



P-ISSN: 2349-8528

E-ISSN: 2321-4902

[www.chemijournal.com](http://www.chemijournal.com)

IJCS 2020; 8(6): 866-872

© 2020 IJCS

Received: 13-08-2020

Accepted: 07-10-2020

**Narendra Singh Dhaka**

Department of Genetics and  
Plant Breeding, G.B. Pant  
University of Agriculture and  
Technology, Pantnagar,  
Uttarakhand, India

**Kamendra Singh**

Department of Genetics and  
Plant Breeding, G.B. Pant  
University of Agriculture and  
Technology, Pantnagar,  
Uttarakhand, India

**PS Shukla**

Department of Genetics and  
Plant Breeding, G.B. Pant  
University of Agriculture and  
Technology, Pantnagar,  
Uttarakhand, India

**AS Jeena**

Department of Genetics and  
Plant Breeding, G.B. Pant  
University of Agriculture and  
Technology, Pantnagar,  
Uttarakhand, India

**Sundip Kumar**

Department of Genetics and  
Plant Breeding, G.B. Pant  
University of Agriculture and  
Technology, Pantnagar,  
Uttarakhand, India

**Corresponding Author:****Narendra Singh Dhaka**

Department of Genetics and  
Plant Breeding, G.B. Pant  
University of Agriculture and  
Technology, Pantnagar,  
Uttarakhand, India

## Qualitative characterization of diverse germplasm of soybean (*Glycine max* (L.) Merrill)

**Narendra Singh Dhaka, Kamendra Singh, PS Shukla, AS Jeena and Sundip Kumar**

DOI: <https://doi.org/10.22271/chemi.2020.v8.i6m.10876>

### Abstract

The present investigation was conducted with 294 genotypes along with 4 checks viz., JS 20-34, JS 95-60, NRC 86 and NRC 37 at N.E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, during *Kharif*, 2016 and 2017. The experimental material was planted in an augmented design-II with 6 blocks, each consisting of 49 test entries and 4 checks planted randomly and in which only checks were repeated in each block. The objectives of the present study were characterization of genotypes based on qualitative characters. A total of 11 qualitative characters were taken up for the present study. The result revealed that morphological characters contributed toward genotype divergence in soybean. The results obtained from the present study indicated a possibility of pubescence colour and pod colour showing linked inheritance and the characters flower colour and hypocotyl colour also showing linked inheritance. It was also found that characters pod colour and hilum colour contributed more toward divergence than the other qualitative characters including the present study.

**Keywords:** Soybean, qualitative, characterization and augmented design

### Introduction

Soybean [*Glycine max* (L.) Merrill] is an important leguminous crop widely cultivated in tropical, sub-tropical and temperate regions of the world. Soybean (2n=40) belongs to order fabales and family *Fabaceae* and North-eastern China region is primary centre of origin of this crop. Soybean is an important multi-purpose leguminous crop known for its highly valued protein and oil, and its use in food, feed and industrial applications. Hence it is popularly known as the “Golden Bean” or “Miracle crop” of the 20<sup>th</sup> century. Apart from that, soybean also enriches the soil productivity by fixing atmospheric nitrogen in the soil at the rate of 65-100kg/hectare (Patil *et al.* 2014) [8] through symbiosis with bacterium *Rhizobium japonicum* and thus rejuvenates and maintains the soil fertility. Soybean has become a major source of protein for feed, edible vegetable oil and food supply in the world. It is also known for an excellent source of good quality unsaturated fatty acids (about 85%) and is extremely high in the essential fatty acids such as linoleic acid (53%), oleic acid (23%) and linolenic acid (7%). Low productivity in India is mainly due to the short growing period available in sub-tropical conditions, limited varietal stability and narrow genetic base of soybean cultivars (Singh and Hymowitz, 1999) [10]. For a plant breeder, a proper understanding and estimation of genetic variability is a pre-requisite. But the continuous exploitation of the variability has narrowed down the genetic base of the cultivated varieties to such an extent that it resulted in an augmentation in the losses due to biotic and abiotic stress factors thereby becoming a major concern for plant breeders. Hence, it is of utmost priority to regenerate the variability among the genotypes. Therefore, the knowledge of variability is desirable for a breeder before making any crop improvement program. The hybrids involving the parents with more diversity among them are expected to exhibit higher amount of heterotic expression and broad spectrum of variability in segregating generations. Genetic variability is useful parameters that can help the breeder during different stages of crop improvement. The success of breeding program will depend largely on the extent of genetic variability and heritability for important economic traits in early generation populations. Genetic variability is essential in any crop as it is the source of variation and also the raw material for yield enhancement. A highly reliable and

precise method for assessment of genetic variability devoid of environmental effects is essential to facilitate a valid estimate of parameters. In order to meet the growing needs of varietal improvement for higher productivity, it is essential to collect, evaluate and document the entire array of available genetic variability in germplasm.

