

## Variability of Agronomic Characters in Soybean (*Glycine max* (L.) Merrill) at Coimbatore, S. India

by

RAM NATH KAW<sup>1</sup> and P. MADHAVA MENON<sup>2</sup>

**Introduction :** Given the suitable variety and the required cultural conditions, soybean with its 42% of high quality protein and 21% of oil, has a high potential in India. A survey of the variability existing in the material is of primary importance, on which depends the correct choice of a suitable variety for growing in a particular tract having a particular set of environmental conditions. The greater the genetic diversity, the wider is the scope for improvement.

Very little data on the genetic variability of different agronomic characters in soybean have so far been reported in India. The present investigation was undertaken to collect information on the range of variability in 37 varieties of soybean with accredited performance elsewhere to test their suitability for direct introduction and for future hybridization programmes. Because of their high sensitivity to conditions of light and temperature, the need for well adapted soybean varieties with the highest yield potential for a particular latitudinal range hardly needs any emphasis. In addition, the sensitivity of varieties to alkaline soil and irrigation water with high soluble salt content is an important feature requiring attention in this region.

**Materials and Methods :** The data reported herein were collected from two sets of field plantings of 37 varieties from U.S.A. (22), Australia (7), Thailand (3), India (2), S. Africa (1), Nigeria (1) and China (1). The experiment was laid out in the Central Farm, Agricultural College and Research Institute, Coimbatore (11°N) during 1969-70 in a split-plot design with two replications. The main plots constituted the two sowing dates (December 20, 1969 and January 20, 1970) and each sub-plot consisted of single rows of each variety 5 meters long and spaced 60 cm apart, with plants in the row being spaced 20 cm apart. A basic dressing of N<sub>20</sub>, P<sub>2</sub>O<sub>5</sub> 80 and K<sub>2</sub>O 60 kgs/hectare of fertilizers was applied. The soil pH value was 8.4 with a high soluble salt content of irrigation water (E. C. 4.2).

Data were collected on individual plant basis on 10 randomly selected plants per replication on : (1) Number of days to first flowering, (2) Number

---

1. Senior Research Fellow and 2. Professor of Genetics, Division of Genetics, Agricultural College and Research Institute, Coimbatore.

of days to 50% flowering, (3) Maturity - number of days taken from the day of seeding to the maturity of the plant for harvest, (4) Number of nodes per plant, (5) Number of pods per plant, (6) Number of beans per plant, (7) Height and (8) Bean yield per plant.

**Results:** The varietal differences exhibited by the various types under study for all the characters were highly significant (Table 1). Highly significant differences were also recorded by sowing dates and varieties interaction for the four characters, days to first flowering, days to 50% flowering, maturity and nodes per plant, whereas the interaction in the remaining four characters were not-significant. Even though a markedly greater 'F' value was obtained for sowing dates for the various characters under study, the significance of difference turned out to be not-significant for want of sufficient degrees of freedom for the error (a) component, except for the character maturity which was, however, significant at 5% level.

The varieties were broadly classified into various groups on the basis of general mean with its 95% confidence limits for the various characters under study. The summary of the results are presented in Table 2.

1. *Number of days to first flowering:* A range of 27.8 to 56.5 days was observed for this character. Of the 37 varieties tested, 25 varieties including 20 from U.S.A., one from India, and four from Australia took the lowest mean number of days for first flowering to be classified as very early (below 33 days) under Coimbatore (11°N) conditions. Eight varieties, viz., EC 39821 and EC 39822 (Thailand), EC 27500 (Geduld, S. Africa), Improved Pelican and Hill (U.S.A.), EC 14450 (Hernon 116) and Mamloxi (Australia) and PLSO-15 (India) were classified as early (33.1-40.0 days). The varieties EC 7034 (CNS, Australia) and EC 9824 (Thailand) which took 43.5 and 45.3 days for first flowering, respectively, were grouped as medium (40.1-47.0 days), Easy-Cook (51.0 days) as medium late (47.1-54.0) and EC 39800 (Dumfied, Nigeria) as late-(54.1-61.0 days).

