Screening of soybean genotypes for the source of soybean mosaic resistance

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Abstract: Soybean mosaic virus (SMV) is the major constraints for soybean cultivation in many parts of the country. Experiments were carried out to study the seed transmission of SMV and to identify the resistant sources through screening of 30 promising soybean genotypes obtained from different sources under natural infections conditions in between 2000 and 2001. Indirect-ELISA was performed against TRSV, TMV, CPMV, CMV, BBSV, BBTMV and SMV in leaf materials, both from healthy and diseased plant materials and the results showed that the seeds and the plants in the field were free from those 6 viruses. The highest seed transmission was found in Gaurab (15.07%) followed by G-2120 and the lowest (1.5%) seed transmission was found in TG-893 followed by BS-32, CM and AGS-129. Seed mottling was found related to seed transmission. No disease incidence was found in AGS-129 but there were seed mottling (1.25%). On the other hand, genotype AGS-160 was free from mottled seeds but produced infected seedlings. Mosaic symptom became apparent 15 days after sowing (DAS), highest at 60 DAS and disappear after 90 DAS. Seeds from seed lot containing up to 20% mottled symptom could not hamper production. Screening of 30 soybean genotypes based on the natural infections revealed that AGS-129 was identified as resistant and grading 1, 10 were identified as moderately resistant (MR) considered as grading 3 and the remaining genotypes were susceptible (S) and moderately susceptible (MS) considered as grading 7 and 5, respectively. The 10 genotypes viz. CM, BS-32, ACAGS-154, G-2261, AGS-129, Durga, Williams, AGS-160, EC-1178 and PR-164 could be used for further study to locate resistant genes against soybean mosaic virus and varietal improvement in breeding purpose.

Keywords: resistant; soybean genotypes; soybean mosaic

1. Introduction
Soybean [Glycine max (L.) Merr.] is the leading oilseed crop produced and consumed in the world (Wilcox, 2004). It has exceptional nutritional value, provides the richest source of protein of any crop (similar to levels found in cow’s milk and meat, fish or poultry) and is able to serve as the core protein supplement to human diets. Soybean, including processed soybean products like tofu, constitutes good nutritional quality for adult humans, containing a high amount of protein (40%–50%), lipids (20%–30%) and carbohydrates (26%–30%), with more than eighty-five percent of its protein content made up of β-conglycinin and glycinin (Gibss et al., 2004). The USDA reports much lower levels of protein (13%), lipids (6.8%), carbohydrates (11%) and dietary
fiber (4%) in raw green soybeans (USDA, 2018a) but higher levels in mature raw soybean seed (36.5%, 20%, 30% and 9%, respectively) (USDA, 2018b).

It improves soil fertility because it fixes nitrogen (94 kg of nitrogen per hectare per season) as a legume crop (Satter, 2001). Bangladesh uses soybean primarily as a poultry feed, but it is also used in the preparation of a variety of healthy dishes and confections (Mondal and Wahhab, 2001). As linoleic and linolenic acids, which are found in soybeans, help the body absorb essential nutrients and regulate smooth muscle contraction, blood pressure, and cell growth, soybeans are an excellent source of these two fatty acids. In addition, it contains 3% lecithine, which is beneficial for brain development (Rahman, 1982).

Worldwide, the total annual production of soybean is 365.79 million tons from an area of land totaling 130.90 million hectares (FAOSTAT 2017). In Bangladesh, total annual production is 96,921 tons from a cultivated area of 62,870 hectares – at 1.54 tons/ha, this is much lower than the world average of 2.79 tons/ha. Much neglected until just a couple of years ago, soybean is gradually gaining popularity as a cash crop, especially among farming households in the country’s southern belt (Noakhal, Lakshmipur and Bhola districts). The socioeconomic condition of these farming communities could be potentially enhanced through the establishment of small soy-based food manufacturing industries, producing milk, curd (yoghurt), flour/breads, meat, halwa, biscuits and assorted snacks, all from soybean. In Bangladesh, there are ample opportunities to increase both the area and productivity of oilseed crops such as soybean because of the availability of short-duration improved varieties and suitable agro-climatic conditions. At the same time, at the production and post-harvest processing levels there is some potential for mechanical interventions. These might enhance current oilseed production and processes and allow farmers to earn more from soybean cultivation (Miah et al., 2017).

Soybean Mosaic Disease (SMD) is one of the most serious, devastating, and widespread diseases of Glycine max (L.) Merry. caused by Soybean Mosaic Virus (SMV) belongs to the genus Potyvirus and the family Potyviridae. It reduces soybean yields from 8 to 35% and occurs in virtually all soybean production areas of the world (Hill, 1999). SMV only infects six plant families, including Fabaceae, Amaranthaceae, Chenopodiaceae, Passifloraceae, Schrophulariaceae, and Solanaceae, with its narrow host range. Both Glycine soja and Glycine max are common hosts for the parasite and with 160 species, the Potyvirus genus is the most diverse in the plant RNA virus world (Hajimorad, 2018). Only the soybean mosaic potyvirus has been found to cause 50% yield loss in experimentally inoculated plants, with yield reductions as high as 93% (Sinclair, 1994). Foliar symptoms range from mild leaf mottling to severe leaf distortion, necrosis, and general stunting, with the infected plants sometimes dying. Most infections occur after flowering and have a negligible effect on seed quality or yield (Bowers and Goodman, 1979; Song et al., 2016). SMV is an aphid-transmitted and seed transmitted virus. Seed transmission rates range from 0% to 64% depending on the virus genotype and soybean variety (Bowers and Goodman, 1991; Domier et al., 2007).

Soybean cultivation is relatively insignificant in Bangladesh, with an area (acres) of 154396, and a production of 110785 (M. Ton), despite the widespread use of soybean oil in cooking. However, the yield losses caused by the attack of soybean mosaic viruses are a major obstacle to successful soybean production in this area and Bangladesh must import 1.20 million metric tons of edible oil each year at a cost of nearly Tk 40 billion to meet its rising demand (Miah et al., 2017). It has thus taken precedence over everything else in the selection of soybean lines for high yield and viral disease resistance. Agricultural studies in Bangladesh have shown how soybean production systems in the districts of Noakhali and Laxmipur are actually working (Research Centre, Bangladesh Agricultural Research Institute, Gazipur. The name and origin of the genotypes are presented in Table 1.

2. Materials and Methods

Thirty different genotypes of soybean were studied. These were collected from Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh. Two genotypes ST-2 and Tampomus were used for check and planted as border crop collected from Pulse Research Centre, Bangladesh Agricultural Research Institute, Gazipur. The name and origin of the genotypes are presented in Table 1.
2.1. Laboratory Experiment
2.1.1. Seed health test
Detection of viruses on leaves and seed samples were performed in the Virology Laboratory, Professor Golam Ali Fakir Seed Pathology Laboratory, Department of Plant Pathology, Bangladesh Agricultural University (BAU) through Indirect-ELISA. Ten samples of symptom bearing seed and ten symptom bearing leaf samples of different genotypes were used to detect viruses. Indirect-ELISA was performed against the following viral antiserum: Tobacco ring spot virus (TRSV), Tobacco mosaic virus (TMV), Cowpea mosaic virus (CPMV), Cucumber mosaic virus (CMV), Broad bean strain virus (BBSV), Broad bean true mosaic virus (BBTMV).

