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Some Morphological Characters of Pulses Collected in the Indian Sub-Continent

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Introduction

From October in 1971 to January in 1972, the writer was sent to India and Ceylon (Sri Lanka). During this trip, 106 strains of pulses were collected.

Grain legumes form a major component of lowland and upland tropical cropping systems. Several species and strains are utilized throughout wet and dry tropics in monoculture and complex multiple cropping and bush-fallow practices. Morphological examinations are requested in the world for agronomical usage.

In the present report, some records of morphological characters of grains, and some considerations of species specificities and ecotypic differentiations have been mainly described.

Materials and Methods

Thirty three strains, belonging to 7 genera and 10 species, were picked out from 106 strains collected in the Indian Sub-Continent, and used for morphological investigations of grains, among them the strains collected in Nepal and near Sikkim, India, were collected by another member of this party. As No.31, a strain of *Dolichos biflorus*, was ascertained to be mixed materials, it was divided into two sub-strains, *i.e.*, No.31A (brown color in grain) and No.31B (black color in grain). Then, the strains used are recorded as 34 in the total.

Distribution and locality of the strains used are listed up in Table 1. In this table, strain number, collection number, date of collection, species name, English name and locality were described. Geographical positions, in which the materials were collected, are shown in Fig. 1. A numerical in this figure shows the strain number used in Table 1.

Measurements were done in length, width and thickness of grains, and done at the most eminent section of the respective character. Fifty grains were used for the measurement of each strain, excepting No.12 (38 grains). The whole data referring to the six characters were illustrated by the average values in the whole grains in the respective strain. Calculations, moreover, were done for the ratios of length to width, of length to thickness and width to thickness. To make clear the relationships between these two characters, correlation coefficient and linear regression of them were calculated.

Table 1. Materials used in the present experiment, species name, English name and locality collected

Strain No.	Collection No.	Date	Species name	English name	Locality
P-1	1-64	11-11*	*Phaseolus aureus*	green gram	Jeypore, Koraput, Orissa, India
P-2	1-91	11-20	*Phaseolus aureus*	green gram	Raipur, Raipur, M. P., India
P-3	1-11	11-11	*Phaseolus mungo*	black gram	Balrampur, U. P., India
P-4	2-16	11-17	*Phaseolus mungo*	black gram	IARI, India
P-5	2-86	11-20	*Phaseolus mungo*	black gram	Raipur, Raipur, M. P., India
P-6	2-96	12-5	*Phaseolus mungo*	black gram	Samalkot, East Godavari, A. P., India
P-7	2-218	11-13	*Phaseolus mungo*	black gram	Mulkoat, Sun Kosi, No. 2 East, Nepal
P-8	1-219	12-1	*Phaseolus mungo*	black gram	Kalimpong, W. B., India
P-9	1-221	12-1	*Phaseolus mungo*	black gram	Kalimpong, W. B., India
P-10	2-318	12-28	*Phaseolus mungo*	black gram	Nuwara Eliya, Sri Lanka
P-11	4-63	11-10	*Phaseolus calcaratus*	rice bean	Pappadahandi, Koraput, Orissa, India
P-12	4-225	12-1	*Phaseolus calcaratus*	rice bean	Kalimpong, W. B., India
P-13	4-227	11-7	*Phaseolus calcaratus*	rice bean	Pokhara, No. 3 West, Nepal
P-14	4-323	12-17	*Phaseolus calcaratus*	rice bean	Kumta, Mysore, India
P-15	22-92	11-20	*Phaseolus aconitifolius*	moth bean	Raipur, Raipur, M. P., India
P-16	5-7	11-17	*Vigna sinensis*	cowpea	IARI, India
P-17	5-67	11-11	*Vigna sinensis*	cowpea	Jeypore, Koraput, Orissa, India
P-18	5-88	11-20	*Vigna sinensis*	cowpea	Raipur, Raipur, M. P., India
P-19	5-97	12-16	*Vigna sinensis*	cowpea	Tirukkalikundra, Chingleput, Tamil Nadu, India
P-20	5-319	12-21	*Vigna sinensis*	cowpea	Mysore, Mysore, India
P-21	5-320	12-17	*Vigna sinensis*	cowpea	Kumta, Mysore, India
P-22	5-80	11-20	*Vigna sesquipedalis*	longyard bean	Raipur, Raipur, M. P., India
P-23	6-51	11-30	*Cajanus cajan*	pigeon pea	Dumka, Bihar, India
P-24	10-155	11-12	*Clitoria ternatea*	butterfly pea	Kongadon, Baster, M. P., India
P-25	14-58	11-6	*Glycine max*	soybean	Similiguda, Koraput, Orissa, India
P-26	14-216	11-11	*Glycine max*	soybean	Rosi Khola, No. 1 East, Nepal
P-27	14-224	12-1	*Glycine max*	soybean	Kalimpong, W. B., India
P-28	21-13	11-24	*Dolichos biflorus*	horse gram	Rajgir, Bihar, India
P-29	21-56	11-3	*Dolichos biflorus*	horse gram	Mandasa, Srikakulam, A. P., India
P-30	21-68-1	11-11	*Dolichos biflorus*	horse gram	Jeypore, Koraput, Orissa, India
P-31	21-68-2	11-11	*Dolichos biflorus*	horse gram	Jeypore, Koraput, Orissa, India
P-32	21-231	11-13	*Dolichos biflorus*	horse gram	Ghan Gholi, Sun Kosi, No. 2 East, Nepal
P-33	21-317	12-28	*Dolichos biflorus*	horse gram	Nuwara Eliya, Sri Lanka

*: November 11, 1971

Results

PART I. Respective character

1. Length

The results are given in Table 2. Length for the individual grain level ranged from 10.85 mm (No.17) to 3.90 mm (No.1). In the strain level, the longest (9.67 mm) was obtained in No.17, followed by No.22 (9.65 mm) and No.19 (8.72 mm). The shortest (4.19 mm) was noted in No.1, followed by No.9 (4.62 mm) and No.2 (4.80 mm). It may be noted that the values were peculiarly large in Nos.17 and 22. Mode was found within 5.21 to 5.60 mm. The differences in length were confirmed to be very large throughout the respective strain. Average and