A significant interaction of sowing dates and varieties was revealed in respect of this character. The varieties EC 7034, Improved Pelican and Petersen 90 Brand (U.S.A.) and EC 39822 and EC 39821 (Thailand) have taken significantly lesser number of days for first flowering under the second sowing.

2. *Number of days to 50% flowering:* The variation in this character ranged from 29.5 to 59.7 days. The twenty-five varieties which were 'very early' for first flowering could be grouped as very early for 50% blooming also, taking less than 37 days in respect of this characteristic. Eight varieties, viz., EC 27500, EC 39821, EC 39822, Hill, Improved Pelican, EC 14450, PLSO-15 and Mamloxi were grouped under the early category (37.1-44.0 days) and

TABLE I. Analysis of variance for eight agronomic characters

Source of variation	Days to first flowering		Days to 50% flowering		Maturity		Nodes per plant		Pods per plant		Beans per plant		Height (cm)		Bean yield per plant (gm)	
	D.F.	M.S.	F	M.S.	F	M.S.	F	M.S.	F	M.S.	F	M.S.	F	M.S.	F	
Blocks	1	1.44		0.26		0.01		3.27		1709.53		9040.2		60.44		81.12
Sowing dates	1	40.04	19.53	25.06	15.0	349.7	874.2	25.14	12.02	5952.51	59.98	32604.6	48.05	535.87	11.99	424.43
Error (a)	1	2.05		1.67		0.4		2.09		99.24		678.6		44.66		18.76
Varieties	36	170.13	425.32	212.62	536.91	324.1	162.8	43.98	89.75	957.35	13.55	3922.3	13.97	425.79	57.13	18.98
Sowing dates X Varieties	36	0.99	2.47	1.38	3.48	138.3	69.5	1.26	2.57	75.71	1.07	366.83	1.31	9.73	1.30	1.93
Error (b)	72	0.42		0.395		1.99		0.49		70.64		280.72		7.45		1.81
Total			147													