2.1.2. Dry inspection of seeds and transmission study of SMV by seedling symptom test
Sorting of mottled seeds were done from 400 randomly taken seeds from the seed lot and counted the symptom bearing seeds and healthy-looking seeds in the laboratory. The percentage of symptom bearing seeds in the seed lot for every genotype under study was calculated. In addition, 100 seed weight of symptom bearing seeds and healthy-looking seeds were taken by an electric balance and calculated out the reduction of seed weight (%) due to SMV infection. The experiment was conducted in the net house and the soil was collected from BAU, Mymensingh. After drying the soil, decomposed cow dung was mixed with collected soil (1:1) and earthen pots of 30 cm dia. were filled two third portions with the mixture. Chemical fertilizers were not used in the pot soil. The pots were arranged in RCBD with 3 replications. The soybean seeds were sown on December 15, 2000. Twenty-five seeds were sown in each pot. As check, five pots were planted with only symptom bearing seeds and three pots with apparently healthy seeds, sowing 10 seeds per pot. Irrigation was done regularly in the pots by supplying water in the trays on which the pots were placed in the net house.

The data recorded for each variable was averaged to obtain mean values and analysis of variance was performed using these mean values. Duncan’s Multiple Range Test (DMRT) was performed for all the variables to locate the difference between them following Steel and Torrie (1960). Multiple regression model was also used to estimate the disease incidence, yield per plant, yield of healthy-looking plant, yield of symptom bearing plant and yield per plot.

For the estimation of disease incidence, the multiple regression model was:

\[ Y_i = a + \sum b_j X_{ij} + e_i \]

Where, \( i = 1 \) .................. 90; \( j = 1 \) .................. 15

\[ Y_{i(k)} = a + \sum b_j X_{ij} + e_i \]

Where, \( i = 1 \) .................. 90; \( j = 1 \) .................. 12; \( k = 1 \) .................. 4

\( k = 1, 2, 3 \) and \( 4 \) represents yield /plant, yield of healthy-looking plant, symptom bearing plant and yield /plot respectively, whereas, \( X=1,2,3,4,5,6,7,8,9,10,11 \) and 12 represents Disease incidence, Plant height, No. of effective nodules per plant, Pod/plant, Pod length, Seeds/pod, 100 seed weight, Days to maturity, Germination (%), Seed transmission (%), Seed infection (%), Reduction in seed weight (%) respectively. In addition, \( a = \) Constant; \( b = \) Regression coefficient; \( c = \) Random error distributed as \( N (0, 2) \).

2.2. Field Experiment
2.2.1. Experimental site and layout
The field experiment was conducted at the experimental field laboratory of the Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh during the period from November 2000 to April 20. Urea, Triple Super Phosphate (TSP), Muriate of Potash (MoP), Gypsum, Zinc Sulphate were applied to @ 40, 120, 60, 25 and 5 kg/ha respectively. All fertilizers except half portion of urea were applied at the time of final land preparation. The remaining half of urea was applied as top dressing at vegetative stage. Rhizobial inoculum was mixed with the seeds @ 25g/Kg seeds just before sowing. The entire field was divided into 90- unit plots for this study. The plots were arranged following Randomized Complete Block Design (RCBD) with 3 replications. The plot size was 3m × 2m with 10 rows of 3 m long each. For each material there were ten rows of plants having 30 cm distance between the rows and aprox. 5 cm distance between the plants. The distance between the blocks were 50 cm. The genotypes were designated as treatment.

2.2.2. Intercultural Operations and Harvesting
Thinning out of seedlings was done 15 days after sowing (DAS) after taking account of the symptom bearing seedlings. Two times weeding was done in the crop field, one at 30 DAS and another at 50 DAS. No irrigation
was done in the field. The plants were harvested at the physiological maturity stage. Such maturity came with yellowing of leaves with completion of leaf shedding and the pod color mostly became dark brown. The varieties were harvested at different dates as they reached maturity. Plants were harvested leaving the root part in the field.

2.3. Data collection

2.3.1. Disease incidence and Disease severity

To record the incidence of mosaic diseases in the experimental plots 6 times regular inspection of the plots was made at 15 days interval starting from 15 DAS. Three lines from each unit plot were selected randomly and number of symptoms bearing plants from the total plants were recorded each time. The data were averaged for each plot and finally the result was expressed as % plant infection indicating the incidence of disease. Soybean mosaic virus disease severity was recorded at 60 DAS (flowering stage) following a 1-9 disease rating scale used for scoring MYMV (Mughbean Yellow Mosaic Virus) by Singh et al. (1988). Ten affected plants of each unit plot were randomly selected for collecting the data on diseases severity. Mottling of leaves on 0.1-5% and 5.1-10% of the plants were found resistant and moderately resistant respectively. Meanwhile, mottling and yellow discoloration of leaves on 10.1-25% and 25.1-50% of the plants were moderately susceptible and susceptible respectively. Severe yellow mottling on more than 50% and up to 100% of the plants were found to be stunted of plants as well as failure of flowering and fruit set occurred in highly susceptible plants. To investigate the mosaic disease progress in the field average of date wise disease incidence was made. From this data a disease progress curve was prepared.

2.3.2. Yield and yield contributing characters

Ten plants were randomly selected from each unit plot except the border lines for collection of data and the plants were tag-marked. Data for the designated yield and yield contributing characters were taken on plot and individual plant basis. The plant heights were measured from ground level to the tip of the main stem after harvest. It was expressed in cm. Number of effected nodules were counted from ten randomly selected plants of each plot and were averaged over per plant. Both fertile and empty pods from each of the sample plant per plot were counted and averaged. Average pod length was collected from the harvested pods of ten randomly selected plants. The pod length was expressed in cm. The average number of seed per pod was determined by counting seeds derived from randomly taken fifty pods per sample handled above. One hundred seeds were taken randomly from the seed lot of each plant and weighted in gram using an electric balance. Recorded from date of sowing to date when most of the plants of a plot were ready to harvest. Weight of the total grains of the sample plants in a plot were taken and averaged to determine the yield per plant data. Five healthy looking and five symptom bearing plants were randomly selected from each of the unit plot. The yield of each of the plant was recorded and finally the yields per healthy looking and symptom bearing plant were calculated. Weight of the total harvested grains per plot was calculated in grams.

3. Results and Discussion

3.1. Laboratory experiment

3.1.1. Seed health test

Indirect-ELISA confirmed that all genotypes were from TRSV, TMV, CPMV, CMV, BBSV and BBTMV (Table 2). Unfortunately, antiserum for SMV was not available in the Plant Virology Laboratory, Professor Golam Ali Fakir Seed Pathology Centre, Bangladesh Agricultural University, Mymensingh during the study (2000-2001). Thus, SMV was confirmed by ELISA at DGISP at Copenhagen, Denmark. The results of ELISA carried out with dried leaf materials; both from healthy and diseased plant confirmed the presence of SMV in different genotypes.