### Material and Methods

The present study was conducted during *Kharif*, 2016 and 2017 season at N. E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India. All the recommended cultural practices were adopted to raise a healthy crop. The experimental material of the investigation comprised of 294 genotypes along with 4 checks *viz.*, JS 20-34, JS 95-60, NRC 86 and NRC 37. The experiment was conducted in augmented design with six blocks. The details of experimental material used in experiment is given in Table 1. Considering each genotype as one treatment, the experiment was laid out in augmented design (Federer, 1956, 1961, and Federre & Raghavrao, 1975) <sup>[1-3]</sup> with six blocks. Each block planted with 49 genotypes including four checks. Each accession planted in a single row of 4 m length with the row to row distance 45 cm and plant to plant distance 5-7 cm. Standard package and practices were followed for raising a healthy crop.

### Characters studied and Observations procedure

All the 11 qualitative characters (Hypocotyl colour, Flower colour, Pubescence colour, Leaf shape, Leaf colour, Pubescence density, Seed coat colour, Hilum colour, Pod colour, Pod shattering character, Growth habit) of soybean plant was recorded or observed based on soybean descriptor (IBPGR, 1984) <sup>[5]</sup>. The hypocotyl pigmentation was observed at 10<sup>th</sup> day after sowing under natural daylight condition and it's classified into two different categories by visual assessment of pigmentation i.e. Green and Purple. On the basis of flower color, two classes were recorded among the genotypes i.e. White and Purple. Based on pubescence colour, genotypes were categorized into three categories i.e. Tawny (brown hair), Grey (white hair) and Light brown. Based on leaf shape all the accessions were divided into three categories i.e. Lanceolate, Pointed ovate and Round ovate. The fourth leaf from the top of the selected and tagged plant was used for the leaf colour at 50% flowering stage under natural daylight condition and the genotypes were classified as Light green, Yellowish green and Dark green. Based on pubescence density, genotypes were categorized into four categories: Sparse, Semi- sparse, Normal and Dense. Seed coat color showed wide range of variation in color and the given genotypes were classified into different colors such as yellowish-white, yellow, black, buff, reddish-brown, grey, green, and imperfect black. Hilum colour also shows considerable variability such as yellow, buff, brown, green, grey, imperfect black and black. The pod colour of soybean genotypes was observed under natural daylight condition at harvesting stage by visual assessment and classified as, Tan (Yellow colour), Brown colour and Black colour. Genotypes were grouped based on pod-shattering characteristic. This observation was taken at maturity. Genotypes were grouped as Shattering and Non- shattering. Based on plant growth habits all the accessions were classified into three categories

Determinate, Semi-determinate and Indeterminate.

### Results and Discussion

Characterization of genotypes is essential for its identification and avoiding duplication. Qualitative characters show stable inheritance over generation and hence are reliable for characterization of genotypes as they are less influenced by environment fluctuations. All the 298 genotypes (294 accessions + 4 checks) under study were classified into discrete groups under major categories representing 11 qualitative characters *viz.*, hypocotyl color, flower color, pubescence color, leaf shape, leaf color, pubescence density, seed coat color, hilum color, pod color, growth habit, and shattering character. Genotypes with accession number and their morphological qualitative characters are given in Table 2. In case of character hypocotyl colour, 236 genotypes had purple colour while 62 genotypes had green colour. In case of character flower colour, 238 genotypes had purple colour while 60 genotypes had white colour. In case of pubescence colour, 25 genotypes were gray, 271 were tawny, 2 were light brown. In case of character leaf shape, 207 were broad, 84 were intermediate while 7 were narrow. In case of leaf colour, 90 were dark green, 3 were yellowish Green and 205 were light green. In case of pubescence density 289 were dense and 9 were sparse. In case of seed coat colour, 145 genotypes were yellowish white, 71 genotypes were yellow, 9 genotypes were chocolate, 36 genotypes were green, 37 genotypes were black. In case of Hilum colour; 111 genotypes were yellow, 167 were black and 20 were brown. In case of pod colour, 110 genotypes were tan, 91 genotypes were black, 97 genotypes were brown. In case of pod shattering, 241 genotypes were non-shattering and 57 genotypes were shattering. In case of growth habit 219 genotypes were determinate, 53 genotypes semi-determinate, 26 were indeterminate. On the basis of result obtained it could be outlined that morphological characters play an important role and they do contribute toward genotype divergence in soybean. Contribution of these characters towards divergence may also be significant. Similar result was also reported by Gawande *et al.* (2001) <sup>[4]</sup>, Ramteke and Muralidharan (2012) <sup>[9]</sup> who characterized soybean accession on the basis of qualitative characters. Yadav and Sharma (2001) <sup>[11]</sup> reported large variation for hilum colour in soybean. The results obtained from the present study indicated a possibility of pubescence colour and pod colour showing linked inheritance and the characters flower colour and hypocotyl colour also showing linked inheritance. It was also found that characters pod colour and hilum colour contributed more toward divergence than the other qualitative characters including the present study. Morphological characters or markers, such as leaf size and shape, pubescence color, flower color, pod color, hilum color, seed shape, seed coat color, seed shape and plant height, etc. have been used traditionally to verify the genetics, association, varietal verification, seed production, maintenance and certification of genetic purity of a variety. Morphological markers are limited in number; their expression is often influenced by environment fluctuation, and many of them are not closely linked with economic traits and even have adverse effects on the development and growth of plants. However, morphological markers have been used for diversity analysis in various plant species (Khanande *et al.* 2016, Kachare *et al.* 2020) <sup>[7, 6]</sup>.