• Significant at 5 per cent level      •• Significant at 1 per cent level

TABLE 2. *The summary of performance of 31 Soybean varieties*

Variety	Bean yield per plant (gm)	Beans per plant	Pods per plant	Days to first flowering	Days to 50% flowering	Plant maturity (days)	Height (cm)	Nodes per plant
EC 7034 (CNS)	10.70	159.9	78.1	43.5	49.0	92.7	45.6	17.4
EC 39822	9.61	105.0	53.8	34.3	37.3	85.6	34.7	14.5
EC 39824	7.46	113.4	56.8	45.3	49.0	91.3	40.0	16.2
EC 39821	7.24	75.4	40.8	33.8	37.3	84.2	32.9	13.2
EC 14475 (Sangalo)	5.83	76.8	33.0	32.5	34.8	80.5	34.0	13.7
EC 27500 (Geduld)	5.82	53.9	24.5	34.5	37.0	87.8	26.8	13.7
Lee	5.81	48.5	22.4	28.0	29.5	73.4	16.8	6.8
EC 39800 (Dumfied)	5.68	99.1	51.5	56.5	59.7	105.4	46.9	17.4
Davis	5.47	54.0	25.4	32.8	35.3	81.7	19.6	9.0
Wills	5.15	54.7	22.9	29.5	31.5	73.2	17.2	7.4
Hernon 49	4.87	56.8	29.8	32.0	36.3	83.6	49.6	15.8
Hill	4.68	51.3	23.4	35.5	37.5	78.0	19.7	8.7
Improved Pelican	4.62	56.9	29.4	34.8	38.0	85.6	33.6	12.6
Hampton-266	3.70	28.4	15.2	29.0	31.3	81.5	16.1	7.2
EC 14450 (Hernon 116)	3.53	34.6	18.1	35.3	38.3	83.2	20.2	9.5
Pickett	3.47	32.0	15.8	28.8	30.5	74.8	41.1	6.9
Mamloxi	3.38	62.8	30.5	37.8	40.0	87.6	20.7	9.8
Easy-Cook	3.23	50.0	23.5	51.0	58.3	126.7	46.3	16.3
Semmes	3.26	38.6	16.8	28.0	31.5	72.4	17.0	7.5
Hardee	3.24	38.3	20.0	32.5	35.8	79.9	17.1	8.6
D 60.9647	3.19	31.8	15.6	27.8	29.8	77.9	15.6	8.0
Punjab-1	3.15	28.8	15.2	29.0	31.3	72.6	15.1	7.1
Norchief	3.11	29.0	13.8	30.0	33.5	77.5	12.6	6.9
Masterpiece	3.02	26.7	14.8	28.3	31.0	78.7	17.9	8.9
Monetta	3.02	35.6	17.6	30.5	33.5	73.3	33.6	12.0
Darc	2.66	31.7	13.3	31.3	33.3	73.9	18.5	8.5
K.74	2.46	38.0	17.6	32.0	33.3	82.5	14.7	7.9
PLSO-15	2.45	29.6	17.2	36.0	39.0	87.4	24.5	12.4
Disoy	2.40	15.7	9.2	28.5	32.3	72.8	23.0	8.6
Clark-63	2.20	23.5	10.2	28.3	29.8	75.1	22.9	9.7
Bragg	2.19	25.2	11.5	29.0	31.3	72.2	22.5	7.9
Rampage	2.07	22.3	11.6	28.5	30.0	72.3	21.8	9.3
Peterson 90 Brand	1.90	21.6	12.6	27.8	29.5	70.8	22.1	8.9
Hood	1.89	23.4	11.1	31.8	33.5	81.6	19.3	7.8
Magna	1.50	11.1	8.5	28.5	31.8	84.5	18.4	8.1
Chippewa	1.47	18.5	7.9	30.1	33.0	74.7	18.6	8.0
Jackson	1.42	16.4	10.1	28.0	29.8	70.3	20.1	7.2
General mean	3.97	46.4	23.0	33.0	35.8	81.3	24.6	10.2
Varieties { S.E.	± 0.67	± 8.37	± 4.20	± 0.316	± 0.314	± 0.70	± 1.36	± 0.35
{ C.D. @ 5%	1.89	23.59	11.40	0.89	0.88	1.97	3.85	0.99
Varieties × Sowing dates { S.E.	—	—	—	± 0.66	± 0.655	± 1.39	—	± 0.73
{ C.D. @ 5%	—	—	—	2.19	2.04	2.85	—	2.28

EC 7034 and EC 39824 under medium category (44.1–51.0 days). While none could be classified as medium late (51.1–58.0 days) for 50% flower production, Easy-Cook (58.3 days) and EC 39800 (59.7 days) were classified as late types. A significant earliness in 50% flower production was exhibited by the varieties EC 39821, EC 7034, Improved Pelican, EC 39822 and Davis (U.S.A.) under the late sowing.

3. *Maturity* : The earliest maturing variety Jackson (70.3 days) was statistically equalled by Peterson 90 Brand (70.8 days), Bragg (72.2 days) and Rampage (72.3 days) all from U.S.A. The other varieties also classified as very early maturing types (72.4–80.3 days) in the present study include 13 from U.S.A., Punjab-1 from India and Wills from Australia. Whereas no variety could be classified as medium late (96.4–104.3 days), the varieties Easy-Cook and EC 39800 took 126.7 and 105.4 days, respectively, to mature and were classed as late types (above 104.3 days). The varieties which could be considered as conforming to early (80.4 to 88.3 days) and medium (88.4–96.3 days) groups suitable for Coimbatore conditions included EC 14475 (Australia), Hampton-266, Hood, Davis (U.S.A.), K. 74, EC 14450, Hernon 49 (Australia), EC 39821 (Thailand), Magna, Improved Pelican (U.S.A.), EC 39822 (Thailand), PLSO-15 (India), Mamloxi (Australia) and EC 27500 (S. Africa) in their ascending order of maturity in the former and two EC 39824 (Thailand) and EC 7034 (Australia) in the latter group.

