immature pods is 15-16% on a dry weight basis which is similar to that of edible pods of other legume species. The pods also provide a good supply of minerals and vitamins. Raw pods and tubers were reported to contain 20 and 26 mg/100g of ascorbic acid, while the content of leaves from plants 2—3 months old was from 55-128 mg/100g (4). Beta-carotene content of leaves expressed as vitamin A International Units ranged from 9730-19300 (4). Dried pods and leaves are reported to contain 2.5 and 15.8 mg/ 100g beta-carotene respectively (21).

The truly unique feature of the winged bean is the exceptionally high level of crude protein found in the root tubersranging from 11--15% on a fresh weight basis, and from 18-25% dry weight (3,4,6,18). No other edible root or tuber even approaches this amount, which is from over 5 to 10 times the level of protein found in sweet potatoes or cassava that are commonly consumed as staples in the tropics. At the same time the winged bean tuber contains from 27-31% carbohydrate on a fresh weight basis, which is as high or higher than that normally found in sweet potatoes in the tropics. This is very important, since a deficiency of energy intake is frequently as deleterious or even more so than lack of protein in many diets in the tropics. A very large number of people throughout the world rely heavily on cassava and other root or tuber crops to provide the major portion of their diet. Gaining acceptance of winged bean tubers in the diets of populations currently subsisting on other less nutritious roots and tubers should not be an insurmountable problem. Dr. R. A. Stephenson, University of Papua New Guinea, Port Moresby, is serving in an interm capacity to coordinate communications and informational requests as well as edit the ''Winged Bean Flyer''.

Research on the winged bean is of recent vintage, with the first major multidisciplinary effort started in Papua New Guinea in 1973. Collection, evaluation, cultivar performance, selection, cultural studies, and studies on the nutritional value followed shortly in Nigeria, Ghana, Malaysia, Indonesia, Thailand, Puerto Rico and few other places. We initiated an active multidisplinary research program in 1977, jointly founded by the Rockefeller Foundation and the University of Gadjah Mada at Yogyakarta in Central Java, Indonesia. Our initial effort was on assembling and evaluation of a germplasm collection from Indonesia and other locations. We currently have a total of 140 accessions. Of the total 88 are from Indonesia, 17 from Papua New Guinea, 14 from Nigeria, 6 from Malaysia, 5 from Puerto Rico, 3 each from India and Ghana, 2 from Thailand and 1 each from Sri Lanka and the Phillippines. Four evaluation plantings were made in 1977. The quantity of seeds was difficult to repeat plantings of the same accessions more than once during the first year of the project. Effort was directed on observations of genetic variability and increasing seed supply of lines in order to be able to conduct larger scale, replicated cultivar tests and cultural experiments. A breeding and selection program was also started. Sufficient seed of one accession (UGM 1) was available to plant a replicated, spacing--plant population experiment in Nopember,

1977. A replicated trial of 69 accessions was planted for evaluation in March, 1978, and 11 accessions were chosen to initiate a study of planting date effects on growth, flowering and production. The latter plantings were started in July, 1978 and contiuied at monthly intervals. An a hoc Working Group of the International Board for Plant Genetic Resources(IBPGR) has met and drawn up a tentative list of descriptors for winged beans. This activity should help standardize the characterization and evaluation of the large array of germplasm that is being assembled. This meeting was held at Pattaya, Bangkok Thailand.

There appears to be two major groups of germplasm of the winged bean--one from Papua New Guinea (PNG) and teh other from Indonesia. The germplam from other area of Southeast Asia is similar to that from Indonesia. The Nigerian material appears to have been derived from PNG germplasm. Our experience has been primarily with the accessions from Indonesia and from PNG. The range of variability of the PNG material has been well summarized (2, 4, 13, 14, 15). The Indonesian germplasm exceeds the range of that from PNG in certain characteristics (10, 25, 26).pod length of PNG material ranged from 5.8—26.4 cm, while an Indonesian accession from Bali is reported to have pods in excess of 70 cm. Seed coat colors range from creamy white to black and mottled, with brown being the most common. A range of leaflet shapes including lanceolate, ovate-lanceolate and long lanceolate are commonly found among Indonesian accessions in addition to the more common ovate and deltoid shapes, which seem to predominate in the PNG material.