**Table 1:** List of soybean germplasm with accessions number

| S. No. | Accession No. | S. No. | Accession No. | S. No. | Accession No. | S. No. | Accession No. | S. No. | Accession No. | S. No. | Accession No. | S. No. | Accession No. |
|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|
| 1      | AGS 129       | 44     | CAT 1151      | 87     | CAT 1258      | 130    | CAT 1416      | 173    | CAT 1541      | 216    | CAT 1587      | 259    | CAT 2008      |
| 2      | AGS 142       | 45     | CAT 1152      | 88     | CAT 1258 B    | 131    | CAT 1420      | 174    | CAT 1543 B    | 217    | CAT 1733      | 260    | CAT 2024A     |
| 3      | AGS 166       | 46     | CAT 1158      | 89     | CAT 1260      | 132    | CAT 1425      | 175    | CAT 1544      | 218    | CAT 1734      | 261    | CAT 2026      |
| 4      | AGS 193       | 47     | CAT 1164      | 90     | CAT 1260 B    | 133    | CAT 1426      | 176    | CAT 1545      | 219    | CAT 1735      | 262    | CAT 2034B     |
| 5      | AGS 205       | 48     | CAT 1166      | 91     | CAT 1266      | 134    | CAT 1429      | 177    | CAT 1548      | 220    | CAT 1752      | 263    | CAT 2039      |
| 6      | AGS 373       | 49     | CAT 1167 A    | 92     | CAT 129       | 135    | CAT 1430      | 178    | CAT 1552 B    | 221    | CAT 1757      | 264    | CAT 204       |
| 7      | BR 4          | 50     | CAT 1167 B    | 93     | CAT 1290      | 136    | CAT 1431      | 179    | CAT 156       | 222    | CAT 1759 A    | 265    | CAT 2041      |
| 8      | CAT 1000      | 51     | CAT 1168      | 94     | CAT 1294      | 137    | CAT 1432      | 180    | CAT 1560      | 223    | CAT 1760      | 266    | CAT 2047      |
| 9      | CAT 1002      | 52     | CAT 1169      | 95     | CAT 1296 B    | 138    | CAT 1435      | 181    | CAT 1562      | 224    | CAT 1768 B    | 267    | CAT 2050      |
| 10     | CAT 1005      | 53     | CAT 1171 A    | 96     | CAT 1297      | 139    | CAT 1437      | 182    | CAT 1573      | 225    | CAT 1773      | 268    | CAT 2055      |
| 11     | CAT 1009      | 54     | CAT 1171 B    | 97     | CAT 1302      | 140    | CAT 1439      | 183    | CAT 1607      | 226    | CAT 178       | 269    | CAT 2056      |
| 12     | CAT 1014      | 55     | CAT 1173      | 98     | CAT 1305      | 141    | CAT 1442      | 184    | CAT 1610      | 227    | CAT 1783      | 270    | CAT 2058      |
| 13     | CAT 1027      | 56     | CAT 1175      | 99     | CAT 1308      | 142    | CAT 1452      | 185    | CAT 1613      | 228    | CAT 18 A      | 271    | CAT 2066      |
| 14     | CAT 1034      | 57     | CAT 1176      | 100    | CAT 1318      | 143    | CAT 1453      | 186    | CAT 1615      | 229    | CAT 1810      | 272    | CAT 2068 B    |
| 15     | CAT 1045      | 58     | CAT 1179      | 101    | CAT 1321      | 144    | CAT 1454      | 187    | CAT 1622      | 230    | CAT 1811      | 273    | CAT 2070A     |
| 16     | CAT 1058      | 59     | CAT 1180      | 102    | CAT 1323      | 145    | CAT 1456      | 188    | CAT 1631      | 231    | CAT 1812      | 274    | CAT 2070B     |
| 17     | CAT 1060      | 60     | CAT 1181 A    | 103    | CAT 1324      | 146    | CAT 1459      | 189    | CAT 1633 A    | 232    | CAT 1816      | 275    | CAT 2072      |
| 18     | CAT 1060 B    | 61     | CAT 1182      | 104    | CAT 1326      | 147    | CAT 1354      | 190    | CAT 1636      | 233    | CAT 1820      | 276    | CAT 2082      |
| 19     | CAT 1062      | 62     | CAT 1185      | 105    | CAT 1328      | 148    | CAT 1353      | 191    | CAT 1641 B    | 234    | CAT 1822      | 277    | CAT 2083A     |
| 20     | CAT 1065      | 63     | CAT 1186      | 106    | CAT 133       | 149    | CAT 1352      | 192    | CAT 1648      | 235    | CAT 1826      | 278    | CAT 2084      |
| 21     | CAT 1077      | 64     | CAT 1187      | 107    | CAT 1330      | 150    | CAT 1471      | 193    | CAT 165       | 236    | CAT 1831 B    | 279    | CAT 2086A     |