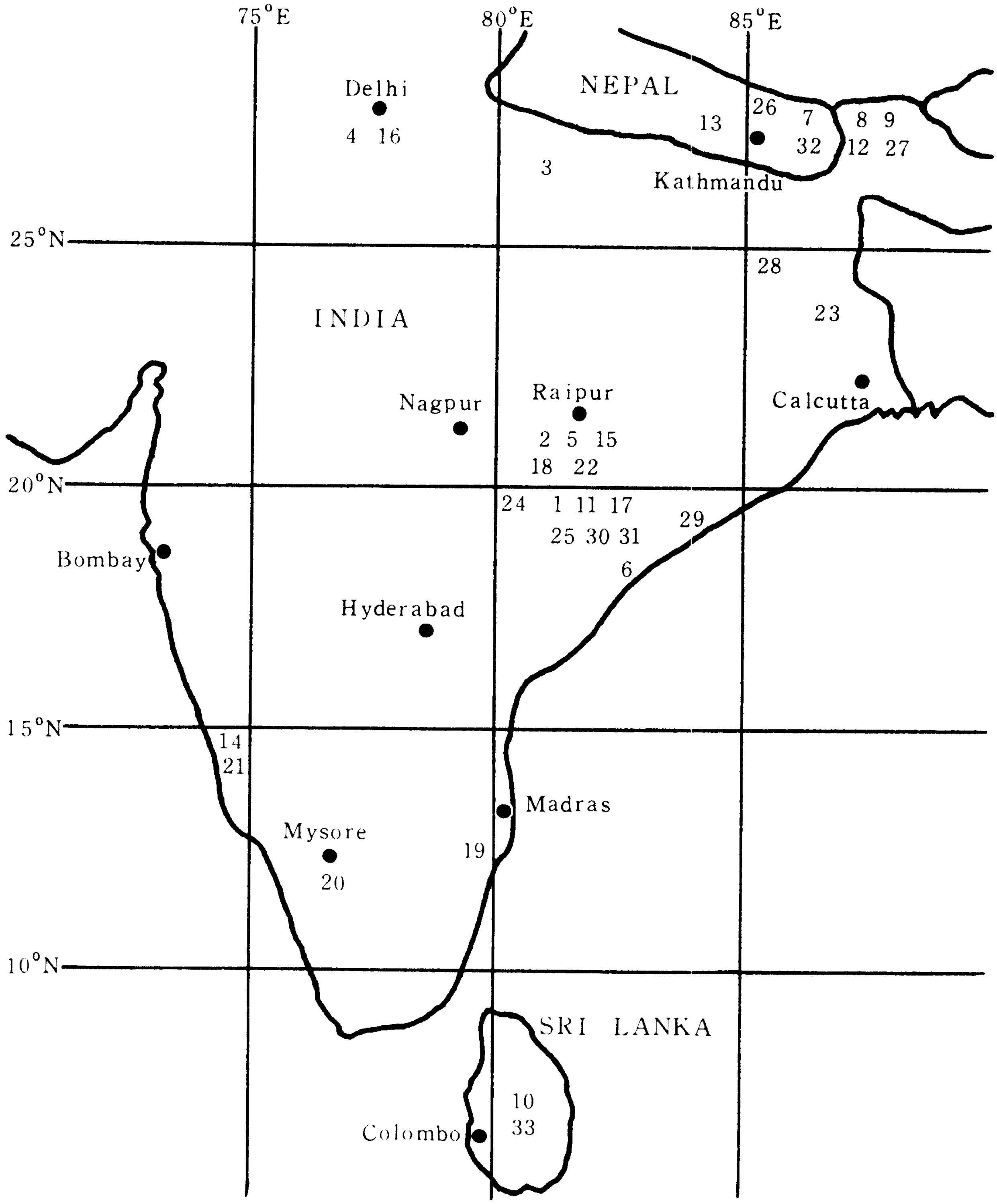

Fig. 1. Location of collecting sites. Numbers used in the figure are corresponding to the strain number which was used in Table 1.

Table 2. Morphological characters of grains

Strain No.	Length (mm)	Width (mm)	Thickness (mm)	L/W	L/T	W/T
1	4.19 ± 0.22	3.46 ± 0.16	3.37 ± 0.15	1.21 ± 0.07	1.25 ± 0.08	1.03 ± 0.03
2	4.80 ± 0.19	3.87 ± 0.15	3.78 ± 0.15	1.24 ± 0.05	1.27 ± 0.05	1.02 ± 0.03
3	4.87 ± 0.21	3.77 ± 0.20	3.21 ± 0.17	1.29 ± 0.07	1.51 ± 0.09	1.18 ± 0.06
4	5.35 ± 0.22	4.18 ± 0.18	3.65 ± 0.23	1.28 ± 0.07	1.47 ± 0.09	1.15 ± 0.05
5	5.55 ± 0.19	4.30 ± 0.16	3.72 ± 0.18	1.29 ± 0.06	1.49 ± 0.08	1.16 ± 0.05
6	5.04 ± 0.17	4.01 ± 0.23	3.51 ± 0.22	1.26 ± 0.08	1.44 ± 0.10	1.14 ± 0.06
7	5.22 ± 0.26	4.01 ± 0.24	3.23 ± 0.22	1.31 ± 0.09	1.62 ± 0.15	1.24 ± 0.12
8	5.06 ± 0.19	3.88 ± 0.19	3.31 ± 0.22	1.31 ± 0.07	1.53 ± 0.11	1.17 ± 0.06
9	4.62 ± 0.15	3.59 ± 0.16	3.01 ± 0.25	1.29 ± 0.06	1.55 ± 0.12	1.20 ± 0.10
10	5.35 ± 0.23	4.31 ± 0.22	3.68 ± 0.11	1.25 ± 0.09	1.46 ± 0.07	1.17 ± 0.06
11	5.78 ± 0.35	3.95 ± 0.26	2.96 ± 0.18	1.47 ± 0.11	1.95 ± 0.16	1.33 ± 0.08
12	5.82 ± 0.55	3.53 ± 0.34	2.84 ± 0.24	1.65 ± 0.14	2.02 ± 0.21	1.25 ± 0.08
13	7.13 ± 0.30	4.41 ± 0.16	3.63 ± 0.13	1.62 ± 0.07	1.96 ± 0.10	1.21 ± 0.04
14	5.43 ± 0.36	3.65 ± 0.15	3.23 ± 0.18	1.49 ± 0.10	1.68 ± 0.13	1.13 ± 0.05
15	4.97 ± 0.18	3.13 ± 0.12	3.08 ± 0.11	1.59 ± 0.08	1.62 ± 0.08	1.02 ± 0.02
16	8.17 ± 0.37	5.48 ± 0.23	4.55 ± 0.16	1.49 ± 0.08	1.80 ± 0.08	1.21 ± 0.06
17	9.67 ± 0.49	7.02 ± 0.38	5.97 ± 0.42	1.38 ± 0.07	1.62 ± 0.12	1.18 ± 0.06
18	8.31 ± 0.44	5.80 ± 0.24	4.65 ± 0.18	1.44 ± 0.08	1.79 ± 0.11	1.25 ± 0.07
19	8.72 ± 0.38	7.11 ± 0.32	6.48 ± 0.29	1.23 ± 0.07	1.35 ± 0.07	1.10 ± 0.04
20	7.52 ± 0.24	5.51 ± 0.28	4.42 ± 0.18	1.37 ± 0.08	1.70 ± 0.08	1.25 ± 0.07
21	8.60 ± 0.54	6.15 ± 0.29	5.17 ± 0.25	1.40 ± 0.10	1.66 ± 0.10	1.19 ± 0.05
22	9.65 ± 0.46	5.17 ± 0.20	3.52 ± 0.17	1.87 ± 0.08	2.74 ± 0.16	1.47 ± 0.08
23	5.77 ± 0.19	4.83 ± 0.25	4.09 ± 0.23	1.20 ± 0.07	1.42 ± 0.10	1.19 ± 0.09
24	6.91 ± 0.40	4.88 ± 0.25	2.57 ± 0.25	1.42 ± 0.11	2.72 ± 0.34	1.92 ± 0.27
25	7.73 ± 0.43	6.42 ± 0.26	5.32 ± 0.23	1.20 ± 0.06	1.46 ± 0.09	1.21 ± 0.04
26	8.02 ± 0.28	6.41 ± 0.20	4.68 ± 0.21	1.25 ± 0.05	1.72 ± 0.08	1.37 ± 0.06
27	7.42 ± 0.38	6.04 ± 0.33	4.51 ± 0.27	1.23 ± 0.11	1.65 ± 0.14	1.34 ± 0.06
28	6.14 ± 0.24	4.09 ± 0.26	2.09 ± 0.19	1.51 ± 0.12	2.96 ± 0.30	1.97 ± 0.23
29	5.89 ± 0.32	4.40 ± 0.23	2.38 ± 0.16	1.34 ± 0.06	2.48 ± 0.20	1.85 ± 0.13
30	5.59 ± 0.36	4.04 ± 0.41	1.98 ± 0.21	1.40 ± 0.15	2.86 ± 0.37	2.06 ± 0.30
31A	6.63 ± 0.26	4.45 ± 0.22	2.52 ± 0.15	1.49 ± 0.10	2.64 ± 0.25	1.77 ± 0.14
31B	6.56 ± 0.30	4.46 ± 0.24	2.06 ± 0.18	1.48 ± 0.10	3.21 ± 0.31	2.19 ± 0.25
32	6.57 ± 0.29	4.37 ± 0.27	2.48 ± 0.14	1.51 ± 0.10	2.66 ± 0.19	1.77 ± 0.14
33	6.43 ± 0.43	4.26 ± 0.34	2.25 ± 0.21	1.52 ± 0.14	2.88 ± 0.37	1.91 ± 0.23