Another important difference is the existence of accessions within the Indonesian population having a high level of resistance to False Rust, a serious fungus disease incited by *Synchytrium psopocarpi* (Rac.) Gaumann (26). No apparent resistance has been found in the PNG material.

In general the Indonesian germplasm lack the various anthocyanin pigmentation patterns on stems, leaves and pods widely found in the PNG lines. White and very pale blue flower color is frequently found in addition to a very dark purple type, which is a much deeper color than that of any PNG material we have observed. The dark purple flower color is also associated with a deeply pigmented sepal, a light flecking on the pods, and a very thin band of pigment running the length of the wings on the pods. A single mutant plant was discovered in 1978 within one of these purple-flowered accessions (UGM 84 or LBN-C10). Which had a noticeably reddish-purple flower color. Another new and unique flower color was discovered in 1978 in two accessions (UGM 128, UGM 129) we collected in Madura. It had a flower with a normal blue base color, but with irregularly shaped patches of purple in the centres of the wing and banner petals. The inheritance of these new flower colors has not yet been determined.

Our observations indicate that the Indonesian accessionss tend to be later in maturity, exhibit more vegetative vigor, and are higher yielding than most of the

PNG accessions we have tested (Table 1). We have not observed and unselected population of accessions from PNG, and it would appear that most of the accessions we have tested have been selected for earliness. We have found a limited number of lines among the Indonesian accessions that are as early as most of PNG line under our conditions. Some of our lines, including UGM 1, are relatively incentive to daylength, and will flower when planted any time of the year under our conditions (8°S. latitude). Many line we have tested exhibit extreme senditivity to our "long" photoperiod (12—12½ hours), and remain vegetative from 4 to 6 months of the year. In contrast, a high percentage of the Indonesian accessions retain their vegetative vigor after fruiting and could be characterized as shortlived perennials. The relatively lower seed and tuber yields of the PNG accessions is undoubtedly related to reduced plant vigor and survival (Table 1). Our limited experience withone Indonesian accesion (UGM 1) indicated that for both green pod and dry seed the best spacing was 1 seed/hill, 50 cm within rows spaced 1 cm apart, yielding a theoritical population of 20,000 plants/ha (Fig. 2, Table 2). UGM 1 appears to be able to compensate for wide spacing by heavy production of basal branches. The PNG lines do not tend to form as many basal branches, but most of the Indonesian accessions do so readily. The data in Table 2 and Fig. 4 are from only one cultivar and have some other limitations. UGM 1 normally produces edible pods within 60 days after planting. The experiment was planted on September 10, 1977. Germination was good and overall plant stands at the time of first harvest, 93 days after planting was 93.4%. Early production was definitely delayed by heavy delayed by heavy soil moisture stress due to inadequate irrigation water supply, which caused reduced vegetative growth and excessive blossom drop. Normal growth was resumed following the onset of the rainy season around the middle of November. The mean green pod weight of UGM 1 was 14.4g, pod length 18.8 cm, with 14.5 seeds/pod, 100 dry seed weight of 33.5g, and a shelling percentage of 51.9%. The mean weight of edible tubers was 31 and 29g respectively from plots harvested as green pods and as dry seed.

At the start of this experiment, it was not even known if UGM 1 could produce tubers. We now believe that an adequate crop of tubers could be produced with this and other cultivars if appropriate cultural practices were employed. It is doubtful if a single cultivar can be developed that would concurrently produce high yields od either green pods or dry seed and tubers. However, it does seem probable that a single cultivar could be developed and used for production of either green pods, dry seed or tubers under the appropriade cultural regime. Much research is needed in this area.