| 22     | CAT 1085      | 65     | CAT 1191      | 108    | CAT 1334      | 151    | CAT 1476      | 194    | CAT 1652      | 237    | CAT 1843 B    | 280    | CAT 2086B     |
| 23     | CAT 1086      | 66     | CAT 1193      | 109    | CAT 1339      | 152    | CAT 1477      | 195    | CAT 1664      | 238    | CAT 1847      | 281    | CAT 2091      |
| 24     | CAT 1091      | 67     | CAT 1195      | 110    | CAT 1341 A    | 153    | CAT 1485      | 196    | CAT 1673 A    | 239    | CAT 1850      | 282    | CAT 2092      |
| 25     | CAT 1094      | 68     | CAT 120       | 111    | CAT 1341 B    | 154    | CAT 1491      | 197    | CAT 1673 B    | 240    | CAT 1858      | 283    | CAT 2094      |
| 26     | CAT 1095      | 69     | CAT 1200      | 112    | CAT 1347      | 155    | CAT 1493      | 198    | CAT 1676      | 241    | CAT 1878      | 284    | CAT 2096B     |
| 27     | CAT 1096      | 70     | CAT 1202      | 113    | CAT 1362      | 156    | CAT 1504      | 199    | CAT 1691      | 242    | CAT 188       | 285    | CAT 2100      |
| 28     | CAT 1099      | 71     | CAT 1208      | 114    | CAT 1366      | 157    | CAT 1507 B    | 200    | CAT 1692      | 243    | CAT 1881      | 286    | CAT 2101      |
| 29     | CAT 1103      | 72     | CAT 1210      | 115    | CAT 1368      | 158    | CAT 1508 B    | 201    | CAT 1694      | 244    | CAT 1882      | 287    | CAT 2104      |
| 30     | CAT 1109      | 73     | CAT 1211      | 116    | CAT 1370      | 159    | CAT 1511      | 202    | CAT 1699      | 245    | CAT 1894      | 288    | CAT 1976      |
| 31     | CAT 1112      | 74     | CAT 1215      | 117    | CAT 1371      | 160    | CAT 1516      | 203    | CAT 17        | 246    | CAT 1898      | 289    | CAT 1957      |
| 32     | CAT 1113      | 75     | CAT 122       | 118    | CAT 1373      | 161    | CAT 1517      | 204    | CAT 1701      | 247    | CAT 1899      | 290    | CAT 195       |
| 33     | CAT 1119      | 76     | CAT 1224      | 119    | CAT 1374 B    | 162    | CAT 1518      | 205    | CAT 1705      | 248    | CAT 1916      | 291    | CAT 194       |
| 34     | CAT 1122      | 77     | CAT 1228 A    | 120    | CAT 1382      | 163    | CAT 1521      | 206    | CAT 171       | 249    | CAT 1917      | 292    | CAT 1936      |
| 35     | CAT 1125      | 78     | CAT 1229      | 121    | CAT 1387      | 164    | CAT 1523A     | 207    | CAT 1710      | 250    | CAT 192       | 293    | CAT 1931      |
| 36     | CAT 1128      | 79     | CAT 1135      | 122    | CAT 1391      | 165    | CAT 1526      | 208    | CAT 1713      | 251    | CAT 1921A     | 294    | CAT 1928B     |
| 37     | CAT 1140      | 80     | CAT 1136      | 123    | CAT 1392      | 166    | CAT 1527      | 209    | CAT 1720      | 252    | CAT 1927A     | 295    | JS 20-34 (C)  |
| 38     | CAT 1141      | 81     | CAT 1238      | 124    | CAT 1396      | 167    | CAT 1529      | 210    | CAT 1726 B    | 253    | AGS 121       | 296    | JS 95-60 (C)  |
| 39     | CAT 1143      | 82     | CAT 1241      | 125    | CAT 1398      | 168    | CAT 153       | 211    | CAT 1582      | 254    | CAT 1912      | 297    | NRC 86 (C)    |
| 40     | CAT 1145      | 83     | CAT 1243B     | 126    | CAT 140A      | 169    | CAT 1530      | 212    | CAT 1578      | 255    | CAT 2005      | 298    | NRC 37 (C)    |
| 41     | CAT 1148      | 84     | CAT 1248      | 127    | CAT 1400      | 170    | CAT 1533      | 213    | CAT 1576      | 256    | CAT 1987B     |        |               |
| 42     | CAT 1149      | 85     | CAT 1254      | 128    | CAT 1404      | 171    | CAT 1539      | 214    | CAT 1575      | 257    | CAT 1993A     |        |               |
| 43     | CAT 1150      | 86     | CAT 1255      | 129    | CAT 1409      | 172    | CAT 1540      | 215    | CAT 1597      | 258    | CAT 2006      |        |               |