The different varieties have taken significantly more number of days for maturity under the earlier sowing. With a delay of 31 days in sowing, a mean early maturity of approximately three days was recorded. A highly significant interaction of sowing dates and varieties was exhibited by the analysis of variance for this character. The varieties EC 39824, Mamloxi, PLSO-15, EC 7034, EC 39822, K.74, Hernon 49, Wills, Semmes, Bragg, Magna, EC 14450, Pickett, Hardee, Dare, Peterson 90 Brand, and Jackson have, however, behaved more or less similarly under both the sowing dates.

4. *Number of nodes per plant* : The number of nodes per plant varied from 6.8 to 17.4 with varieties EC 39800 and EC 7034 having the highest number (17.4), closely followed by Easy-Cook (16.3), EC 39824 (16.2) and Hernon 49 (15.8). Seven varieties produced medium number of nodes per plant, seven others had low number of nodes and eighteen varieties exhibited very low number of nodes. Except for Punjab-1 and Wills, all the remaining sixteen varieties producing very low number of nodes were from U.S.A. Varieties Jackson, EC 14450, Hernon 49, EC 27500, Improved Pelican, EC 39822, and PLSO-15 had lesser number, while all the remaining thirty varieties produced greater number of nodes per plant in the first sowing than in the second sowing, though deviation was significant only in EC 39800 and Mamloxi.

5. *Number of pods per plant* : The mean number of pods per plant varied from 7.9 to 78.1 with the variety EC 7034 producing the highest number of pods. Among the other four varieties that exceeded the upper confidence limit of the general mean, varieties EC 39824 with 56.8 pods, EC 39822 with 53.8 pods, and EC 39800 with 51.5 pods per plant were statistically at par and differed significantly from the variety EC 39821 producing 40.8 pods per plant. Fourteen varieties were classified as having medium number (17.3-40.1) of pods per plant, whereas eighteen varieties, viz., PLSO-15 (India), Semmes, Pickett, D60.9647 (U.S.A.), Punjab-1 (India), Hampton-266, Masterpiece, Norchief, Dare, Peterson 90 Brand, Rampage, Bragg, Hood, Clark-63, Jackson, Disoy, Magna and Chippewa (U.S.A.) in the descending order, were low bearers (5.8-17.2 pods per plant). There was no significant interaction between varieties and sowing dates as pointed out earlier.

6. *Number of beans per plant* : A very wide range in values from 11.1 to 159.9 was observed with respect to this character and the variety EC 7034 exhibited the highest bean number (159.9) per plant, followed by EC 39824 (113.4), EC 39822 (105.0) and EC 39800 (99.1) in the very high group. Three varieties EC 14475 (76.8), EC 39821 (75.4) and Mamloxi (62.8) were found to be having a high (58.5-82.1) bean number per plant. Twelve varieties which were statistically at par constituted the medium class (34.8-58.4) and the remaining eighteen varieties also at par, had a low (11.1-34.7) bean number per plant. Except for EC 14450 (Australia), PLSO-15 and Punjab-1 (India) all the low bearers were of U.S.A. origin.

7. *Height* : The plant height varied from 12.6 cm to 49.6 cm, variety Hernon 49 from Australia being the tallest, closely followed by EC 39800 (46.9 cm), Easy-Cook (46.3 cm) and EC 7034 (45.6 cm). Seven varieties, viz. EC 39824 (40.0 cm), EC 39822 (34.7 cm), EC 14475 (34.0 cm), Monetta (33.6 cm), Improved Pelican (33.6 cm), EC 39821 (32.9 cm) and EC 27500 (26.8 cm) could be classified as medium tall (26.6-42.0 cm). Twenty-six varieties were classified as short (11.1-26.5 cm) under Coimbatore conditions with variety Norchief (12.6 cm) from U.S.A. which was statistically equalled by five others, viz., Pickett, K.74, Punjab-1, D 60.9647 and Hampton-266, being the shortest.