No. of grains used = 50 (38 only in No. 12).

its standard deviations in the whole strains were found to be 6.46 ± 1.48.

Values of length in the genus *Dolichos* were clearly larger than those of other genera. Values of length in the genus *Phaseolus* were noted in the following order; *P. calcaratus* > *P. aconitifolius* > *P. mungo* > *P. aureus*.

2. Width

Width for the individual grain level ranged from 7.80 mm (No.19) to 2.80 mm (No.15). In the strain level, the widest (7.11 mm) was obtained in No.19, followed by No.17 (7.02 mm) and No.25 (6.42 mm). The narrowest (3.13 mm) was noted in No.15, followed by No.1 (3.46 mm) and No.12 (3.53 mm). It may be noted that the values were peculiarly large in Nos.17 and 19. Mode was found within 4.01 to 4.40 mm. The differences in width were confirmed to be large throughout the respective strain. Average and its standard deviations in the whole strains were found to be 4.68 ± 1.06.

Values of width in the genus *Dolichos* were clearly larger than those of other genera.

Values of width in the genus *Phaseolus* were noted in the following order; *P. mungo* > *P. calcaratus* > *P. aureus* > *P. aconitifolius*.

3. Thickness

Thickness for the individual grain level ranged from 7.20 mm (No.19) to 1.55 mm (No. 31B). In the strain level, the thickest (6.48 mm) was obtained in No.19, which was the same as the width, followed by No.17 (5.97 mm) and No.25 (5.32 mm). The thinnest (1.98 mm) was noted in No.30, followed by No.31B (2.06 mm) and No.28 (2.09 mm). It may be noted that the values were peculiarly large in Nos. 17 and 19, which were the same as width. Mode was found within 3.51 to 3.80 mm. The differences in thickness were confirmed to be large throughout the respective strain. Average and its standard deviations in the whole strains were found to be 3.59 ± 1.11.

Values of thickness in the genus *Dolichos* were clearly larger than those of other genera. Values of thickness in the genus *Phaseolus* were noted to be nearly the same throughout the whole species.

4. Ratio of length to width

Ratio of length to width (abbreviated as R·L/W) for the individual grain level ranged from 2.08 (No.22) to 1.04 (No.23). In the strain level, the largest (1.87) was obtained in No.22, followed by No.12 (1.65) and No.13 (1.62). The smallest (1.20) were noted in Nos.23 and 25, followed by No.1 (1.21). It may be noted that the value was peculiarly large in No.22. Mode was found within 1.21 to 1.25. The differences in R·L/W were confirmed to be large throughout the respective strain. Average and its standard deviations in the whole strains were found to be 1.39 ± 0.15.

It does not necessarily follow that the values of R·L/W in the genus *Dolichos* were larger than those of other genera. This finding was clearly different from the former 3 characters mentioned above. Values of R·L/W in the genus *Phaseolus* were noted in the following order; *P. calcaratus* ≑ *P. aconitifolius* > *P. mungo* > *P. aureus*.

5. Ratio of length to thickness

Ratio of length to thickness (abbreviated as R·L/T) for the individual grain level ranged from 4.00 (No.31B) to 1.08 (No.1). In the strain level, the largest (3.21) was obtained in No.31B, followed by No.28 (2.96) and No.33 (2.88). The smallest (1.25) was noted in No.1 likewise in case of the length, followed by No.2 (1.27) and No.19 (1.35). It may be noted that the value was peculiarly large in No.31B. Mode was found within 1.61 to 1.70. The differences in R·L/T were confirmed to be very large throughout the respective strain. Average and its standard deviations in the whole strains were found to be 1.92 ± 0.57.

Values of R·L/T in the genera *Vigna, Cajanus, Clitoria, Glycine* and *Dolichos* were clearly larger than those of other genera, the gap being within 2.11 to 2.40. Values of R·L/T in the genus *Phaseolus* were noted in the following order; *P. calcaratus* > *P. aconitifolius* > *P. mungo* > *P. aureus*.

6. Ratio of width to thickness

Ratio of width to thickness (abbreviated as R·W/T) for the individual grain level ranged from 2.90 (No.31B) to 1.00 (Nos.2 and 3), both of which were the same as in case of R·L/T. In the strain level, the largest (2.19) was obtained in No.31B likewise in case of R·L/T, followed by No.30 (2.06) and No.28 (1.97). The smallest (1.02) were noted in Nos.2 and 15, followed by No.1 (1.03). Mode was found within 1.16 to 1.20. The differences in R·W/T were found to be very large throughout the respective strain. Average and its standard deviations in the whole strains were found to be 1.37 ± 0.33.

Values of R·W/T in the genera *Vigna, Cajanus, Clitoria, Glycine* and *Dolichos* were clearly larger than those of other genera, the gap being within 1.51 to 1.75. Values of R·W/T in the genus *Phaseolus* were noted in the following order; *P. calcaratus* ≑ *P. mungo* > *P. aconitifolius* ≑ *P. aureus*.

PART II. Relations between the respective two characters

1. Length and width

Whole strains: Correlation coefficient of width on length in the whole strains was +0.8520 to the degree of freedom of 32, which was significant at 0.1% level (Table 3). Generally speaking, the longer is the length, the wider is the width. Linear regression of length on width was calculated as follows; Y = 0.594X − 0.112, where Y and X indicate length and width, respectively. This formula indicates that the length becomes 0.594 mm longer, by becoming 1 unit wider the width (0 points, 7.00 mm in length and 5.10 mm in width, respectively).

Strain level: Correlation coefficient and linear regression of width on length in the same strain were calculated and are shown in Table 4. Five, 3, 7 and 19 strains showed significances at 0.1%, 1%, 5% levels and no significance even at 5% level, respectively, and the last of which was clearly large in comparison with those in the latter 4 relations.

Significant correlations in the genera *Cajanus, Clitoria, Glycine* and *Dolichos* were clearly lesser than those in other genera. Those in the genus *Phaseolus* were lesser in *P. aconitifolius* than those in other species.