The wide range in genetic variability leads us to conclude that the winged bean can and will become a commercial as well as a home garden crop, which will significantly contribute to the production of needed protein and edible oil throughout the tropics. It would appear likely that its range can also be extended to the subtropics and temperate zone under certain conditions. However, much effort on research and development must be expended to fully capitalize upon the species potential.

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Tabel 1. Comparison of performance of 69 winged bean accessions from various sources, planted March 6, 1978, Yogyakarta, Indonesia

	Sources of accessions				
	Indonesia	Nigeria	Papua New Guinea	Malaysia	Ghana
Number of accessions :	43	12	11	2	1
Days to following^{z}:					
Mean	82	73	57	87	79
Range	55—95	54—92	54—62	77—97	—
Plant survival^{y}:					
Mean	86	69	38	87	47
Range	27—100	8—96	11—72	83—93	—
Seed yield-g/plant :					
Mean	187	161	77	267	198
Range	83—294	56—248	26—129	235—299	198
Seed yield (est.)-kg/ha :					
Mean	2282	2054	976	4491	3339
Range	885—4480	853—3307	320—2389	4160—5013	—
Pod length-cm :					
Mean	19.7	18.0	17.5	18.3	19.7
Range	15—27	13—22	9—24	16—20	—
Seeds/pod :					
Mean	11.4	10.6	11.2	11.1	11.3
Range	9—14	9—12	8—14	10—12	—
Shelling % :					
Mean	51	48	48	54	51
Range	40—59	41—55	44—53	50—58	—
100 seed weight-g :					
Mean	36.4	31.4	32.2	38.8	37.4
Range	27—46	26—36	21—38	36—41	—
Edible tuber production :					
Number of accessions harvested^{x}	26	12	10	2	1
Accessions producing tubers-%	88	67	70	100	100
Plant within accessions producing tubers-%					
Mean	52	15	15	18	21
Range	16—100	8—43	7—47	4—33	—
Tuber weight-g/plant :					
Mean	74.6	14.0	13.5	5.10	7.34
Range	6.6—293.3	3.8—36.2	2.1—32.0	1.4—8.7	9.34
Tuber yield (est.)-T/ha :					
Mean	1.3	0.5	0.5	0.5	0.6
Range	0.2—4.1	0.3—1.1	0.3—1.0	0.5—0.6	—

^{z} Number of daya from planting to 50% of plants with first flower open.

^{y}Percentage of plants surviving 210 days after planting.

^{x}Some accessions were retained for further evaluation of False Rust resistance, and tuber production not determined.

Table 2. Yield Parameters of Indonesian winged bean cultivar UGM 1 at various spacings-plant populations, 245 days after planting.

Spacing Row (cm	With Seeds / hill	Flant population /ha	Branches /plant	Green pods (T/ha)	Dry seed (kg/ha)	Tuber yield (T/ha) Green pod harvest	Tuber yield (T/ha) Dry seed harvest
75	1	12,500	3,6	10,6ab[z]	2522a	.35cde	.13e
50	1	18,500	3.4	11.8a	2642a	.43bcde	.38cde
25	1	37,000	2.8	8.8ab	2513a	.64bcde	.26de
75	3	37,500	1.9	9.6ab	1822bc	.81bcd	.24de
50	3	56,000	2.2	9.0ab	2091ab	.91bc	.58bcde
12.5	1	75,000	2.5	9.9ab	2523a	.82bcd	.70bcde
25	3	106,000	2.0	7.6b	1576bc	.82bcd	.80bcd
12.5	3	212,000	1.4	7.7b	1304c	1.67a	1.06ab
Mean		69,300	2.5	9.4	2124	.81	.52

[z]Mean separation within columns is by Duncan's multiple range test, 5% level.

fig 1. Fully developed green pods of Indonesian winged bean cultivar UGM I.