8. *Bean yield per plant* : The bean yield per plant in different varieties varied from 1.42 gm to 10.70 gm. The highest yield of 10.7 gm was recorded by EC 7034 (CNS), a variety from Australia which was statistically at par with EC 39822 a variety from Thailand giving a yield of 9.61 gm and was followed by EC 39824 and EC 39821 also from Thailand with a yield of 7.46 gm and 7.24 gm respectively. Six varieties, viz., EC 14475, EC 27500, Lee, EC 39800, Davis and Wills producing statistically equal yields have been classified as

medium yielders and the remaining 27 varieties as low yielders. The lowest yield of 1.42 gm per plant was exhibited by the variety Jackson, which was statistically at par with 19 varieties, viz., Chippewa, Magna, Hood, Peterson 90 Brand, Rampage, Bragg, Clark-63, Disoy (U.S.A.), PLSO-15 (India), K.74 (Australia), Dare, Monetta, Master-piece, Norchief (U.S.A.), Punjab-1 (India), D 60.9647, Hardee, Semmes (U.S.A.) and Easy-Cook (China).

**Discussion:** Most of the varieties of U.S.A. origin were the earliest to produce flowers under Coimbatore conditions and the varieties of tropical origin were either medium in first flowering like EC 7034 (Australia) and EC 39824 (Thailand), medium late like Easy-Cook (Originally from China) or late like EC 39800 (Nigeria). Variety Easy-Cook was however, late in 50% flowering like EC 39800. That soybean varieties are adapted to rather narrow belts of latitude is well known (Cartter, 1958). According to Parker and Borthwick (1950), the length of period of darkness determined the flowering in soybeans. The best-known example of this photoperiodic effect is the earliness in date of blooming and maturity of a soybean variety as it is moved south. Garner and Allard (1920) have reported reduction in the period of germination to blossoming for four soybean varieties grown under summer day conditions from 27-105 days to 21-28 days, when the daylight was shortened to 12 hours.

Mooers (1908) concluded that there is not only a steady shortening of the season of growth as the date of planting is made late, but also that the shortening is much more marked in some varieties than in others. Similar to these conclusions, a significant shortening of days to blooming was exhibited by varieties EC 7034, Improved Pelican, EC 39822, EC 39821 and Peterson 90 Brand by delayed planting.

Seventeen of the 22 U.S.A. varieties belonging to maturity Group O to Group VIII (Morse and Cartter, 1949) included in the present study were found to have very early maturity. The variety Jackson (Group VII) showed a mean maturity period of 70.3 days, Bragg (Group VII) of 72.2 days, Semmes (Group VII) of 72.4 days, Monetta (Group VIII) of 73.3 days and Lee (Group VI) of 73.4 days compared to the varieties Chippewa (Group O) which showed a mean of 74.7 days, Norchief (Group O) of 77.5 days and Magna (Group II) of 84.5 days. Hartwig (1954) from Mississippi and Garner and Allard (1920) from Washington, D. C., among others have reported similar results. In Mississippi, Wabash a Group IV strain matured 33 days later for a 72-day delay in planting, whereas Roanoke, a Group VII variety showed only a five day difference in maturity for the same delay. At Washington, D. C. on shortening the day light exposure to 12 hours in a study on four varieties of soybeans, the period from germination to blossoming of the earliest variety was reduced only slightly by the shortened day length, whereas that of the late variety, Biloxi was radically reduced.