2. Length and thickness

Whole strains: Correlation coefficient of thickness on length in the whole strains was +0.5924 to the degree of freedom of 32, which was significant at 0.1% level. Generally speaking, the thicker is the thickness, the longer is the length. Linear regression of length on thickness was calculated as follows; Y = 0.599X − 0.630, where Y and X indicate length and thickness, respectively. This formula indicates that the length becomes 0.599 mm longer, by becoming 1 unit thicker the thickness (0 points, 7.00 mm in length and 3.95 mm in thickness, respectively).

Strain level: Correlation coefficient and linear regression of thickness on length in the same strain were calculated and are shown in Table 4. Eight, 5 and 21 strains showed significances at 1%, 5% levels and no significance even at 5% level, respectively, and last of which was clearly large in comparison with those of the latter 4 relations.

Species specificity was not recognized clearly.

3. Width and thickness

Whole strains: Correlation coefficient of thickness on width in the whole strains was +0.7843 to the degree of freedom of 32, which was significant at 0.1% level. Generally speaking, the thicker is the thickness, the wider is the width. Linear regression of width on thickness was calculated as follows; Y = 1.155X − 0.695, where Y and X indicate width and thickness, respectively. This formula indicates that the width becomes 1.155 mm wider, by becoming 1 unit thicker the thickness (0 points, 5.10 mm in width and 3.95 mm in thickness, respectively).

Strain level: Correlation coefficient and linear regression of thickness on width in the same strain were calculated and are shown in Tables 4 and 5. Seventeen, 3, 5 and 9 strains

Table 3. Length of the whole strains measured in relation to their width

Length (mm)	Width (mm) 7.20 ~ 7.01	.	6.60 ~ 6.41	6.40 ~ 6.21	6.20 ~ 6.01	6.00 ~ 5.81	5.80 ~ 5.61	5.60 ~ 5.41	5.40 ~ 5.21	5.20 ~ 5.01	5.00 ~ 4.81	4.80 ~ 4.61	4.60 ~ 4.41	4.40 ~ 4.21	4.20 ~ 4.01	4.00 ~ 3.81	3.80 ~ 3.61	3.60 ~ 3.41	3.40 ~ 3.21	3.20 ~ 3.01	Total
10.00 ~ 9.61	1									1											2
.																					.
8.80 ~ 8.41	1				1																2
8.40 ~ 8.01			1				1	1													3
8.00 ~ 7.61			1																		1
7.60 ~ 7.21					1			1													2
7.20 ~ 6.81											1		1								2
6.80 ~ 6.41													2	2							4
6.40 ~ 6.01															1						1
6.00 ~ 5.61											1			1		1		1			4
5.60 ~ 5.21														2	3		1				6
5.20 ~ 4.81															1	1	1			1	4
4.80 ~ 4.41																1		1			2
4.40 ~ 4.01																		1			1
Total	2	.	2	0	2	0	1	2	0	1	2	0	3	5	5	3	2	3	0	1	34

Figure used in the table shows number of strains. $\gamma = +0.8520^{***}$ (d.f. = 32), significant at 0.1% level.

Table 4. Correlation coefficient and linear regression of the three components; expressed by the values of the latter on the former components

Strain	Length and Width		Length and Thickness		Width and Thickness		O points		
No.	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Length	Width	Thickness
1	0.3388*	Y = 0.426X − 3.518	0.1281	—	0.5116***	Y = 0.559X + 1.854	4.30	3.30	3.25
2	0.4790***	Y = 0.614X − 3.823	0.3894**	Y = 0.497X − 2.662	0.7312***	Y = 0.728X + 1.835	4.95	3.80	3.80
3	0.4080**	Y = 0.426X − 1.233	0.4257**	Y = 0.509X − 1.210	0.5571***	Y = 0.638X + 0.700	4.90	3.70	3.15
4	0.1186	—	0.4472**	Y = 0.424X − 1.913	0.7630***	Y = 0.691X − 0.123	5.40	4.05	3.55
5	0.2880*	Y = 0.330X − 2.640	0.2122	—	0.4858***	Y = 0.439X − 1.694	5.65	4.20	3.75
6	0.1006	—	0.1025	—	0.6418***	Y = 0.677X + 1.710	—	3.85	3.40
7	0.2561	—	−0.0604	—	−0.2184	—	—	—	—
8	0.1690	—	0.1865	—	0.6820***	Y = 0.590X − 1.175	—	3.90	3.25
9	0.3414*	Y = 0.323X − 0.846	0.3873**	Y = 0.231X − 0.652	0.3681**	Y = 0.233X + 0.667	4.65	3.55	3.00
10	−0.1594	—	0.1416	—	0.2941*	Y = 0.496X + 1.446	—	4.20	3.60
11	0.4061**	Y = 0.550X − 0.075	0.2057	—	0.5727***	Y = 0.415X + 1.217	5.73	3.83	2.95
12	0.6048***	Y = 0.974X + 0.924	0.4887**	Y = 0.541X + 1.585	0.7357***	Y = 0.505X + 0.720	5.63	3.43	2.80
13	0.3326*	Y = 0.643X − 0.233	0.1431	—	0.5977***	Y = 0.737X − 0.069	7.10	4.35	3.55
14	0.3242*	Y = 0.395X − 0.541	0.1369	—	0.5850***	Y = 0.489X − 0.305	5.53	3.70	3.30
15	0.1153	—	0.1232	—	0.8340***	Y = 0.910X − 1.731	—	3.10	2.95
16	0.2856*	Y = 0.450X − 0.755	0.4488**	Y = 0.522X − 0.409	0.0991	—	8.23	5.43	4.55
17	0.4855***	Y = 0.625X − 0.800	0.3035*	Y = 0.354X + 0.691	0.6785***	Y = 0.615X + 2.412	9.63	6.83	6.03

Table 4. (Continued)

Strain	Length and Width		Length and Thickness		Width and Thickness		O points		
No.	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Length	Width	Thick-ness
18	0.3579*	Y = 0.519X − 1.987	0.1575	—	0.3461*	Y = 0.282X − 0.123	8.53	5.83	4.65
19	0.1387	—	0.2514	—	0.6742***	Y = 0.743X + 1.242	—	7.03	6.53
20	0.0373	—	0.0967	—	0.3329*	Y = 0.292X + 0.471	—	5.43	4.35
21	0.2262	—	0.3899**	Y = 0.426X − 2.682	0.4294**	Y = 0.251X + 1.994	8.83	5.93	5.10
22	0.5128***	Y = 1.146X − 1.307	0.2506	—	0.2725	—	9.73	5.13	—
23	−0.0995	—	−0.2489	—	0.0857	—	—	—	—
24	0.0447	—	−0.2376	—	−0.6069***	Y = −0.607X − 0.041	—	4.90	2.55
25	0.5243***	Y = 0.886X − 0.994	0.3572*	Y = 0.331X − 2.648	0.7205***	Y = 0.395X − 1.916	7.93	6.53	5.20
26	0.2491	—	0.2831*	Y = 0.380X − 0.871	0.4427**	Y = 0.429X + 0.877	8.05	6.35	4.65
27	−0.1835	—	−0.0985	—	0.6808***	Y = 0.808X + 0.444	—	5.93	4.43
28	0.0004	—	−0.1534	—	−0.0866	—	—	—	—
29	0.1367	—	0.2824*	Y = 0.151X − 0.021	0.3155*	Y = 0.225X − 0.903	5.93	4.53	2.45
30	0.1809	—	−0.1324	—	0.0717	—	—	—	—
31A	0.1463	—	0.4135**	Y = 0.706X + 0.795	−0.1404	—	6.65	—	2.60
31B	0.0497	—	−0.0240	—	−0.2898*	Y = −0.377X − 0.398	—	4.50	2.00
32	0.3895**	Y = 0.429X − 3.161	0.0991	—	0.1697	—	6.83	4.23	—
33	0.1573	—	−0.2845*	Y = −0.296X + 0.454	0.0452	—	6.43	—	2.20

d.f. = 48 in each strain (36 only in No.12). ***, **, *: significant at 0.1%, 1% and 5% levels, respectively.

showed significances at 0.1%, 1%, 5% levels and no significance even at 5% level, respectively. Significant correlations in the genera *Vigna* and *Dolichos* were lesser than those in other genera.

