Bean Pod Mottle Virus (BPMV) (Genus *Comovirus*): A Limiting Factor in the Production of Soybean (*Glycine max* (L) Merril) in Humid Tropical Zone of Nigeria

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Abstract

The reactions of twenty soybean varieties to infection with Bean Pod Mottle Virus (BPMV) (Genus Comovirus) disease were studied for 2 consecutive years in the Department of Crop Science University of Nigeria, Nsukka Farm (Latitude 06^0 25^N; Longitude 07^0 24^N; attitude 447.26 m above sea level). Factorial arrangement of treatments involving twenty soybean varieties was laid out in the field in a randomized complete block design (RCBD) with three replications. The fields were exposed to natural infection by vectors of BPMV, surveyed for symptoms of BPMV, screened using DAS ELISA for BPMV and differentiated infected soybean plants from healthy plants by tagging. The twenty soybean varieties differed significantly (P<0.05) in the incidence and disease severity rating of BPMV disease. BPMV disease infections significantly (P <0.05) reduced soybean plant height from 36.8 cm to 32.5 cm in year 2005 and from 48.3 cm to 41.3 cm in year 2006; number of branches from 5.3 to 4.8 in year 2005 and from 4.7 to 2.8 in year 2006; number of pods from 62.8 to 42.0 in year 2005 and from 85.4 to 43.2 in year 2006. Healthy soybean plants produced the highest grain yield (1.56t/ha) while infected soybean plants produced the least grain yield (0.90t/ha).

Keywords: Soybean, Bean Pod Mottle Virus, Limiting factors, Tropical zone

Introduction

Soybean (*Glycine max* (*L*) Merril) is an important crop plant among the grain legumes recognized for high protein content but its production in Nigeria is less than its requirement (Jackai, 1985; Woodworth *et al.,* 1992). Disease causing agents among which are viruses are important constraints that limit the production of soybean (Sinclair, 1982; FAO, 1988). Bean pod mottle virus (BPMV) *Genus Comovirus* infects soybean causing a severe systemic mottling with mild puckering of the trifoliate leaves (Zaumeyer and Thomas, 1957). It has been reported that virus of legumes have worldwide distribution and that infection by BPMV can cause losses of 10-17% (Suzanne, 2001). To increase the production of soybean, there is the need to grow soybean outside the traditionally soybean grown areas and to integrate soybean crop into the cropping systems of southeastern states of Nigeria which may lead to efficient disease control. It is therefore necessary to evaluate the susceptibility of soybean varieties to Bean pod mottle virus in Nsukka plains of southeastern Nigeria. This is aimed at determining the effect of BPMV on the yield and yield components of soybean and identifying soybean varieties that should be recommended for the area.

Materials and Methods

The studies were conducted in 2005 and 2006 cropping seasons in the field and laboratory of the Department of Crop Science, Faculty of Agriculture, University of Nigeria (Latitude 06^0 $25'^N$; Longitude $07^0 24'^N$, Attitude 447.26 m above sea level). Soil samples were collected at random from ten representative locations of the field using a soil auger to a depth of 20 cm. these were bulked together to form a composite sample. The sample was analyzed for mechanical and chemical properties at the Department of Soil Science Laboratory, University of Nigeria, Nsukka. The monthly rainfall (mm) was collected from the Department of Crop Science, University of Nigeria, Nsukka Meteorological Station.

Types and source of soybean varieties: Twenty soybean varieties in three classes of Early, medium and late maturing types were collected from International Institute of Tropical Agriculture (IITA), Ibadan and Institute for Agricultural Research and Training (IART), Ibadan (Table 1).

Field studies: The experimental site was cleared, ploughed, harrowed and marked out into three blocks, each measuring 14.5 m x 4.5 m. Each block was divided into 20 plots. Each plot had the dimension of 2 m x 1m and separated by 0.5 m path. A mixed fertilizer of single super phosphate (SSP) and NPK 15: 15: 15: compound fertilizer at the rate of 200 kg/ha and 150 kg/ha, respectively were worked into the soil (40 g/plot of SSP and 30 g/plot of NKP 15: 15: 15) at 2 weeks after planting (WAP). The 20 soybean varieties were randomly assigned to each of the twenty plots in each of the three blocks. The seeds were sown in 4 rows per plot at spacing of 5 cm within row and 50 cm between rows. Each plot had a total of 80 plants. Weeding was manually done using hoe at three weekly intervals. The experiment was laid out in Randomized Complete Block Design (RCBD) with treatments replicated three times. Data were collected on the following: BPMV disease incidence,

severity rating of BPMV disease, Days to 50% flowering, plant height/plant and number of branches/plant, number of pods/plant, number of seeds/pods.