**Table 2:** Classification of 298 genotypes under study into distinct groups based on eleven qualitative characters in soybean

| Character         | Group        | Serial number of genotypes included in the group                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Number of genotypes |
|-------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| Hypocotyl colour  | Purple       | 1, 2, 3, 4, 5, 6, 8, 9, 12, 13, 14, 15, 18, 19, 21, 23, 24, 27, 28, 29, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 88, 90, 91, 92, 94, 95, 96, 97, 98, 99, 100, 102, 104, 105, 106, 108, 110, 111, 113, 115, 116, 117, 119, 120, 121, 122, 123, 124, 125, 128, 129, 132, 133, 135, 137, 138, 140, 141, 143, 144, 145, 146, 147, 153, 154, 155, 158, 160, 163, 164, 173, 174, 175, 176, 177, 179, 180, 181, 183, 184, 185, 186, 188, 189, 190, 191, 192, 193, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 247, 248, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 263, 264, 265, 266, 267, 268, 269, 271, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 292, 293, 294, 295                                                                                                                                                                       | 236                 |
|                   | Green        | 7, 10, 11, 16, 17, 20, 22, 25, 26, 30, 31, 68, 87, 89, 93, 101, 103, 107, 109, 112, 114, 118, 126, 127, 130, 131, 134, 136, 139, 142, 148, 149, 150, 151, 152, 156, 157, 159, 161, 162, 165, 166, 167, 168, 169, 170, 171, 172, 178, 182, 187, 194, 246, 249, 250, 262, 270, 272, 291, 296, 297, 298                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 62                  |
| Flower Colour     | Purple       | 1, 2, 3, 4, 5, 6, 8, 9, 12, 13, 15, 18, 19, 20, 21, 23, 24, 26, 27, 28, 29, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 88, 90, 91, 92, 94, 95, 96, 97, 98, 99, 100, 102, 104, 105, 106, 108, 109, 111, 113, 115, 116, 117, 119, 120, 121, 123, 124, 125, 128, 129, 130, 131, 132, 133, 135, 137, 138, 140, 141, 143, 144, 145, 146, 147, 152, 153, 154, 158, 160, 161, 162, 163, 164, 169, 173, 174, 175, 176, 177, 179, 180, 181, 183, 184, 185, 186, 188, 189, 190, 191, 192, 193, 195, 196, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 220, 221, 222, 223, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 247, 248, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 263, 264, 265, 266, 267, 268, 269, 271, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 292, 294, 295, 298                                                                                                                                                              | 238                 |
|                   | White        | 7, 10, 11, 14, 16, 17, 22, 25, 30, 31, 68, 87, 89, 93, 101, 103, 107, 110, 112, 114, 118, 122, 126, 127, 134, 136, 139, 142, 148, 149, 150, 151, 155, 156, 157, 159, 165, 166, 167, 168, 170, 171, 172, 178, 182, 187, 194, 197, 219, 224, 246, 249, 250, 262, 270, 272, 291, 293, 296, 297,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 60                  |
| Pubescence Colour | Gray         | 1, 16, 22, 62, 89, 94, 112, 126, 127, 130, 131, 134, 150, 151, 156, 157, 160, 163, 168, 170, 174, 179, 210, 229, 246                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 25                  |
|                   | Towny        | 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 90, 91, 92, 93, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 128, 129, 132, 133, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 152, 153, 154, 155, 158, 159, 161, 162, 164, 165, 166, 167, 169, 171, 172, 173, 175, 176, 177, 178, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 297 | 271                 |
|                   | Light Brown  | 296, 298                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 2                   |
| Leaf shape        | Broad        | 1, 2, 5, 6, 7, 8, 9, 11, 12, 13, 14, 17, 18, 19, 21, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 38, 41, 42, 43, 44, 45, 46, 48, 49, 50, 53, 54, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 75, 76, 77, 78, 81, 82, 84, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 99, 101, 102, 104, 105, 106, 107, 108, 110, 111, 112, 116, 118, 119, 120, 121, 122, 123, 124, 125, 126, 128, 129, 130, 131, 133, 134, 135, 136, 137, 138, 139, 142, 143, 144, 145, 151, 152, 154, 155, 156, 157, 158, 159, 167, 170, 171, 172, 173, 176, 179, 180, 183, 184, 185, 186, 188, 189, 190, 191, 203, 204, 206, 207, 208, 209, 210, 215, 216, 217, 218, 219, 222, 223, 224, 225, 226, 227, 228, 229, 230, 232, 235, 237, 238, 240, 241, 242, 243, 244, 245, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 258, 259, 260, 261, 263, 264, 265, 266, 269, 270, 271, 273, 274, 275, 276, 278, 279, 281, 282, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297                                                                                                                                                                                                                                                                                                             | 207                 |
|                   | Intermediate | 3, 4, 10, 15, 16, 20, 22, 24, 36, 37, 39, 40, 47, 51, 52, 56, 57, 79, 80, 83, 85, 100, 103, 109, 113, 114, 117, 127, 132, 140, 141, 146, 147, 148, 149, 150, 153, 160, 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 84                  |