4. Ratio of length to width and ratio of length to thickness

Whole strains: Correlation coefficient of R·L/T on R·L/W in the whole strains was +0.6200 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally speaking, the larger is the R·L/W, the larger is the R·L/T. Linear regression of R·L/W on R·L/T was calculated as follows; $Y = 0.338X - 1.690$, where Y and X indicate R·L/W and R·L/T, respectively. This formula indicates that R·L/W becomes 0.338 larger, by becoming 1 degree larger R·L/T (0 points, 1.53 in R·L/W and 2.26 in R·L/T, respectively).

Strain level: Correlation coefficient and linear regression of R·L/T on R·L/W in the same strain were calculated and are shown in Tables 6 and 7. Twenty three, 2, 2 and 7 strains showed significances at 0.1%, 1%, 5% levels and no significance even at 5% level, respectively. Significant correlations in the genus *Dolichos* were lesser than those in other genera.

5. Ratio of length to width and ratio of width to thickness

Whole strains: Correlation coefficient of R·W/T on R·L/W in the whole strains was +0.3422 to the degree of freedom of 32, which was significant at 5% level. It was noticeable that correlation coefficient in the whole strains was found in positive value, but those in the respective strain were all found in negative values. Generally speaking, the larger is R·L/W, the larger is R·W/T. Linear regression of R·L/W on R·W/T was calculated as follows; $Y = 0.158X - 2.163$, where Y and X indicate R·L/W and R·W/T, respectively. This formula indicates that R·L/W becomes 0.158 larger, by becoming 1 degree larger R·W/T (0 points, 1.53 in R·L/W and 1.58 in R·W/T, respectively).

Strain level: Correlation coefficient and linear regression of R·W/T on R·L/W in the same strain were calculated and are shown in Table 6. Ten, 7, 7 and 10 strains showed significances at 0.1%, 1%, 5% levels and no significance even at 5% level, respectively.

Table 5. Width (mm) of No.15 measured in relation to its thickness (mm)

Width	Thickness (mm)												
(mm)	3.25	3.20	3.15	3.10	3.05	3.00	2.95	2.90	2.85	2.80	2.75	2.70	Total
3.45			1										1
3.40													0
3.35	1	2											3
3.30	2												2
3.25			1	1	1								3
3.20		2	3										5
3.15			8	1	2								11
3.10				6	4		1						11
3.05					1	4							5
3.00						3	1			1			5
2.95							1	1					2
2.90								1					1
2.85													0
2.80												1	1
Total	3	4	13	8	8	7	3	2	0	1	0	1	50

Figure used in the table shows the number of grains.
$r = +0.8340^{***}$ (d.f. = 48), significant at 0.1% level.

Table 6. Correlation coefficient and linear regression of the three components; expressed by the values of the latter on the former components

Strain	L/W and L/T		L/W and W/T		L/T and W/T		O points		
No.	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	L/W	L/T	W/T
1	0.8838***	Y = 0.808X − 0.545	−0.0190	—	0.4021**	Y = 0.506X + 2.774	1.22	1.24	1.07
2	0.7421***	Y = 0.688X − 1.960	−0.2516	—	0.4048**	Y = 0.708X + 2.841	1.26	1.27	1.06
3	0.5366***	Y = 0.630X − 0.525	−0.4958***	Y = −0.568X − 0.091	0.3440*	Y = 0.336X + 1.802	1.29	1.47	1.20
4	0.6445***	Y = 0.523X − 1.029	−0.2476	—	0.5529***	Y = 0.947X + 3.093	1.30	1.46	1.20
5	0.5929***	Y = 0.439X − 0.368	−0.2574	—	0.5090***	Y = 0.747X − 0.640	1.30	1.48	1.16
6	0.6510***	Y = 0.550X − 0.683	−0.3162*	Y = −0.442X − 1.879	0.2343	—	1.30	1.48	1.16
7	0.1262	—	−0.5372***	Y = −0.600X − 0.556	0.6723***	Y = 0.804X − 0.451	1.32	1.64	1.25
8	0.7174***	Y = 0.498X − 1.340	−0.1641	—	0.5565***	Y = 1.000X + 0.020	1.34	1.54	1.18
9	0.2766	—	−0.3082*	Y = −0.180X −0.664	0.8231***	Y = 1.014X + 2.420	1.30	1.56	1.26
10	0.6617***	Y = 0.804X − 3.480	−0.7101***	Y = −1.039X − 4.520	0.0596	—	1.32	1.46	1.20
11	0.6542***	Y = 0.857X − 7.403	−0.3040*	Y = −0.416X − 7.035	0.4181**	Y = 0.436X + 2.235	1.60	1.90	1.38
12	0.6307***	Y = 0.718X − 2.427	−0.2944	—	0.2509	—	1.69	1.93	—
13	0.7920***	Y = 0.588X − 0.226	−0.1396	—	0.4811***	Y = 0.598X + 2.831	1.60	1.92	1.22
14	0.8354***	Y = 0.949X − 1.374	−0.0381	—	0.5319***	Y = 0.471X + 1.572	1.48	1.62	1.12
15	0.9246***	Y = 0.959X + 0.930	−0.3788**	Y = −0.660X − 2.266	−0.1877	—	1.60	1.64	1.05
16	0.4497**	Y = 0.464X + 0.652	−0.6378***	Y = −0.800X + 1.093	0.4198**	Y = 0.511X − 2.717	1.50	1.84	1.18
17	0.6827***	Y = 0.654X − 1.399	−0.0498	—	0.7045***	Y = 0.935X − 0.610	1.42	1.64	1.18

Table 6. (Continued)