Table 1: Types and sources of soybean varieties

Soybean varieties	Type	Source
TGX 1843-3E	Medium maturing	IAR & T, Ibadan
TGX1448-2E	Medium maturing	IAR & T, Ibadan
TGX1878-30E	Medium maturing	IAR & T, Ibadan
Sam soy 2	Late maturing	IAR & T, Ibadan
TGX1835-3E	Early maturing	IAR & T, Ibadan
TGX1866-7F	Early maturing	IAR & T, Ibadan
TGX923-2E	Late maturing	IAR & T, Ibadan
TGX1866-12E	Medium maturing	IAR & T, Ibadan
TGX1440-1E	Late maturing	IAR & T, Ibadan
TGX1828-4E	Late maturing	IAR & T, Ibadan
TGX1864-25F	Late maturing	IAR & T, Ibadan
TGX1866-5F	Late maturing	IAR & T, Ibadan
TGX1884-10E	Late maturing	IAR & T, Ibadan
TGX1875-2E	Medium maturing	IAR & T, Ibadan
TGX1829-6E	Medium maturing	IAR & T, Ibadan
TGX1485-1D	Early maturing	IAR & T, Ibadan
TGX1807-19F	Medium maturing	IITA, Ibadan
TGX1448-1E	Medium maturing	IITA, Ibadan
TGX1740-2F	Late maturing	IITA, Ibadan
TGX1440-2E	Medium maturing	IITA, Ibadan

BPMV disease incidence: The field was surveyed for plant with typical symptoms of BPMV starting from 4 weeks after planting (WAP) and the total number recorded. Infected plants in each plot of every block were tagged with yellow tag to distinguish them from the healthy plants. The survey for plant with BPVM disease symptoms was repeated at 7 and 10 WAP. At 10 WAP most of the soybean plants were flowering and were no longer producing new leaves. Recording of number of infected plants stopped and healthy samples were selected. The field was surveyed for apparently healthy soybean plants and a sample of five healthy plants were randomly drawn from each plot of every block and tagged with white tag.

Severity ratings of BPMV disease: Severity of BPMV disease was recorded by scoring using a five point scale ranging from 0-4, where 0 represents no symptoms, I represents mild symptoms, 2 represents moderate symptoms, 3 represents severity symptoms and 4 represents very severe symptoms. Five plants with yellow tag showing symptoms of BPMV in each plot were randomly selected and the two youngest leaves of each plant scored and average of the score from 5 plants taken for the soybean variety score.

Days to 50% flowering: At the initiation of flower buds, which commenced 5 weeks after planting, the field was visited every morning to record additively (cumulatively) the number of plants that produced flower in each plot, this continued till when 50 percent of plants in all the plots flowered.

Plant height (cm)/plant: The heights of healthy and infected plants identified with yellow and white tags in each plot were measured 14 WAP, using a metre rule. The distance from the stem base at the soil level to the tip of the terminal bud was measured. Five plants each of healthy and infected in each plot were measured.

Number of branches/plant: The number of branches of healthy and infected soybean plants identified with yellow and white tags in each plots was counted 14 WAP. Five plants each of healthy and infected in each plot were counted.

Number of pods/plant: The number of pods borne per plant of healthy and infected soybean plants identified with yellow and white tags in each plot were counted at maturity (when the leaves were beginning to turn brown). Five plants each of healthy and infected in each plot were counted.

Grains yield/ plant: Five plants were randomly selected from the identified healthy and infected plants in each plot. Their pods were harvested at maturity, sun-dried, shelled and weighed to obtain their grain yield.