|                    |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |     |
|--------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|                    |                 | 61,162,163,164,165,166,168,169,174,175,177,178,181,182,187,192,193,194,195,196,197,198,199,200,201,202 205 211 212 213 214 220<br>231 233 234 236 239 246 257 262 267 268 272 277 280 283                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |     |
|                    | Narrow          | 55, 73 , 74, 98, 115, 221, 298                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 7   |
| Leaf colour        | Dark Green      | 1,5,7,14,17,25,33,34,35,36,38,39,40,41,66,67,68,69,71,72,73,74,75,76,79,80,82,83,84,85,86,87,88,89,90,112,113,114,115,116,117,118,119,122,129,130,149,150,151,152,153,155,175,176,177,178,181,182,183,185,186,187,188,189,190,192,213,214,216,217,218,220,221,222,23,226,233,236,256,258,261,262,263,285,286,287,288,289,295,298                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 90  |
|                    | Yellowish Green | 2,3,4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 3   |
|                    | Light Green     | 6,8,9,10,11,12,13,15,16,18,19,20,21,22,23,24,26,27,28,29,30,31,32,37,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,70,77,78,81,91,92,93,94,95,96,97,98,99,100,101,102,103,104,105,106,107,108,109,110,111,120,121,123,124,125,126,127,128,131,132,133,134,135,136,137,138,139,140,141,142,143,144,145,146,147,148,154,156,157,158,159,160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,179,180,184,191,193,194,195,196,197,198,199,200,201,202,203,204,205,206,207,208,209,210,211,212,215,219,224,225,227,228,229,230,231,232,234,235,237,238,239,240,241,242,243,244,245,246,247,248,249,250,251,252,253,254,255,257,259,260,264,265,266,267,268,269,270,271,272,273,274,275,276,277,278,279,280,281,282,283,284,290,291,292,293,294,296,297,                                                                                                                                                                                                                                                                                                     | 205 |
| Pubescence density | Dense           | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100,101,102,104,105,106,107,108,109,110,111,112,113,114,115,116,117,118,119,120,121,122,123,124,125,126,127,128,129,130,131,132,133,134,135,136,137,138,139,140,141,142,143,144,145,146,147,148,149,150,151,152,153,154,155,156,157,159,160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,175,176,177,178,179,180,181,182,183,184,185,186,187,188,189,190,191,192,194,195,196,197,198,199,200,201,202,204,205,206,207,208,209,210,211,212,213,214,215,216,217,218,219,220,221,222,223,224,225,226,227,228,229,230,231,232,233,234,235,236,237,238,239,240,241,242,243,244,245,246,247,248,249,250,254,255,256,257,258,259,260,,261,262,263,264,265,266,267,268,269,270,271,272,273,274,275,276,277,278,279,280,281,282,283,284,285,286,287,288,289,290,291,292,293,294,295,297 | 289 |
|                    | Sparse          | 103,158,193,203,251,252,253,296,298                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 9   |
| Seed coat colour   | Yellowish white | 1,2,3,6,13,16,18,20,21,23,27,28,29,30,31,32,34,35,36,37,41,42,43,46,47,48,50,51,53,55,58,59,63,66,68,71,72,75,78,82,85,86,89,90,91,95,96,102,106,107,108,110,111,113,116,117,120,121,123,124,129,130,133,134,135,136,137,139,143,144,145,147,150,152,153,155,156,158,160,161,162,164,168,169,171,178,179,181,183,186,188,189,190,193,195,196,200,203,205,207,212,214,217,218,219,221,225,234,235,239,240,242,244,248,251,252,253,256,258,259,260,261,262,263,264,265,266,268,269,270,271,273,275,276,277,279,280,281,282,285,286,287,289,296,297,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 145 |
|                    | Yellow          | 4,5,8,9,10,15,19,22,26,38,40,45,54,62,74,79,83,84,87,88,93,94,99,101,112,114,118,126,131,142,151,159,165,166,167,170,172,173,174,176,177,180,191,194,204,206,209,210,211,215,216,220,223,227,228,229,230,233,238,241,245,246,247,254,255,274,283,284,294,295,298                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 71  |
|                    | Chocolate       | 7,14,25,76,182,187,199,249,291,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 9   |
|                    | Green           | 11,12,17,24,33,52,56,57,60,61,64,65,80,81,97,98,103,105,125,127,138,148,149,157,192,197,201,202,208,224,231,236,250,257,267,278,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 36  |
|                    | Black           | 39,44,49,67,69,70,73,77,92,100,104,109,115,119,122,128,132,140,141,146,154,163,175,184,185,198,213,222,226,232,237,243,272,288,290,292,293,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 37  |
| Hilum colour       | Yellow          | 1,3,7,13,14,16,18,21,25,28,34,36,41,42,43,47,48,50,51,54,55,58,59,63,65,75,76,78,82,86,89,90,91,95,96,105,106,107,108,110,112,116,120,121,123,126,127,130,131,133,134,143,144,145,147,150,153,156,157,164,172,173,177,179,181,182,187,199,200,207,212,224,225,227,228,233,234,240,242,244,248,249,250,256,258,259,260,262,263,264,265,266,268,269,270,273,275,276,277,279,280,282,285,286,287,289,290,291,295,297,298                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 111 |
|                    | Black           | 2,4,5,6,8,9,10,11,12,15,17,19,20,22,23,24,26,27,30,32,33,35,37,38,39,40,44,45,49,52,53,56,57,60,61,62,64,66,67,68,69,70,71,72,73,74,77,79,80,81,83,84,85,87,88,92,93,94,97,98,99,100,102,103,104,109,111,113,114,115,117,118,119,122,124,128,129,132,135,136,137,138,139,140,141,142,146,148,149,151,154,155,159,161,162,163,165,166,167,168,169,174,175,176,184,185,188,189,190,191,192,193,194,195,196,197,198,201,202,203,206,208,209,210,211,213,214,215,216,217,218,219,221,222,226,229,230,231,232,235,236,237,238,239,241,243,2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 167 |