Strain	L/W and L/T		L/W and W/T		L/T and W/T		O points		
No.	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	L/W	L/T	W/T
18	0.7525***	Y = 0.847X + 1.671	−0.3866**	Y = −0.499X + 0.918	0.4666***	Y = 0.535X − 2.779	1.44	1.85	1.22
19	0.7843***	Y = 0.746X − 0.967	−0.4199**	Y = −0.381X − 1.371	0.2477	—	1.26	1.36	1.10
20	0.5005***	Y = 0.492X − 1.005	−0.6445***	Y = −0.776X − 1.650	0.3272*	Y = 0.401X − 0.520	1.40	1.72	1.26
21	0.7240***	Y = 0.678X − 2.307	−0.4964***	Y = −0.884X − 1.352	0.0961	—	1.46	1.68	1.16
22	0.4829***	Y = 0.589X − 0.884	−0.2790*	Y = −0.280X − 1.707	0.7194***	Y = 0.592X + 0.077	1.90	1.78	1.50
23	0.3410*	Y = 0.386X + 0.680	−0.4957***	Y = −0.403X − 2.441	0.6358***	Y = 0.457X + 1.526	1.20	1.46	1.32
24	0.1503	—	−0.4213**	Y = −0.439X − 0.013	0.8801***	Y = 1.124X − 0.105	1.42	2.73	1.93
25	0.8406***	Y = 0.605X − 1.095	−0.0430	—	0.4928***	Y = 0.558X − 4.454	1.28	1.54	1.20
26	0.5634***	Y = 0.593X − 0.758	−0.2865*	Y = −0.498X − 0.940	0.6445***	Y = 0.911X + 0.195	1.26	1.72	1.38
27	0.8182***	Y = 0.953X − 0.825	−0.3830**	Y = −0.602X − 1.743	0.1660	—	1.28	1.69	1.32
28	0.2069	—	−0.4449**	Y = −0.562X − 1.179	0.7444***	Y = 0.973X + 2.686	1.52	2.88	2.03
29	0.5627***	Y = 0.664X + 1.627	−0.3498*	Y = −0.374X + 0.337	0.5720***	Y = 0.519X − 2.052	1.34	2.58	1.85
30	0.2995*	Y = 0.403X + 0.393	−0.5020***	Y = −0.437X − 1.374	0.6570***	Y = 0.425X − 0.381	1.42	2.96	2.13
31A	−0.0122	—	−0.7784***	Y = −1.346X + 0.170	0.6154***	Y = 0.784X − 0.520	1.54	2.61	1.68
31B	0.0491	—	−0.5540***	Y = −0.548X − 1.993	0.8106***	Y = 0.700X + 0.544	1.50	3.27	2.28
32	0.2693	—	−0.3652**	Y = −0.416X − 2.876	0.6547***	Y = 0.885X − 2.232	1.59	2.78	1.78
33	0.3864**	Y = 0.501X + 0.810	−0.3517*	Y = −0.368X + 0.739	0.7249***	Y = 0.568X + 0.651	1.49	2.86	1.93

d.f. = 48 in each strain (36 only in No. 12). ***, **, *: significant at 0.1%, 1% and 5% levels, respectively.

Table 7. Ratio of length to width of No. 15 fixed in relation to its ratio of length to thickness

Ratio of length to width	Ratio of length to thickness 1.84 ~ 1.83	1.82 ~ 1.81	1.80 ~ 1.79	1.78 ~ 1.77	1.76 ~ 1.75	1.74 ~ 1.73	1.72 ~ 1.71	1.70 ~ 1.69	1.68 ~ 1.67	1.66 ~ 1.65	1.64 ~ 1.63	1.62 ~ 1.61	1.60 ~ 1.59	1.58 ~ 1.57	1.56 ~ 1.55	1.54 ~ 1.53	1.52 ~ 1.51	1.50 ~ 1.49	1.48 ~ 1.47	1.46 ~ 1.45	Total
1.78 ~ 1.77			1	1																	2
1.76 ~ 1.75																					0
1.74 ~ 1.73						2															2
1.72 ~ 1.71	1				1		1														3
1.70 ~ 1.69																					0
1.68 ~ 1.67																					0
1.66 ~ 1.65							1			1											2
1.64 ~ 1.63									2	1	1										4
1.62 ~ 1.61								1			1	3									5
1.60 ~ 1.59										1		2	4								7
1.58 ~ 1.57								1				1	1	4							7
1.56 ~ 1.55												1	4	1	2						8
1.54 ~ 1.53												1									1
1.52 ~ 1.51														1	1	1	1				4
1.50 ~ 1.49																					0
1.48 ~ 1.47																			1		1
1.46 ~ 1.45																				1	1
1.44 ~ 1.43																		2			2
1.42 ~ 1.41															1						1
Total	1	0	1	1	1	2	2	2	2	3	2	8	9	6	4	1	1	2	1	1	50

Figure used in the table shows the number of grains. $\gamma = +0.9246^{***}$ (d.f. = 48), significant at 0.1% level.

Significant correlations in the genus *Dolichos* were clearly more abundant than those in other genera. On the other hand, significant correlations in the genus *Phaseolus*, especially in *P. aureus*, were clearly lesser than those in other species. This findings were clearly different from 4 relationships mentioned above.

6. Ratio of length to thickness and ratio of width to thickness

Whole strains: Correlation coefficient of R·W/T on R·L/T in the whole strains was +0.9438 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally speaking, the larger is the R·L/T, the larger is R·W/T. Linear regression of R·L/T on R·W/T was calculated as follows; $Y = 0.800\ X - 0.011$, where Y and X indicate R·L/T and R·W/T, respectively. This formula indicates that R·L/T becomes 0.800 larger, by becoming 1 degree larger R·W/T (0 points, 2.26 in R·L/T and 1.58 in R·W/T, respectively).

Strain level: Correlation coefficient and linear regression of R·W/T on R·L/T in the same strain were calculated and are shown in Table 6. Twenty one, 4, 2 and 7 strains showed significances at 0.1%, 1%, 5% levels and no significance even at 5% level. Significant correlations in the genus *Dolichos* were clearly more abundant than those in other genera.

PART III. Standard deviations

1. Practical values

In Table 2, the standard deviations, *i.e.*, intra-strain's variations, are given. Standard deviations (abbreviated as S. D.) of length ranged from 0.55 to 0.15. The average and its standard deviations in the whole strains were found to be 0.31 ± 0.11. Species specificity of S. D. was not recognized clearly. S. D. of width ranged from 0.41 to 0.12. Mode was found within 0.22 to 0.24. The average and its standard deviations in the whole strains were found to be 0.24 ± 0.07. Species specificity of S. D. was not recognized clearly, either. S. D. of thickness ranged from 0.42 to 0.11. Mode was found within 0.16 to 0.18. The average and its standard deviations in the whole strains were found to be 0.20 ± 0.06. Species specificity was not recognized clearly, either.

S. D. of R·L/W ranged from 0.15 to 0.05. Mode was found as 0.07. The average and its standard deviations in the whole strains were found to be 0.09 ± 0.03. Species specificity of S. D. was not recognized clearly, either. S. D. of R·L/T ranged from 0.37 to 0.05. Mode was found within 0.07 to 0.08. The average and its standard deviations in the whole strains were found to be 0.15 ± 0.09. S. D. of R·L/T found in the genus *Dolichos* were clearly larger than those in other genera. This finding was clearly different from the 4 characters mentioned above. S. D. of R·W/T ranged from 0.30 to 0.02. Mode was found within 0.05 to 0.06. The average and its standard deviations in the whole strains were found to be 0.10 ± 0.07. S. D. of R·W/T found in the genus *Dolichos* were clearly larger than those in other genera likewise in case of S. D. of R·L/T.

2. Relations between the standard deviations on the respective two characters

Correlation coefficient of S. D. of length on width in the whole strains was +0.6167 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally speaking, the larger is the S. D. of length, the larger is the S. D. of width. Linear regression of S. D. of length on width was calculated as follows; $Y = 1.004X - 0.437$, where Y and X indicate the S. D. of length and width, respectively. This formula indicates that the S. D. of length becomes 1.004 larger, by becoming 1 degree larger the S. D. of width (0 points, 0.33 in S. D. of length and 0.26 in S. D. of width, respectively).