3.1.2. Percentage of SMV symptoms bearing seeds in different genotypes

Among 30 genotypes highest (64%) symptoms bearing seed was found in BS-14 followed by THINUNG-154 (28.25%), G-2261 (26.75%), GAURAB (24.25%) while AGS-160 showed no symptoms bearing seed followed by AGS129 (1.25%), PR-164 (1.25%), DURGA (1.75%), BS-16 (2%) and remaining others genotype revealed lower moderate level of symptoms bearing seeds. Above mentioned results were calculated based on the data obtained from number of symptom bearing seed and number of healthy looking seed (Table 2). In this
experiment, results of ELISA tests showed that the seeds and the plants in the field were free from TRSV, TMV, CPMV, CMV, BBSV and BBTMV. However, visual symptoms were confirmed by indirect ELISA and results from Andayani et al. (2011) indicated that soybean plants infected with SMV produced mosaic symptom as shown by positive reaction in indirect ELISA with SMV antiserum (Table 2).

### 3.1.3. Performance of soybean genotypes depending on seed germination, transmission, infection and reduction in seed weight

Considering germination percentage, BS-14 was recorded highest (98.33%) germination followed by Acadian (97.66%), Williams (97.66%), Sau-Luis (96.67%), G-2261 (96.67%), G-2120 (96.67%), ACAGS-154 (96.67%), EC-1178 (95%) and Gaurab (95%) exhibiting statistically similar. BS-29 showed lowest (36.67%) germination while others were in moderate amount of germination (Table 3). With a view to percent seed transmission, highest (15.07%) seed transmission was found in Gaurab which was statistically similar to G-2120 and the lowest was found in TG-893 (1.5%) which was statistically similar to AGS-129, BS-32, and CM (Table 3). According to Balgude et al. (2012), SMV was accounted for 6-8% seed transmission in soybean, whereas in our case seed transmission was found 1.3 to 16%. Despite the presence of mottled or symptom bearing seeds (1.25%) in the working sample of AGS-129 (Table 6) there was no disease incidence in the field. The reason is that when the seed coat is only infected (producing typical mottling symptom) the seed transmission to seedling does not take place as Khetarpal et al. (1992) showed, to transmit from seed to seedling, an embryo must be infected. On the other hand, AGS-129 may be a very good tolerant genotype, not really resistant. That's why it did not produce any symptom. A positive correlation was found between the percentage of symptom bearing seed and seed transmission indicating one percent increase in symptoms bearing seed leads to 0.075 percent seed transmission, when symptoms bearing seed was more than 60% then seed transmission was 19.314 (Figure 2E). Moreover, a negative correlation was found between the percentage of symptom bearing seed and seed germination revealing one percent increase in symptoms bearing seed accounted for 0.160% reduction of germination (Figure 1A). In terms of percent seed infection, BS-29 was responsible for highest (64%) infection while minimum seed infection was found in AGS-160 followed by AGS-129 (1.25%), PR-164 (1.25%). The highest reduction in seed weight was recorded in Gaurab (56.65%) and the lowest seed weight reduction was found in AGS-160 followed by PB-1 (0.36%), others genotypes were recorded moderate to lower reduction in seed weight. Negative correlation was observed between the percentage of reduction in seed weight and yield (g/plant) showing one percent decrease of reduction in seed weight resulted in 0.0089% decrease of yield (Figure 2D). Earlier research revealed that identifying sources of YMV resistance is a viable strategy for addressing this viral disease. Numerous researchers have previously identified similar types of genotype analyses (Kumar et al., 2008; Talukdar et al., 2013; Baruah et al., 2014).

### 3.2. Field experiment

#### 3.2.1. Disease incidence and disease severity

The highest (15.3%) disease incidence was calculated in G-2120 followed by Bs-29 (9%) and BS-23 (8.3%) which were statistically similar. No disease incidence was recorded in AGS-129 and rest of the genotypes showed lower to moderate level of incidence (Table 6). Disease incidence differences among the genotypes were found highly significant which is in an agreement with the findings of Bachkar et al. (2019) as well. On the other hand, AGS-129 may be a very good tolerant genotype, not really resistant. That's why it did not produce any symptom. It was also interesting to note that genotype AGS-160 did not have mottled seeds in the working sample but disease incidence (1.5%) due to seed transmission was observed (Table 6). This reveals the fact that, unmottled seeds of seeds producing without seed coat symptom are not necessarily healthy. Similar findings were obtained by Parakh et al. (1994). Leaves showing different levels of severity as compared with the healthy leave [Figure 1 (A-E)]. Disease severity was recorded according to Singh et al. (1988) which conceded that out of 30 genotypes only one genotype (AGS-129) showed resistance with a grading scale one while ten genotypes (PR-164, AGS-160, G-2261, Williams, Durga, Ec-1178, ACAGS-154, BS-32, BS-10 and CM) were under the group of grading three exhibiting moderately resistance (MR). Ten genotypes (Colombus, BS-11, THINUNG-154, G-2120, BS-23, BS-15, BS-16, BS-60, Sau-Luis and TG-893) were recorded as moderately susceptible having grading scale five while nine (Gaurab, Acadian, PB-1, BS-13, BS-14, Cobb, BS-29, CH-1 and BS-17) genotypes were recorded as susceptible having grading scale seven (Table 5). Bachkar et al. (2019) screened 36 varieties against the disease, among them two were resistant, seven moderately resistant;
twenty moderately susceptible, five susceptible while two varieties recorded highly susceptible reaction to SMV. Akhtar et al. (1992) conducted an SMV resistance screening on twelve cultivars. Four cultivars (Crow ford, Cico, Zane, and 80-B4007) were shown to be viral resistant. Zheng et al. (2000) evaluated 348 soybean accessions for resistance to soybean mosaic virus (SMV) using SMV3, a highly pathogenic strain from north east China. 113 accessions were found to be very resistant, 113 to be moderately resistant, and 122 to be vulnerable. Shirirao et al. (2009) tested 16 genotypes and discovered that 14 were completely resistant to SMV and two were extremely resistant. Positive correlation was observed between the percentage of disease incidence and seed transmission which showed one percent increase of seed transmission resulted in 0.547 percent increases of disease incidence (Figure 2B). SMV strain, soybean cultivar, soybean development stage, and the incidence of infection all play a role in the magnitude of yield loss caused by SMV (Ross, 1983).

### 3.2.2. Yield of healthy-looking plant and symptom bearing plant

Highest yield of healthy-looking plant was found in CM (9.977%) followed by TG-893 (9.943%), ACAGS-154 (9.897%), BS-10 (9.723%), BS-32 (9.573) and G-2261 (9.387%) exhibiting statistically identical while the lowest was found in BS-29 (3.330%). Highest yield of symptom bearing plant was found in BS-10 (8.74%) and lowest yield was found in BS-29 (0.903%) followed by BS-16 (1.720%) (Table 6). A negative correlation was observed between seed transmission and yield conceded that one percent increase in seed transmission reduces 0.245 g yield/plant (Figure 2B). Understanding the relationship between grain yield and other characteristics aids in selecting the most suitable plant type (Adiya et al., 2011). There is considerable genetic variation across soybean genotypes in terms of leaf area (cm), days to flowering initiation, days to blooming, and days to maturity, Plant height (cm) Pods/plant, Branches/plant, 100-seed weight (g), Seed yield/plant (g) Oil content (%) were observed by various researchers in different countries (Sihag et al., 2004, Chettri et al., 2005, Muhammad et al., 2003, Malik et al., 2006).