|                |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |     |
|----------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|                |                  | 46,247,251,252,253,254,255,257,261,267,271,272,274,278,283,284,288,292,293,294,296                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |     |
|                | Brown            | 29,31,46,101,125,152,158,160,170,171,178,180,183,186,204,205,220,223,245,281,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 20  |
| Pod colour     | Tan              | 1,3,6,11,12,13,16,18,21,34,36,41,42,43,47,48,49,50,51,54,55,58,59,63,65,75,76,78,82,86,89,90,91,95,96,105,106,107,108,110,112,116,120,121,123,126,130,131,133,134,143,144,145,147,150,153,156,157,161,164,172,173,177,179,181,182,187,199,200,207,212,224,225,227,228,233,234,240,242,244,248,249,250,256,258,259,260,262,263,264,265,266,268,269,270,273,275,276,277,279,280,282,285,286,287,289,290,291,296,297                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 110 |
|                | Black            | 2,4,5,8,9,15,19,20,22,23,24,26,27,30,32,33,35,37,39,44,45,46,52,56,60,61,64,67,68,69,70,71,72,73,77,79,84,87,88,92,97,98,100,103,104,109,111,114,119,122,124,127,128,129,132,135,138,140,141,146,148,149,151,154,159,175,184,185,189,192,198,201,202,208,213,214,221,222,226,232,236,237,243,257,267,274,288,292,293,295,298,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 91  |
|                | Brown            | 7,10,14,17,25,28,29,31,38,40,53,57,62,66,74,80,81,83,85,93,94,99,101,102,113,115,117,118,125,136,137,139,142,152,155,158,160,162,163,165,166,167,168,169,170,171,174,176,178,180,183,186,188,190,191,193,194,195,196,197,203,204,205,206,209,210,211,215,216,217,218,219,220,223,229,230,231,235,238,239,241,245,246,247,251,252,253,254,255,261,271,272,278,281,283,284,294,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 97  |
| Pod shattering | Non Shattering   | 1,2,3,7,8,9,10,11,13,15,16,17,20,21,22,23,24,25,28,29,30,31,33,34,35,36,38,39,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,57,58,59,61,62,63,64,65,66,67,69,70,72,73,74,75,77,78,80,81,82,84,86,87,88,90,91,93,96,97,98,99,101,103,104,105,106,107,108,109,110,111,112,113,114,115,116,117,118,119,120,121,122,123,124,126,127,128,130,132,133,134,135,136,137,138,139,140,141,142,143,144,145,146,147,148,149,150,151,152,153,155,156,158,159,160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,175,176,178,179,180,181,182,183,184,185,186,187,188,189,192,193,194,196,197,198,199,200,201,202,204,205,208,209,210,211,212,213,215,216,217,218,221,222,225,226,227,228,229,230,231,232,233,234,237,238,239,240,241,242,243,244,248,249,250,252,255,256,258,259,260,262,263,264,265,266,268,269,270,271,273,274,275,276,277,278,279,280,282,283,284,285,286,287,289,290,291,292,293,294,295,296,297,298 | 241 |
|                | Shattering       | 4,5,6,12,14,18,19,26,27,32,37,40,56,60,68,71,76,79,83,85,89,92,94,95,100,102,125,129,131,154,157,177,190,191,195,203,206,207,214,219,220,223,224,235,236,245,246,247,251,253,254,257,261,267,272,281,288,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 57  |
| Growth habit   | Determinate      | 2,3,5,6,7,8,9,10,11,12,13,14,15,16,17,18,20,21,22,23,24,26,27,28,29,30,32,33,34,35,36,38,41,42,43,45,46,47,48,49,50,51,52,53,54,58,59,61,62,63,65,66,71,72,75,76,78,81,85,86,87,88,89,90,91,93,94,96,97,98,99,101,102,103,106,107,108,110,111,112,113,114,116,117,118,120,121,122,123,124,129,130,131,132,133,134,135,136,137,138,142,143,144,148,149,150,151,153,155,156,157,159,160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,177,178,179,180,181,182,186,187,188,189,190,192,194,195,196,197,199,200,204,205,206,207,209,210,211,212,213,215,216,218,219,220,223,224,225,226,227,228,233,234,238,239,240,242,243,244,246,247,248,249,250,251,252,253,254,255,256,258,259,260,261,262,263,264,265,266,267,268,270,271,272,273,274,275,276,277,278,280,281,282,283,285,286,287,289,290,293,294,295,296,297,298                                                                                      | 219 |
|                | Semi Determinate | 1,4,25,31,37,40,55,56,57,60,64,67,68,69,77,79,80,82,83,84,92,95,100,104,105,125,126,127,141,145,146,147,152,154,158,175,176,191,193,201,202,217,230,231,236,237,241,245,269,279,284,291,292                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 53  |
|                | Indeterminate    | 19,39,44,70,73,74,109,115,119,128,139,140,183,184,185,198,203,208,214,221,222,229,232,235,257,288,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 26  |