Correlation coefficient of S. D. of length on thickness in the whole strains was +0.4059 to the degree of freedom of 32, which was significant at 5% level. Generally speaking, the larger is the S. D. of length, the larger is the S. D. of thickness. Linear regression of the S. D. of length on thickness was calculated as follows; $Y = 0.772X + 0.389$, where Y and X indicate the S. D. of length and thickness, respectively. This formula indicates that the S. D. of length becomes 0.772 larger, by becoming 1 degree larger the S. D. of thickness (0 points, 0.33 in S. D. of length and 0.23 in S. D. of thickness, respectively).

Correlation coefficient of S. D. of width on thickness in the whole strains was +0.5861 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally speaking, the larger is the S. D. of width, the larger is the S. D. of thickness. Linear regression of the S. D. of width on thickness was calculated as follows; $Y = 0.685X + 0.598$, where Y and X indicate the S. D. of width and thickness, respectively. This formula indicates that the S. D. of width becomes 0.685 larger, by becoming 1 degree larger the S. D. of thickness (0 points, 0.26 in S. D. of width and 0.23 in S. D. of thickness, respectively).

Correlation coefficient of S. D. of R·L/W on R·L/T in the same strains was +0.7669 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally speaking, the larger is the S. D. of R·L/W, the larger is the S. D. of R·L/T. Linear regression of the S. D. of R·L/W on R·L/T was calculated as follows; $Y = 0.429X - 0.167$, where Y and X indicate the S. D. of R·L/W and R·L/T, respectively. This formula indicates that the S. D. of R·L/W becomes 0.429 larger, by becoming 1 degree larger the S. D. of R·L/T (0 points, 0.10 in S. D. of R·L/W and 0.22 in S. D. of R·L/T, respectively).

Correlation coefficient of S. D. of R·L/W on R·W/T in the whole strains was +0.6341 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally

Table 8. Standard deviations of ratio of length to thickness found in the whole strains in relation to standard deviations of their ratio of width to thickness

Standard deviations of L/T	Standard deviations of W/T												
	0.30 ~ 0.29	0.28 ~ 0.27	0.26 ~ 0.25	0.24 ~ 0.23	·	0.14 ~ 0.13	0.12 ~ 0.11	0.10 ~ 0.09	0.08 ~ 0.07	0.06 ~ 0.05	0.04 ~ 0.03	0.02 ~ 0.01	Total
0.37 ~ 0.36	1			1									2
0.35 ~ 0.34		1											1
0.33 ~ 0.32													0
0.31 ~ 0.30			1	1									2
·													·
0.25 ~ 0.24						1							1
0.23 ~ 0.22													0
0.21 ~ 0.20						1			1				2
0.19 ~ 0.18						1							1
0.17 ~ 0.16									2				2
0.15 ~ 0.14							1			1			2
0.13 ~ 0.12								1		2			3
0.11 ~ 0.10								1	1	3	1		6
0.09 ~ 0.08									1	5	2	1	9
0.07 ~ 0.06										1	1		2
0.05 ~ 0.04											1		1
Total	1	1	1	2	·	3	1	2	5	12	5	1	34

Figure used in the table shows the number of strains.
$\gamma = +0.9590^{***}$ (d.f. = 32), significant at 0.1% level.

speaking, the larger is the S. D. of R·L/W, the larger is the S. D. of R·W/T. Linear regression of the S. D. of R·L/W on R·W/T was calculated as follows; Y = 0.428X − 0.069, where Y and X indicate the S. D. of R·L/W and R·W/T, respectively. This formula indicates that the S. D. of R·L/W becomes 0.428 larger, by becoming 1 degree larger the S. D. of R·W/T (0 points, 0.10 in S. D. of R·L/W and 0.16 in S. D. of R·W/T, respectively).

Correlation coefficient of S. D. of R·L/T on R·W/T in the whole strains was +0.9590 to the degree of freedom of 32, which was obviously significant at 0.1% level (Table 8). Generally speaking, the larger is the S. D. of R·L/T, the larger is the S. D. of R·W/T. Linear regression of the S. D. of R·L/T on R·W/T was calculated as follows; Y = 1.136X+0.643, where Y and X indicate the S. D. of R·L/T and R·W/T, respectively. This formula indicates that the S. D. of R·L/T becomes 1.136 larger, by becoming 1 degree larger the S. D. of R·W/T (0 points, 0.22 in S. D. of R·L/T and 0.16 in S. D. of R·W/T, respectively).

3. Relations between the practical values and its standard deviations

Correlation coefficient of practical value on its S. D. among lengths in the whole strains was +0.7273 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally speaking, the longer is the practical value of length, the larger is the S. D. of length. Linear regression of practical value on the S. D. was calculated as follows; Y = 1.227X − 0.847, where Y and X indicate practical value and its S. D., respectively. This formula indicates that the practical value becomes 1.227 mm longer, by becoming 1 degree larger the S. D. (0 points, 7.00 mm in the practical value and 0.33 in S. D., respectively).

Correlation coefficient of practical value on its S. D. among widths in the whole strains was +0.4208 to the degree of freedom of 32, which was significant at 5% level. Generally speaking, the wider is the practical value of width, the larger is the S. D. of width. Linear regression of practical value on the S. D. was calculated as follows; Y = 0.929X − 1.405, where Y and X indicate practical value and the S. D., respectively. This formula indicates that the practical value becomes 0.929 mm wider, by becoming 1 degree larger the S. D. (0 points, 5.10 mm in the practical value and 0.26 in S. D., respectively).

Correlation coefficient of practical value on its S. D. among thicknesses in the whole strains was +0.4747 to the degree of freedom of 32, which was significant at 1% level. Generally speaking, the thicker is the practical value of thickness, the larger is the S. D. of thickness. Linear regression of practical value on the S. D. was calculated as follows; Y = 0.937X − 0.214, where Y and X indicate practical value and the S. D., respectively. This formula indicates that the practical value becomes 0.937 mm thicker, by becoming 1 degree larger the S. D. (0 points, 3.95 mm in the practical value and 0.23 in S. D., respectively).

Correlation coefficient of practical value on its S. D. among R·L/W in the whole strains was +0.4420 to the degree of freedom of 32, which was significant at 1% level. Generally speaking, the larger is the practical value of R·L/W, the larger is the S. D. of R·L/W. Linear regression of practical value on the S. D. was calculated as follows; Y = 0.543X − 2.089, where Y and X indicate practical value and the S. D., respectively. This formula indicates that the practical value becomes 0.543 larger, by becoming 1 degree larger the S. D. (0 points, 1.53 in the practical value and 0.10 in S. D., respectively).

Correlation coefficient of practical value on its S. D. among R·L/T in the whole strains was + 0.8918 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally speaking, the larger is the practical value of R·L/T, the larger is the S. D. of

R·L/T. Linear regression of practical value on the S. D. was caluclated as follows; Y = 1.104X + 0.302, where Y and X indicate practical value and the S. D., respectively. This formula indicates that the practical value becomes 1.104 larger, by becoming 1 degree larger the S. D. (0 points, 2.26 in the practical value and 0.22 in S. D., respectively).

Correlation coefficient of practical value on its S. D. among R·W/T in the whole strains was +0.9197 to the degree of freedom of 32, which was obviously significant at 0.1% level. Generally speaking, the larger is the practical value of R·W/T, the larger is the S. D. of R·W/T. Linear regression of practical value on the S. D. was calculated as follows; Y = 1.649X + 0.770, where Y and X indicate practical value and the S. D., respectively. This formula indicates that the practical value becomes 1.649 larger, by becoming 1 degree larger the S. D. (0 points, 1.58 in the practical value and 0.16 in S. D., respectively).