### 3.2.3. Plant height and Number of effective nodules per plant, Pod/plant, Pod length and Seeds per pod

Considering plant height, the top most height (69.60 cm) was recorded in Gaurab followed by THINUNG-154 (64.13cm), BS-11 (59.32%), EC-1178 (56.82%) and ACAGS-154 (56.82%) representing statistically identical data while the minimal plant height (12.63 cm) was found in PB-1 which were statistically similar to BS-60, BS-23, BS-16, BS-29, Acadian, BS-10 and BS-13. Moreover, others genotype exhibited moderate plant height (Table 7). PR-164 showed best (32.23) number of effective nodules per plant while the lowest was found in AGS-129 (3.95), remaining genotypes showed lower to moderate number of effective nodules per plant. Highest number of pods per plant was found in ACAGS-154 which was statistically similar to EC-1178, Williams, Acadian, G-2261, Gaurab, Thinung-154, Sau-Luis, G-2120 and CM. The lowest number of pods per plant was found in PB-1 which was statistically similar to BS-60 and BS-29 (Table 7). The highest (4.747) pod length was found in BS-32 followed by BS-15 (4.653), BS-11 (4.643), AGS-160 (4.593), Durga (4.520), AGS-129 (4.467), BS-29 (4.373), Cobb (4.330), PR-164 (4.300), BS-60 (4.277) and TG-893 (4.23) while the lowest was found in PB-1 (2.897), rest of the genotypes resulted moderate pod length(Table 7). The highest number of seeds per pod was found in Williams (3.023) which was statistically similar to G-2120, G-2261, Acadian, ACAGS-154, Thinung-154, Gaurab and CM whereas the lowest was found in BS-17 (1.167). Genotypes were accounted for insignificant results considering plant height and number of effective nodules per plant, pod/plant, pod length and seeds per pod, as these genotypes showed moderate susceptible (MS) to susceptible (S) reaction which is in accordance with the results of Naveesh et al. (2020), they also observed susceptible genotypes showing pronounced yellow mottling discoulouration of leaves, reduction in leaf size and stunting of plants and reduction in pod size. According to Baruah et al. (2014), found Pod weight was substantially and positively linked with the number of seeds and pods/plant. Malik et al. (2011) found a similar result in terms of days to maturity and days to flowering. Baruah et al. (2014) also revealed that increased seed yield/plant was associated with increase in 100-seed weight which in turn showed negative correlation with number of pods/plant and seeds/plant.
Table 1. List of soybean genotypes with their country of origin.

| Serial No. | Genotypes   | Country of Origin            | Indirect ELISA | ELISA for SMV |
|------------|-------------|------------------------------|----------------|---------------|
| 1          | COLOMBUS    | USA                          | +              | +             |
| 2          | BS-11       | Bangladesh (BCSRP)           | +              | +             |
| 3          | PR-164      | USA                          | +              | +             |
| 4          | GAURAB      | India                        | +              | +             |
| 5          | THINUNG-154 | AVRDC                        | +              | +             |
| 6          | G-2120      | AVRDC                        | +              | +             |
| 7          | AGS-160     | AVRDC                        | +              | +             |
| 8          | BS-23       | Bangladesh (BCSRP)           | +              | +             |
| 9          | BS-15       | Bangladesh (BCSRP)           | +              | +             |
| 10         | ACADIAN     | USA                          | +              | +             |
| 11         | G-2261      | AVRDC                        | +              | +             |
| 12         | WILLIAMS    | USA                          | +              | +             |
| 13         | BS-16       | Bangladesh (BCSRP)           | +              | +             |
| 14         | BS-60       | Bangladesh (BCSRP)           | +              | +             |
| 15         | PB-1        | India                        | +              | +             |
| 16         | BS-13       | Bangladesh (BCSRP)           | +              | +             |
| 17         | DURGA       | India                        | +              | +             |
| 18         | EC-1178     | USA                          | +              | +             |
| 19         | SAU-LUIS    | Philippines                  | +              | +             |
| 20         | ACAGS-154   | AVRDC                        | +              | +             |
| 21         | BS-32       | Bangladesh (BCSRP)           | +              | +             |
| 22         | BS-14       | Bangladesh (BCSRP)           | +              | +             |
| 23         | COBB        | USA                          | +              | +             |
| 24         | BS-29       | Bangladesh (BCSRP)           | +              | +             |
| 25         | BS-10       | Bangladesh (BCSRP)           | +              | +             |
| 26         | CH-1        | USA                          | +              | +             |
| 27         | TG-893      | Thailand                     | +              | +             |
| 28         | CM          | AVRDC                        | +              | +             |
| 29         | BS-17       | Bangladesh (BCSRP)           | +              | +             |
| 30         | AGS-129     | AVRDC                        | +              | +             |
Table 2. Percentage of symptom bearing seeds in different genotypes of soybean.

| Sl. No. | Name of genotypes | No. of symptom bearing seed | No. of healthy-looking seed | % Symptoms bearing seed |
|---------|-------------------|-----------------------------|----------------------------|------------------------|
| 1       | COLOMBUS          | 24                          | 376                        | 6                      |
| 2       | BS-11             | 15                          | 385                        | 3.75                   |
| 3       | PR-164            | 5                           | 395                        | 1.25                   |
| 4       | GAURAB            | 97                          | 303                        | 24.25                  |
| 5       | THINUNG-154       | 113                         | 287                        | 28.25                  |
| 6       | G-2120            | 104                         | 296                        | 26                     |
| 7       | AGS-160           | 0                           | 400                        | 0.000                  |
| 8       | BS-23             | 7                           | 393                        | 1.75                   |
| 9       | BS-15             | 20                          | 380                        | 5                      |
| 10      | ACADIAN           | 45                          | 355                        | 11.25                  |
| 11      | G-2261            | 107                         | 293                        | 26.75                  |
| 12      | WILLIAMS          | 37                          | 263                        | 9.25                   |
| 13      | BS-16             | 8                           | 392                        | 2                      |
| 14      | BS-60             | 18                          | 382                        | 4.5                    |
| 15      | PB-1              | 15                          | 385                        | 3.75                   |
| 16      | BS-13             | 14                          | 386                        | 3.5                    |
| 17      | DURGA             | 7                           | 393                        | 1.75                   |
| 18      | EC-1178           | 88                          | 312                        | 22                     |
| 19      | SAU-LUIS          | 35                          | 365                        | 8.75                   |
| 20      | ACAGS-154         | 60                          | 340                        | 15                     |
| 21      | BS-32             | 80                          | 320                        | 20                     |
| 22      | BS-14             | 38                          | 362                        | 9.5                    |
| 23      | COBB              | 30                          | 370                        | 7.5                    |
| 24      | BS-29             | 256                         | 144                        | 64                     |
| 25      | BS-10             | 50                          | 350                        | 12.5                   |
| 26      | CH-1              | 24                          | 376                        | 6                      |
| 27      | TG-893            | 16                          | 384                        | 4                      |
| 28      | CM                | 7                           | 393                        | 1.75                   |
| 29      | BS-17             | 15                          | 385                        | 3.75                   |
| 30      | AGS-129           | 5                           | 395                        | 1.25                   |