## References

1. Federer WT. Augmented. (Or Hoonuiaku) design. Hawai. Plant. Rec 1956;55:191-208.
2. Federer WT. Augmented designs with one way elimination of heterogeneity. Biometrics 1961;17:447-473.
3. Federer WT, Raghavarao D. On augmented designs. Biometrics 1975;31(1):29- 35.
4. Gawande P, Patil S, Joshi S. Selection of superior germplasm lines for soybean based on morphological characters for hybridization. J of Physiological Res 2001;14(2):125-130.
5. IBPGR. Descriptors for soybean. International Board for Plant Genetic Resources, IBPGR Secretariat, Rome, Italy 1984, 20.
6. Kachare S, Tiwari S, Tripathi N, Thakur VV. Assessment of Genetic Diversity of Soybean (*Glycine max*) Genotypes Using Qualitative Traits and Microsatellite Markers. Agric Res 2020;9:23-34.
7. Khanande AS, Jadhav PV, Kale PB, Madavi SM, Mohari MP *et al.* Genetic Diversity in Vegetable and Grain Type Soybean Genotypes Identified using Morphological Descriptor and EST-SSR Markers. Vegetos. 2016;29:3.
8. Patil SS, Patil PP, Lodam VA, Chaudhari MH. Character association and genetic diversity in soybean to formulate a sound breeding program – A review. Trends in Biosciences 2014;7(7):508-511.
9. Ramteke R, Murlidharan P. Characterization of soybean (*Glycine max*) varieties as per DUS guidelines. Indian Journal of Agricultural Sciences 2012;82(7):572-577.
10. Singh RJ, Hymowitz T. Soybean genetic resources and crop improvement. Genome 1999;42(4):605-616.
11. Yadav SP, Sharma SP. Variation for hilum colour and its stability during four crop seasons in soybean (*Glycine max*). Indian Journal of Agricultural Sciences 2001;71(1): 23-26.