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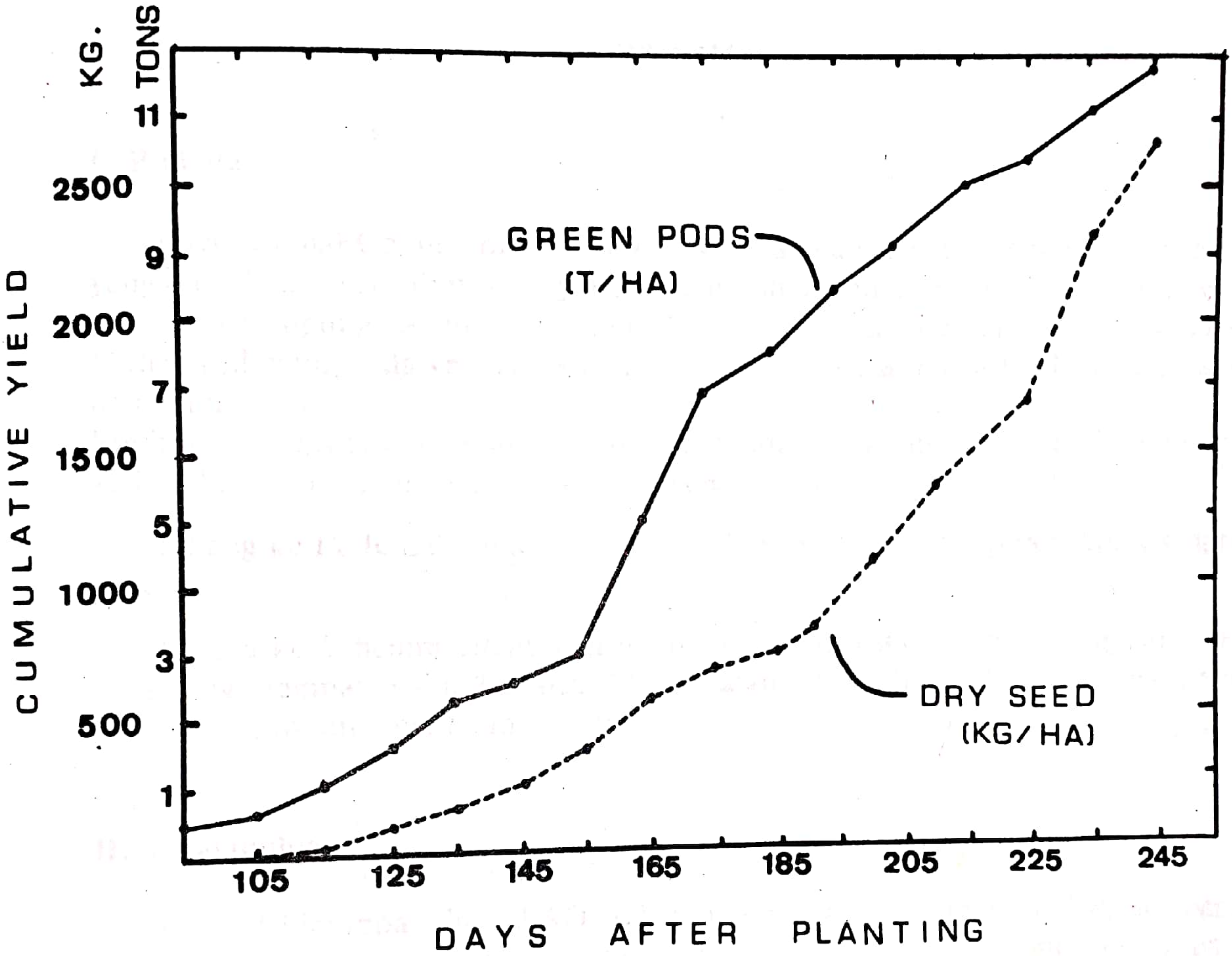

Fig. 2. Cumulative yields of green pods and dry seed of Indonesian winged bean cultivar UGM 1 planted at an optimal population of 18,500 plants/hectare utilizing a spacing of 1 seed/hill, 50 cm within and 1 meter between rows.