Each sample contain 400 seeds
Table 3. Performance of 30 selected soybean genotypes: percentage of seed germination, transmission, infection and reduction in seed weight.

| Sl. No. | Name of genotypes | % of germination | % of seed transmission | % Seed infection | % Reduction in seed weight |
|---------|-------------------|------------------|------------------------|-----------------|--------------------------|
| 1       | COLOMBUS          | 65.00 gh         | 5.000 k                | 6.000 jkl       | 11.67 hijk               |
| 2       | BS-11             | 76.67 def        | 6.000 j                | 3.750 lmno      | 43.47 c                  |
| 3       | PR-164            | 56.67 h          | 3.033 mn               | 1.250 op        | 50.16 b                  |
| 4       | GAURAB            | 95.00 a          | 15.07 a                | 24.25 cd        | 56.65 a                  |
| 5       | THINUNG-154       | 91.67 ab         | 7.000 i                | 28.25 b         | 7.770 klm                |
| 6       | G-2120            | 96.67 a          | 14.97 a                | 25.67 bc        | 2.243 mn                 |
| 7       | AGS-160           | 81.67 cde        | 2.333 no               | 0.000 p         | 0.000 n                  |
| 8       | BS-23             | 80.00 def        | 12.57 b                | 1.750 nop       | 32.90 ef                 |
| 9       | BS-15             | 78.33 def        | 13.00 b                | 5.000 klm       | 31.03 efg                |
| 10      | ACADIAN           | 97.66 a          | 11.00 c                | 11.25 gh        | 11.19 hijk               |
| 11      | G-2261            | 96.67 a          | 3.500 lm               | 26.75 bc        | 8.903 kl                 |
| 12      | WILLIAMS          | 97.66 a          | 4.067 l                | 9.250 hi        | 5.533 klmnn              |
| 13      | BS-16             | 58.33 h          | 7.000 i                | 2.000 mnop      | 9.930 ijk                |
| 14      | BS-60             | 73.33 efg        | 11.00 e                | 4.500 lmn       | 4.503 lmm                |
| 15      | PB-1              | 75.00 ef         | 8.967 fg               | 3.750 lmlno     | 0.360 n                  |
| 16      | BS-13             | 92.00 ab         | 8.033 h                | 3.500 lmlno     | 27.27 fg                 |
| 17      | DURGA             | 85.00 bcd        | 3.767 lm               | 1.750 nop       | 16.42 h                  |
| 18      | EC-1178           | 95.00 a          | 3.067 mn               | 22.00 de        | 7.070 klm                |
| 19      | SAU-LUIS          | 96.67 a          | 7.167 i                | 8.750 hij       | 38.58 cd                 |
| 20      | ACAGS-154         | 96.67 a          | 3.100 mn               | 15.00 f         | 9.340 jkl                |
| 21      | BS-32             | 90.00 abc        | 1.733 o                | 20.00 e         | 15.50 hi                 |
| 22      | BS-14             | 98.33 a          | 12.97 b                | 9.500 hi        | 15.18 hij                |
| 23      | COBB              | 85.00 bcd        | 8.633 gh               | 7.600 ijk       | 16.55 a                  |
| 24      | BS-29             | 36.67 i          | 11.13 c                | 64.00 a         | 28.56 efg                |
| 25      | BS-10             | 60.00 h          | 9.567 ef               | 12.50 fg        | 4.483 lmn                |
| 26      | CH-1              | 78.33 def        | 10.53 cd               | 5.980 jkl       | 33.94 de                 |
| 27      | TG-893            | 80.00 def        | 1.500 o                | 4.000 lmlno     | 26.73 g                  |
| 28      | CM                | 93.33 ab         | 1.900 o                | 1.750 nop       | 25.17 g                  |
| 29      | BS-17             | 71.67 fg         | 9.867 de               | 3.750 lmlno     | 29.52 efg                |
| 30      | AGS-129           | 80.00 def        | 1.600 o                | 1.250 op        | 43.29 c                  |
| CV      | 173.46            | 173.17           | 173.52                 | 173.44          |
| LSD     | 3.0212            | 0.5814           | 1.072                  | 1.275           |
Table 4. Performance of 30 selected Soybean genotypes: yield and yield contributing characters.

| Sl. No. | Name of genotypes | 100 seed weight (g) | Days to maturity | Yield/plant (g) | Yield/plot (g) |
|---------|-------------------|---------------------|-----------------|----------------|---------------|
| 1       | COLOMBUS          | 12.33 klm           | 140.0 e         | 5.200 defghij  | 783.3 ghijk   |
| 2       | BS-11             | 16.67 defg          | 140.0 e         | 6.500 bcdefgh  | 791.7 ghij    |
| 3       | PR-164            | 17.00 def           | 160.0 e         | 6.667 abcdefgh | 858.3 fgh     |
| 4       | GAURAB            | 6.667 o             | 121.0 j         | 6.900 abcdefgh | 865.0 fgh     |
| 5       | THINUNG-154       | 7.000 o             | 121.0 j         | 6.750 abcdefgh | 870.0 fgh     |
| 6       | G-2120            | 6.333 o             | 121.0 j         | 6.317 cdefgh   | 693.3 ijk     |
| 7       | AGS-160           | 21.00 a             | 149.3 a         | 7.033 abcdefg  | 1083.0 cd     |
| 8       | BS-23             | 13.00 jklm          | 117.0 k         | 3.823 hij      | 820.0 ghi     |
| 9       | BS-15             | 16.33 efjh          | 140.0 k         | 6.633 abcdefgh | 790.0 ghi     |
| 10      | ACADIAN           | 5.333 o             | 135.0 g         | 7.483 abcde    | 980.0 def     |
| 11      | G-2261            | 5.667 o             | 132.0 h         | 8.300 abcde    | 115.0 bc      |
| 12      | WILLIAMS          | 6.667 o             | 124.3 i         | 8.217 abcde    | 1083.0 cd     |
| 13      | BS-16             | 14.33 hijk          | 122.0 j         | 2.753 ij       | 795.0 ghi     |
| 14      | BS-60             | 13.67 ikl           | 121.0 j         | 4.017 ghi      | 753.3 hijkl   |
| 15      | PB-1              | 11.00 mn            | 145.3 c         | 5.660 defghi   | 646.7 kl      |
| 16      | BS-13             | 17.00 def           | 138.7 ef        | 4.200 fghij    | 613.3 l       |
| 17      | DURGA             | 21.00 a             | 146.0 bc        | 7.167 abcdefg  | 1103.0 bcd    |
| 18      | EC-1178           | 6.000 o             | 122.0 j         | 7.367 abcde    | 1017.0 cde    |
| 19      | SAU-LUIS          | 9.667 n             | 121.0 j         | 7.733 abcde    | 906.7 efg     |
| 20      | ACAGS-154         | 6.667 o             | 121.0 j         | 9.050 abc      | 1155.0 bc     |
| 21      | BS-32             | 20.67 ab            | 138.7 ef        | 9.250 abc      | 1233.0 ab     |
| 22      | BS-14             | 14.67 ghij          | 120.0 j         | 5.317 defghi   | 710.0 ikl     |
| 23      | COBB              | 18.33 cde           | 140.0 e         | 6.937 abcdefgh | 916.7 efg     |
| 24      | BS-29             | 14.67 ghij          | 117.0 k         | 2.333 j        | 450.0 m       |
| 25      | BS-10             | 18.67 bcd           | 146.0 e         | 9.533 ab       | 1313.0 a      |
| 26      | CH-1              | 13.00 jklm          | 118.0 k         | 5.120 defghi   | 738.0 hijkl   |
| 27      | TG-893            | 20.33 abc           | 148.0 ab        | 9.167 abc      | 993.3 def     |
| 28      | CM                | 12.00 lm            | 147.0 bc        | 9.833 a        | 1327.0 a      |
| 29      | BS-17             | 15.33 fghi          | 137.3 f         | 5.017 efghi    | 670.0 jkl     |
| 30      | AGS-129           | 20.33 abc           | 143.3 d         | 8.033 abcde    | 1143.0 bc     |
| CV      | 173.59            | 173.36              | 169.46          | 173.09         |
| LSD     | 1.154             | 2.634               | 0.8             | 1.549          |
Table 5. Disease severity of different genotypes of soybean.