The accession EC 7034 (CNS, Australia) the highest bean yielder (10.70 gm per plant) with a height of 45.6 cm had incidentally the highest number of pods per plant, beans per plant and nodes per plant, besides being medium in maturity (92.7 days). This variety was statistically at par in bean yield per plant with EC 39822 (a variety from Thailand) with a yield of 9.61 gm, a fairly high number of pods (53.8) and beans (105.0) per plant and having medium height (34.7 cm) and early maturity (85.6 days). These varieties were closely followed in bean yield by EC 39824 and EC 39821 (both from Thailand) with a yield of 7.46 gm and 7.24 gm respectively. Both these cultures were medium tall with variety EC 39824 having second highest number of pods (56.8), number of beans (113.4) and number of nodes (16.2) besides being medium in maturity (91.3 days). The variety EC 39821 also exhibited a fairly high number of beans per plant (75.4), high number of nodes per plant (13.2) and was classed as an early maturing type. All these four varieties, viz., EC 7034, EC 39822, EC 39824 and EC 39821 had yellow shining beans, were non-shattering, besides being fairly tolerant to *Rhizoctonia* rot and could as such, be considered as the more suitable types for immediate cultivation as long as no variety better in yield and adaptability and producing bolder beans is available. The superior performance of three of these in July-October season has earlier been indicated by investigations at the Indian Agril. Research Institute Regional Station, Coimbatore (Krishnaswami, 1970).

Besides the above, the varieties Hennon 49, Wills, from Australia, EC 27500 from South Africa and EC 39800 from Nigeria need special mention. All these varieties produced bright green, luxuriant vegetative growth in the early stages, undeterred by the high salinity and 'pH' of soil and water in addition to having other desirable agronomic traits. These varieties could not, however, produce impressive yield of beans on account of their high susceptibility to *Rhizoctonia* disease in January sowing. The varieties EC 27500, Hennon 49 and Wills proved to have high shattering resistance and good bold grains. EC 39800 exhibited the highest number of nodes per plant and produced a reasonably high number of pods per plant and beans per plant. On account of these desirable attributes, the varieties could be utilised in suitable breeding programmes with other agronomically desirable types for recovering superior recombinants.

Amongst the twenty-two varieties from U.S.A. included in the present study, all excepting Lee and Davis identified themselves as low yielders. The varieties Lee with a yield of 5.81 gm per plant, Davis with 5.47 gm per plant from amongst the medium yielders and Hill with 4.68 gm per plant from the low yielders, have, however, shown some promise. The varieties Lee and Davis had very bold grains and all the three had medium number of pods per plant, medium number of beans per plant and low node number. The



variety Davis had early maturity (81.7 days) whereas Lee (73.4 days) and Hill (78.0 days) were very early maturing types. The significant variability for the agronomic characteristics expressed by the varieties studied, would point to the potentialities in breeding new types by hybridization for improving the yield itself and for incorporating synchronization of flowering and determinate growth habit, in addition to the resistance to various diseases and to their use in direct cultivation when early maturing types are desired.

The very low nodulation of the soybeans even after bacterial inoculation under the conditions of high soluble salt content and 'pH' of irrigation water and soil, has been mainly responsible for less impressive yields obtained. These edaphic conditions also inhibited the efficiency of 'active' iron utilization, resulting in chlorosis which had to be corrected by foliar application of iron. Weiss (1943) and Mc George (1949) have stressed the significance of plant acidity in keeping iron active. Another factor responsible for causing low yield was the onset of *Rhizoctonia* root rot in January, 1970 sowing and onwards, when the weather became warm and humid. It may be that these tests have not fully revealed the varietal potentialities but the greater efficiency of the better performers under adverse conditions obtained herein, is clearly indicative of their superior potential.

**Summary:** A set of 37 varieties of soybeans of diverse origin was evaluated to find out the range of variability. Observations were recorded for two sets of sowings with respect to the attributes—days to first flowering, days to 50% flowering, days to maturity, number of nodes per plant, number of pods per plant, number of beans per plant, plant height and bean yield per plant.