Discussion

1. Annual legumes did not appear as significant components of the vegetation of Asia before the Neothermal, some 11,000 years B. P. Neolithic revolution depended on a climate-induced physiological change in plants leading to the evolution of the primitive grain legumes, with man showing a slow, step by step evolution parallel with the other components of his ecosystem[8]. If one applies the climatic concept of operative factors in isoxerothermic zones to the problem of the origin of the grain legumes, there is nothing particularly remarkable in the finding of material of these crops in archeological sites dated at or shortly after the first reports of cereal grain[10]. India together with the central Asiatic center has been believed to be the home of some species of grain legumes. Hitherto the oldest records of both *Phaseolus mungo* and *P. aureus* are from the Chalcolithic site, Navdatoli-Maheshwar dated to 1,660–1,440 B. C.[7].

2. The total benifits from growing legumes are frequently ignored in commercial cropping systems, but the positive aspects of growing tropical legumes have been emphasized for some problems such as collection germplasm, for example, as drought or insect resistances[6]. So, grain legumes are naturally to be put into consideration in the scheme of agricultural improvement. In view of agricultural status, grain legumes have been widely cultivated in the whole land of India[1]. On the other hand, grain legumes as materials of bean sprouts are very important in Japan. Basing on the data obtained by Maeda[5], the following 10 strains may be looked upon as promising legumes in view of soil improvement, food and/or fodder crops, *i.e.*, *P. aureus* (Nos.1 and 2), *P. mungo* (Nos. 3, 4, 5, 6 and 10), *P. calcaratus* (No.13), *C. cajan* (No.23) and *D. biflorus* (No.32). Moreover, it was recognized that the relatively large grains in soybean showed generally late growing habit and high-yielding ability[9]. Hitherto no full studies have been performed on these problems, which were left uninvestigated, and could not be solved only by an uncomplicated experiment.

3. It is to be expected that if the practical values and ranging variations are to be found in the respective morphological character, together with the ascertainment of the natural dispersals of the respective species, it might naturally throw a light on the species differentiation or historical prospect of grain legumes. Through the whole characters, it was noted that the number of strains showing values smaller than the respective average value was clearly more abundant than those showing values larger than the average value.

4. In view of the standard deviations, *i.e.*, intra-strain's variations, the following facts were ascertained. In the whole characters, it was ascertained that number of strains show-

ing values smaller than the respective average value were clearly more abundant than those showing values larger than the average value. In general aspect, the smaller is the variation, the longer is the history of cultivation. Intra-strain's variations of grains in the most species and strains, in view of the morphological characters, have been looked upon as relatively small (Table 2). So, it may be concluded that they have a long history from introduced or migrated times here, and fit well to the natural conditions and/or agricultural practices in the respective areas. Moreover, it was ascertained, as characteristics of standard deviations, that the values were noted in the following order; length > width > thickness and R·L/T > R·W/T > R·L/W. It may be concluded that the thickness and R·L/W were almost stable characteristics through the whole characters measured and they could not be affected by any environmental conditions. These findings propose a quite interesting problem concerning the strain or variety-differentiations.

5. Yoshitomi studied the correlations among several characters of *Glycine max* and *G. soya* and found the significant correlations in almost all the characters[9]. In the present study, correlation coefficients among the respective two characters in the whole strains, including 7 genera, were calculated and found expectedly as positive significant through all cases. Nearly the same fact was ascertained in the strain level. Generally speaking, the larger is the practical value in one character, the larger is the practical value in another character (Tables 3 to 7). It may be concluded that the six components, *i.e.*, length, width, thickness, R·L/W, R·L/T and R·W/T, are fundamentally exhibited independently of the other components. In other words, it means that the whole components mentioned above are relatively of stable characters. These findings were clearly different from the data obtained in *Vigna* sp. collected in the Republic of Nauru[4].

Correlation coefficient between R·L/W and R·W/T in the whole strains was found to be positively significant at 5% level. It in view of strain level were almost decided as negatively significant (Table 6). Those in *Vigna* sp.[4], unhusked and husked grains of Sikkimese rice strains[2,3] were shown all as negative relations. These discrepancies may be partly due to the fact that in the present experiment mixed samples were used, seen in view of the genus of species. This problem may be clarified by the detailed experiment using as many materials.

6. Correlation coefficients of intra-strain's variations of the respective two characters were also expectedly decided to be positively significant through all cases (=6). Generally speaking, the larger is the variation in one character, the larger is the variation in another character. It may be affirmed that through almost all cases, negligible variations were shown by the strains considered to be stable, and considerable variations by those considered to be unstable. This findings were nearly the same as in the data obtained in *Vigna* sp. collected in the Republic of Nauru[4].

7. Relations among the practical values of six characters were measured, and the respective intra-strain's variations were also calculated, and significances were shown in the whole cases. Generally speaking, the larger is the practical value in one character, the larger is the standard deviations in its character. In the conclusion, it was ascertained that the whole characters measured here were of approximately stable characters. This is to say that no environmental condition was capable of affecting them.

8. Six relationships among the respective characters were analyzed by the author, basing on the correlation coefficient and linear regression calculated. One, 9, 10, 12 and 2 strains showed significant correlations in 6, 5, 4, 3 and 2 relations between the two characters, respectively. It may be an exceptional phenomenon that No.3, *P. mungo*, showed significant correlations through the whole cases.

Summary

During the trip made from October in 1971 to January in 1972 in the Indian Sub-Continent, 106 strains of legumes were collected. Thirty four strains, belonging to 10 species and to 7 genera, were picked up and some morphological characters and ecotypic differentiations of these materials were reported here. The results obtained were summarized as follows:

Length, width and thickness of grains were found to be 6.46 mm, 4.68 mm and 3.59 mm in average values, respectively. Correlation coefficients between length and width, length and thickness, and width and thickness, were +0.8520, +0.5924 and +0.7843, respectively. All of them showed significances at 0.1% level. Ratios of length to width (R·L/W), of length to thickness (R·L/T), and of width to thickness (R·W/T) were found to be 1.39, 1.92 and 1.37 in average values, respectively. Correlation coefficients of R·L/W on R·L/T, of R·L/W on R·W/T, and of R·L/T on R·W/T, were +0.6200, +0.3422 and +0.9438, respectively. All of them showed significances at 0.1%, 5% and 0.1%, levels, respectively.

Correlation coefficients among intra-strain's variations in the respective character were +0.6167, +0.4059, +0.5861, +0.7669, +0.6341 and +0.9590 in the same order mentioned above, respectively. These values showed significances among them at 0.1%, 5%, 0.1%, 0.1%, 0.1% and 0.1% levels, respectively. Correlation coefficients among the practical values and its intra-strain's variations were +0.7273, +0.4208, +0.4747, +0.4420, +0.8918 and +0.9197 in the same order, respectively. These values showed significances among them at 0.1%, 5%, 1%, 1%, 0.1% and 0.1% levels, respectively.

Species' specific and ecotypic differentiations were extensively discussed in view of values found in six characters and mutual relations. It may be noticeable that the thickness and ratio of length to width were almost stable characteristics in the whole characters measured and they could not be affected by any environmental conditions.

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