| SL No. | Name of genotypes | Grading | Disease incidence (%) | Reaction |
|--------|-------------------|---------|-----------------------|----------|
| 1      | COLOMBUS          | 5       | 1.8 gh                | MS       |
| 2      | BS-11             | 5       | 1.9 gfh               | MS       |
| 3      | PR-164            | 3       | 2.3 fgh               | MR       |
| 4      | GAURAB            | 7       | 7.9 bc                | S        |
| 5      | THINUNG-154       | 5       | 3.0 fg                | MS       |
| 6      | G-2120            | 5       | 15.3 a                | MS       |
| 7      | AGS-160           | 3       | 1.5 gh                | MR       |
| 8      | BS-23             | 5       | 8.3 b                 | MS       |
| 9      | BS-15             | 5       | 5.9 cde               | MS       |
| 10     | ACADIAN           | 7       | 3.6 efg               | S        |
| 11     | G-2261            | 3       | 2.3 fgh               | MR       |
| 12     | WILLIAMS          | 3       | 2.6 fg                | MR       |
| 13     | BS-16             | 5       | 4.1 efg               | MS       |
| 14     | BS-60             | 5       | 4.5 def               | MS       |
| 15     | PB-1              | 7       | 3.1 fg                | S        |
| 16     | BS-13             | 7       | 3.6 efg               | S        |
| 17     | DURGA             | 3       | 2.1 fgh               | MR       |
| 18     | EC-1178           | 3       | 2.2 fgh               | MR       |
| 19     | SAU-LUIS          | 5       | 3.5 efg               | MS       |
| 20     | ACAGS-154         | 3       | 2.6 fg                | MR       |
| 21     | BS-32             | 3       | 2.2 fgh               | MR       |
| 22     | BS-14             | 7       | 6.7 bcd               | S        |
| 23     | COBB              | 7       | 2.8 fg                | S        |
| 24     | BS-29             | 7       | 9.0 b                 | S        |
| 25     | BS-10             | 3       | 6.8 bcd               | MR       |
| 26     | CH-1              | 7       | 3.7 efg               | S        |
| 27     | TG-893            | 5       | 3.2 fg                | MS       |
| 28     | CM                | 3       | 2.4 fgh               | MR       |
| 29     | BS-17             | 7       | 3.1 fg                | S        |
| 30     | AGS-129           | 1       | 0.0 h                 | R        |
| CV     |                   |         | 173.34                |          |
| LSD    |                   |         | 0.9462                |          |
Table 6. Performance of 30 selected Soybean genotypes: percentage of disease incidence, Yield of healthy-looking and symptom bearing plant and plant height.

| Sl. No. | Name of genotype | Disease incidence (%) | Yield of healthy-looking plant (g) | Yield of symptom bearing plant (g) |
|---------|------------------|------------------------|-----------------------------------|-----------------------------------|
| 1       | COLOMBUS         | 1.8 gh                 | 5.837 g                           | 4.253 mm                          |
| 2       | BS-11            | 1.9 gfh                | 7.600 def                         | 4.860 kl                          |
| 3       | PR-164           | 2.3 fgh                | 7.423 ef                          | 5.693 i                           |
| 4       | GAURAB           | 7.9 bc                 | 8.397 bc                          | 4.570 lm                          |
| 5       | THINUNG-154      | 3.0 fg                 | 7.320 f                           | 5.560 ij                          |
| 6       | G-2120           | 15.3 a                 | 7.197 f                           | 4.313 mm                          |
| 7       | AGS-160          | 1.5 gh                 | 7.257 f                           | 6.497 h                           |
| 8       | BS-23            | 8.3 b                  | 8.623 b                           | 5.680 i                           |
| 9       | BS-15            | 5.9 cde                | 7.200 f                           | 5.140 ijk                         |
| 10      | ACADIAN          | 3.6 efg                | 7.657 cdef                         | 5.290 ijk                         |
| 11      | G-2261           | 2.3 fgh                | 9.387 a                           | 7.587 de                          |
| 12      | WILLIAMS         | 2.6 fg                 | 8.357 bcd                         | 7.327 ef                          |
| 13      | BS-16            | 4.1 efg                | 3.377 j                           | 1.720 s                           |
| 14      | BS-60            | 4.5 def                | 4.330 i                           | 3.127 q                           |
| 15      | PB-1             | 3.1 fg                 | 5.830 g                           | 4.103 n                           |
| 16      | BS-13            | 3.6 efg                | 4.593 hi                           | 2.433 r                           |
| 17      | DURGA            | 2.1 fgh                | 7.637 cdef                         | 6.657 gh                          |
| 18      | EC-1178          | 2.2 fgh                | 7.797 cdef                         | 6.967 fg                          |
| 19      | SAU-LUIS         | 3.5 efg                | 8.327 bcd                         | 6.607 gh                          |
| 20      | ACAGS-154        | 2.6 fg                 | 9.897 a                           | 8.453 ab                          |
| 21      | BS-32            | 2.2 fgh                | 9.573 a                           | 8.087 bc                          |
| 22      | BS-14            | 6.7 bcd                | 5.913 g                           | 3.617 o                           |
| 23      | COBB             | 2.8 fg                 | 7.870 bcdef                        | 5.353 ij                          |
| 24      | BS-29            | 9.0 b                  | 3.330 j                           | 0.903 t                           |
| 25      | BS-10            | 6.8 bcd                | 9.723 a                           | 8.740 a                           |
| 26      | CH-1             | 3.7 efg                | 6.137 g                           | 3.583 op                          |
| 27      | TG-893           | 3.2 fg                 | 9.943 a                           | 7.740 cde                         |
| 28      | CM               | 2.4 fgh                | 9.977 a                           | 7.943 cd                          |
| 29      | BS-17            | 3.1 fg                 | 5.120 h                           | 3.173 pq                          |
| 30      | AGS-129          | 0.0 h                  | 8.107 bcde                        | 7.677 cde                         |
| CV      |                  |                        | 173.41                            | 173.34                            | 173.57                            |
| LSD     |                  |                        | 0.9256                            | 0.9462                            | 0.9345                            |
Table 7. Performance of 30 selected Soybean genotypes: plant height, no. of effective nodules per plant, pods per plant, pod length and seeds per pod.