The varietal differences for all the characters were highly significant. Highly significant differences for sowing dates and varieties interaction were recorded for four characters, viz., days to first flowering, days to 50% flowering, days to maturity and nodes per plant. Except for days to maturity, the differences exhibited by the two sowing dates were not significant. Most of the varieties from U.S.A. were found to be very early to bloom, whereas those of tropical origin were medium to late under Coimbatore conditions. The varieties from U.S.A. belonging to late maturity Groups (VI, VII, VIII) were found to be early maturing like their counterparts in the early maturity groups, (0 I, II). Delayed sowing in January in general, resulted in earlier flower production, earlier maturity, lesser number of nodes and pods per plant and lesser yield per plant than when sown in December.

EC 7034 (Australia), a medium maturing variety gave the best yield performance, followed by EC 39822, EC 39824 and EC 39821 (all from Thailand). This variety also produced the highest number of pods, beans and

nodes per plant. EC 39824 was second only to EC 7034 in number of pods per plant and number of beans per plant. All the four varieties listed, proved to be suitable to Coimbatore conditions and tolerant to high salinity.

**Acknowledgements:** Appreciation is extended to Dr. C. N. Hittle of U.S.A.I.D Program and Dr. M. S. Lal of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Dr. D. E. Byth of University of Queensland, Australia, Dr. C. R. Weber of Peterson Seed Company, U.S.A., Dr. B. B. Singh of Uttar Pradesh Agricultural University, Pantnagar and Dr. R. Krishnaswami of I.A.R.I Regional Centre, Coimbatore for having supplied the seed materials for the present investigation.

We are grateful to Dr. K. Ramakrishnan, Dean, Agricultural College and Research Institute, Coimbatore for his keen interest and encouragement and to the Council of Scientific and Industrial Research for the financial support to one of us (R.N.K.).

#### REFERENCES

- Cartter, J. L. 1958. *Soybean Dig*, 18(7): 12-14.
- Garner, W. W. and H. A. Allard. 1920. Effect of the relative length of day and night and other factors of the environment on growth and reproduction in plants. *J. Agr. Res.*, 3: 227-49.
- Hartwig, E. E. 1954. Factors affecting time of planting soybeans in the Southern States. *U S Dept. Agr. Circ.* 943.
- Johnson, W. W. and R. L. Bernard. 1963. Soybean genetics and breeding. In *The Soybean* ed. A. G. Norman, Academic Press Inc., N.Y. pp: 1-73.
- Krishnaswami, R. 1970. Studies in Soybean. In abstr. of papers presented in the "Seminar on Significant Results during 1969". I.A.R.I. Reg. Station, Coimbatore, 34-5.
- Lu Y. C., K. H. Tsai and H. I. Oka. 1967. Studies on soybean breeding in Taiwan. I. Growing seasons and adaptabilities of introduced varieties. *Bot. Bull. Acad. Sinica.*, 8: 37-53.
- McGeorge, W. T. 1949. Lime-induced chlorosis: relation between active iron and citric and oxalic acids. *Soil Sci.*, 68: 381-96.
- Mooers, C. A. 1908. The Soybean, a comparison with the cowpea. *Tennessee Univ. Agr. Expt. Sta. Bull.* 82.
- Morse, W. J. and J. L. Cartter. 1949. Soybeans: Culture and Varieties. *U.S. Dept. Agr., Farmers Bull.* 1520.
- Parker, M. W. and H. A. Borthwick. 1950. Influence of light on plant growth. *Ann. Rev. Plant Physiol.*, 1: 43-58.
- Weiss, M. G. 1943. Inheritance and physiology of efficiency in iron utilisation in Soybeans. *Genetics*, 28: 253-68.
- , C. R. Weber, L. F. Williams and A. H. Probst 1950. Variability of agronomic characters and seed compositional characters in soybeans, as influenced by variety and time of planting. *U.S. Dept. Agr. Tech. Bull.* 1017.