| Sl. No. | Name of genotypes | Plant height (cm) | No. of effective nodules/plant | Pods per plant | Pods length (cm) | Seeds/pod |
|---------|-------------------|------------------|-------------------------------|----------------|-----------------|-----------|
| 1       | COLOMBUS          | 49.66 bcdef      | 25.37 cde                     | 29.87 bcd      | 3.710 hijk      | 2.233 fghi  |
| 2       | BS-11             | 59.32 abc        | 17.90 hij                     | 28.59 cde      | 4.643 ab        | 2.000 ijk  |
| 3       | PR-164            | 50.30 bcdef      | 32.23 b                       | 20.73 def      | 4.300 abcddef   | 2.367 defghijk |
| 4       | GAURAB            | 69.60 a          | 12.63 efg                     | 44.00 ab       | 3.647 ijk       | 2.667 abcdfg |
| 5       | THINUNG-154       | 64.13 ab         | 18.40 hij                     | 43.17 a        | 3.707 hijk      | 2.700 abcd  |
| 6       | G-2120            | 51.01 bcdef      | 16.67 ij                      | 40.88 abc       | 3.743 ghijk     | 2.990 ab    |
| 7       | AGS-160           | 44.40 cdefg      | 28.73 e                       | 22.73 def       | 4.593 abcddef   | 2.440 cdefghijk |
| 8       | BS-23             | 25.88 hi         | 21.43 fgh                     | 18.33 defdef    | 4.020 cdefghij  | 2.067 hijk  |
| 9       | BS-15             | 42.92 cdefg      | 17.03 ij                      | 22.65 ab       | 4.653 abcddef   | 2.233 fghijk |
| 10      | ACADIAN           | 34.80 fg          | 14.84 jk                      | 46.44 a        | 3.633 ijk       | 2.833 abcd  |
| 11      | G-2261            | 47.57 cdefg      | 18.30 hij                     | 44.93 a        | 3.630 ijk       | 2.933 abc   |
| 12      | WILLIAMS          | 44.24 cdefg      | 17.87 ghi                     | 47.13 a        | 3.693 hijk      | 3.023 a     |
| 13      | BS-16             | 32.87 ghi        | 26.50 cd                      | 12.30 fg       | 3.773 k         | 1.923 kl    |
| 14      | BS-60             | 25.13 hi         | 24.93 def                     | 19.40 def      | 4.277 abcddef   | 2.287 efghijk |
| 15      | PB-1              | 12.63 i          | 8.90 l                        | 3.50 g         | 2.897 1         | 1.567 1     |
| 16      | BS-13             | 35.98 fg         | 18.87 ghi                     | 19.78 def      | 3.883 efghijk   | 1.933 kl    |
| 17      | DURGA             | 47.35 cdefg      | 19.00 ghi                     | 46.44 a        | 4.520 abc       | 2.233 fghijk |
| 18      | EC-1178           | 56.82 abcd       | 19.50 ghi                     | 47.44 a        | 3.497 jk        | 2.500 bcddefghi |
| 19      | SAU-LUIS          | 46.93 cdefg      | 22.73 efg                     | 43.00 ab       | 3.800 fghijk    | 2.167 ghijk |
| 20      | ACAGS-154         | 55.83 abcd       | 18.27 hij                     | 52.93 a        | 3.803 fghijk    | 2.767 abcd  |
| 21      | BS-32             | 45.70 cdefg      | 24.90 def                     | 30.13 bcd      | 4.747 a         | 1.9667 jkl  |
| 22      | BS-14             | 44.97 cdefg      | 18.60 hij                     | 26.40 def      | 3.940 defghij   | 2.267 efghijk |
| 23      | COBB              | 39.91 defgh       | 14.63 ji                      | 28.43 cde      | 4.330 abcddef   | 2.100 hij   |
| 24      | BS-29             | 34.68 fg          | 17.80 hij                     | 14.63 efg      | 4.373 abcddef   | 2.100 hij   |
| 25      | BS-10             | 35.92 fg          | 20.53 ghi                     | 23.80 def      | 4.183 abcddefghi| 2.233 fghijk |
| 26      | CH-1              | 41.532 defgh      | 20.53 ghi                     | 24.77 def      | 4.110 bcddefghi | 2.000ijkl  |
| 27      | TG-893            | 44.07 cdefg      | 27.67 cd                      | 30.47 bcd      | 4.233 abcddefghi| 2.433 cdefghijk |
| 28      | CM                | 48.08 bcdefg      | 12.33 kl                      | 40.78 abc      | 3.997 cdefghijk | 2.550 abcddefgh |
| 29      | BS-17             | 39.23 efgh        | 9.28 l                        | 20.12 def      | 4.030 cdefghijk | 1.167 ghijk |
| 30      | AGS-129           | 40.90 defgh       | 3.950 a                       | 25.47 def      | 4.467 abcd      | 2.483 cdefghijk |
| CV      | 173.31            | 171.64           | 173.76                        | 173.48         | 173.30          |           |
| LSD     | 1.1662            | 1.037            | 0.9188                        | 0.6324         | 0.4744          |           |
Figure 1. Soybean leaves showing mosaic symptoms of different levels of severity (B-E) compared to healthy looking leaves (A), healthy looking (F) and symptoms bearing pods (G) that are smaller, discolored, mottled and having less number of seeds, healthy looking (H) and symptoms bearing mottled seeds (I) of BS-29 genotype.

Figure 2. Regression analyses showing the relationship a) between % of symptom bearing seed and germination, b) % of seed transmission and disease incidence, c) % of seed transmission and yield (g/plant) d) % of reduction in seed weight and yield (g/plant) and e) % of symptom bearing seed and seed transmission.
4. Conclusions
SMV's growing impact on soybeans underscores the importance of introducing SMV resistance into Bangladeshi soybeans. 11 genotypes viz. AGS-129, AGS-160, G-2261, Williams, CM, Durga, EC-1178, ACAGS-154, BS-32, BS-10 and PR-164 cultivars can be selected to locate resistant genes against SMV while the remaining cultivars experienced an increase in disease severity and incidence. However, more research is needed to identify the resistance sources of these soybean genotypes and to further validate them before they can be applied in breeding programs.

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Conflict of interest
None to declare.

Authors' contribution
Uttam Kumar Mozumdar: methodology, data collection, analysis and draft manuscript writing; Md. Mostafa Masud: draft manuscript writing and revision; Mamuna Mahjabin Mita: draft manuscript writing; Samrin Bashar: draft manuscript writing; Md. Mahboob Hossain: conceptualization and supervision; M. Ashrafuzzaman: conceptualization and supervision; Md. Rashidul Islam: supervising the draft writing and final editing. All authors have read and approved the final manuscript.

References
Adiya JP, P Bhartiya and A Bhartiy, 2011. Genetic variability, heritability and character association for yield and component characters in soybean (G. max (L.) Merrill). J. Cent. Eur. Agric., 12: 27-34.
Akhtar A, H Sher, A Ali and S Hassan, 1992. Biological characterization of soybean mosaic virus. Sarhad J. Agric., 8: 555-561.
Andayani WR, YB Sumardiyono, S Hartono and P Yudono, 2011. Incidence of soybean mosaic disease in East Java Province. AGRIVITA J. Agric. Sci., 33: 15-21.
Bachkar CB, YS Balgude, PB Shinde and CD Deokar, 2019. Screening of soybean genotypes against soybean mosaic virus under natural and glass house conditions. Int. J. Commun. Syst., 7: 2267-2269.
Balgude YS, Sawant DM and AP Gaikwad, 2012. Transmission studies of Soybean mosaic virus. J. Plant Dis. Sci., 7: 52-54.
Baruah S, MK Sharma, D Baishya, AA Sharma, R Borah and Bhuyan, 2014. Genetic variation for seed yield and yellow mosaic virus resistance in soybean [Glycine max (L.) Merrill]. Int. J. Sci. Res., 4: 1-5.
Bowers JrG R and RM Goodman, 1979. Soybean mosaic virus: infection of soybean seed parts and seed transmission. Phytopathology, 69: 569-572.
Bowers JrGR, and RM Goodman, 1991. Strain specificity of soybean mosaic virus seed transmission in soybean. Crop Sci., 3: 1171-1174.
Chettri MS, Mondal and R Nath, 2005. Studies on genetic variability in soybean (Glycine max (L.) Merril) in the mid hills of Darjeeling District. J. Interacademia., 9: 175-178.
Domier LL, TA Steinlage, HA Hobbs, Y Wang, G Herrera-Rodriguez, JS Haudenshield and GL Hartman, 2007. Similarities in seed and aphid transmission among Soybean mosaic virus isolates. Plant Dis., 91: 546-550.
FAOSTAT, 2017. Food and Agriculture Organization. (www.fao.org/faostat/en/#data/qc).
Galvez LC, J Banerjee, H Pinar and A Mitra, 2014. Engineered plant virus resistance. Plant Sci., 228: 11-25.
Gibbs BF, A Zougman, R Masse, C Mulligan, 2004. Production and characterization of bioactive peptides from soy hydrolysate and soy-fermented food. Food Res Int., 37: 123-131.
Hajimorad M, LL Domier, S Tolin, S Whitham, M SaghaiMaroof, 2018. Soybean mosaic virus: a successful potyvirus with a wide distribution but restricted natural host range. Mol. Plant Pathol., 19: 1563–1579.
Hill JH, 1999. Soybean Mosaic Virus. In: Hartman GL, Sinclair JB, Rupe JC (eds) Compendium of soybean diseases. The American Phytopathological Society, St. Paul, MN, pp. 70–71.
Khetarpal RK, DB Parakh, S Singh and R Nath, 1992. ELISA detection of soybean mosaic virus in testas, embryos and seedlings from mottled and unmottled seeds of imported soybean germplasm. Indian J. Virol., 8: 106-110.
Kumar B, A Talukdar, K Verma, V Girmilla, I Bala, SK Lal, KP Singh and RL Sapra, 2008. Screening of soybean \textit{[Glycine max (L.) Merr.]} genotypes for yellow mosaic virus (YMV) disease resistance and their molecular characterization using RGA and SSRs markers. Aust. J. Crop Sci., 8: 27-34.
Malik MFA, AS Qureshi, A Muhammad and G Abdul, 2006. Genetic variability of the main yield related characters in soybean. Int. J. Agric. Biol., 8: 815-819.
Malik MF, A Muhammad, SA Qureshi, M Ashraf and MR Khan, 2011. Investigation and comparison of some morphological traits of the soybean populations using cluster analysis. Pak. J. Bot., 43: 1249-1255.
Miah MAM and MRI Mondal, 2017. Oilseeds sector of Bangladesh: challenges and opportunities. SAARC J. Agri., 15: 161-172.
Mondal RI and A Wahhab, 2001. Production technology of oilcrops. Oilseed Research Centre.
Muhammad A and P Shah, 2003. Comparative yield and yield components of land races and improved varieties of soybean. Sarhad J. Agric, 19: 459-461.
Naveesh YB, HA Frameela, S Basavaraj and KT Rangaswamy, 2020. Screening of Soybean Genotypes to Soybean Yellow Mosaic Virus Disease. Int. J. Curr. Microbiol. App. Sci., 9: 2070-2076.
Parakh DB, RK Khetarpal, S Singh and R Nath, 1994. Post entry quarantine detection of soybean mosaic virus by ELISA in soybean germplasm. Indian J. Virol., 10: 17-21.
Rahman L, 1982. Cultivation of soybean and its uses. Citypress, Dhaka, 5-7.
Ross JP, 1983. Effect of Soybean Mosaic on Component Yields from Blends of Mosiac Resistant and Susceptible Soybeans 1. Crop Sci., 23: 343-346.
Salam MA and M Kamruzzaman, 2015. Comparative and competitive advantage of soybean cultivation in Noakhali and Laxmipur District of Bangladesh. J. Bangladesh Agric. Univ., 13: 265-272.
Satter MA, 2001. Biofertilizers in Bangladesh: problem and prospect. Proc. 3rd Nat. Workshop on Pulses, 11-12.
Shrirao AV, DB Gawade, RA Shrirao, SP Patil and AC Khote, 2009. Evaluation of soybean genotypes against the major diseases. J. Plant Dis. Sci., 4: 92-94.
Sihag R, JS Hooda, RD Vashishtha and BPS Malik, 2004. Genetic divergence in soybean \textit{[Glycine max (L.) Merrill]}. Ann. Biol., 20: 17-21.
Sinclair JB, 1994. Reducing losses from plant diseases. World Soybean Research Conference V. In Abstracts, pp. 10.
Singh BR, PP Singh, MD Vyas, AK Sharma, HB Grewal and OP Girothia, 1988. Yield loss of mungbean due to yellow mosaic. Indian J. Puls. Res., 11: 124-127.
Song P, H Zhi, B Wu, X Cui and X Chen, 2016. Soybean Golgi SNARE 12 protein interacts with Soybean mosaic virus encoded P3N-PIPO protein. Biochem. Biophys. Res. Commun., 478: 1503–1508.
Steel RGD and JH Torrie, 1960. Principles and procedures of statistics. McGraw Hill Book Co. Inc. New York. pp. 107-109.
Talukdar A, GD Harish, M Shivakumar, B Kumar, K Verma, SK LAL, RL Sapra and KP Singh, 2013. Genetics of yellow mosaic virus resistance in cultivated soybean. Legume Res., 36: 263-267.
USDA (United States Department of Agriculture), 2018a. Basic Report: 11450, Soybeans, green, raw. Agricultural Research Service. National Nutrient Database for Standard Reference Legacy Release.
USDA (United States Department of Agriculture), 2018b. Basic Report: 16108, Soybeans, mature seeds, raw. Agricultural Research Service. National Nutrient Database for Standard Reference Legacy Release.
Wilcox JR, 2004. World distribution and trade of soybean. Soybeans: improvement, production, and uses, 16: 1-14.
Zheng Z, R Chang, L Qui, Z Wu and F Gao, 2000. Identification of the resistance of soybean germplasm to SMV3. Soybean Sci., 19: 299-306.