Determination of serological test using double antibody sandwich enzyme linked immunosorbent assay (DAS-ELISA): DAS-ELISA test was run on the samples of infected and healthy leaves of the 20 soybean varieties. The tissue saps 1/1000 w/v of BPMV infected and healthy control leaves were prepared in ELISA extracting buffer (PAS Tween +2% PVP). Protein A diluted in coating buffer was added at 100 ml per well and the plates were incubated for 2 hours at 37 ^{0}C. The plates were washed three times with PBS-Tween. Polyclonal antiserum diluted 1/100 in PBS- Tween was added at 100 ml per well and the plate incubated for 2 hours at 37 ^{0}C. The plates were washed three times with PBS-Tween. The prepared samples of BPMV infected and healthy control tissue sap were added at 100 ml per well to three wells per sample in the plates and incubated overnight at 4 ^{0}C. The plates were washed three times with PBS-Tween. Polyclonal antiserum diluted 1/100 in PBS-Tween was added at 100 ml per well and the plate incubated for 2 hours at 37 ^{0}C. The plates were washed three times with BPS-Tween. Protein A Alkaline phosphate conjugate diluted 1/100 in conjugate buffer was added at 100 ml per well and the plates incubated for 2 hours at 37 ^{0}C. Then 200 ml per well of 1 mg/ml of P. nitrophenol phosphate substrate buffer was added. The values on the wells in the plates were determined overnight using electronic reader.

Results

Soil analysis before planting in 2005 and 2006 showed that the soil was acidic with a textural class of sandy clay loam, pH in water of 4.83 and 4.80, respectively and pH in KCl of 4.40 and 4.38, respectively (Table 2). The organic matter content in terms of percentage organic carbon was high (2.10%) in both years. Total nitrogen was low (0.06%) in 2005 and 0.08% in 2006. Sodium and potassium were moderate. Sodium was 0.84 milligram equivalent (meq) /100g soil and 0.82 meq/100g soil in 2005 and 2006 respectively while potassium was 0.56 meq/100g soil in both years.

The cation exchange capacity was low (2.5 meq/100g soil) in both years. Total precipitations were 1716.60 mm and 1253.93 mm in 2005 and 2006, respectively (Table 3). The precipitation was concentrated in the months of May, June, July, August, September and October.

Table 2: Physical and Chemical Prosperities of the Soil in 2005 and 2006 cropping season

Physical properties	2005	2006
Sand	71.00%	71.00%
Clay	21.005%	21.00%
Silt	8.00%	8.00%
Textural class	Sand clay	Sandy clay
Chemical Properties		
pH (in H_2O)	4.83%	4.80%
pH (in Kcl)	4.40	4.38
Organic carbon	2.10	2.10
Organic nitrogen	0.06	0.08
Organic matter	1.38	1.36
Base saturation	41.00	40.00
Cation exchange capacity (CEC)	2.50	2.50
Exchangeable base (meq/100g soil)		
Sodium (Na)	0.84	0.82
Potassium (K)	0.56	0.56
Magnesium (Mg)	0.38	0.36
Calcium (Ca)	0.80	0.80
Phosphorous (ppm)	5.20	5.20
Exchangeable acidity (meq/100g soil)	0.60	0.60

Table 3: Monthly Rainfall Data (mm) of the study site in 2005 and 2006

Month	2005	2006
January	1.27	0.25
February	0.00	0.00
March	21.08	33.27
April	136.40	143.50
May	161,29	102.10
June	413.01	262.13
July	258.39	109.45
August	314.17	126.26
September	235.72	305.03
October	172.22	126.22
November	3.05	45.72
December	0.00	0.00
Total	1716.60	1253.93

PBMV disease incidence: Soybean varieties infected with BPMV showed symptoms of systems mottling with puckering of leaves. Incidence of BPMV varied considerably and increased progressively with increase in the number of weeks after planting (Table 4). There was progressive increase in BPMV disease incidence at 4, 7 and 10 weeks after planting (WAP) (5.0%, 20.0% and 35.0%, respectively in 2005 and 2.5%, 20% and 35% respectively in 2006). At 10 WAP TGX 1835-3E had the highest BPMV disease incidence of 72.5% and 75.0% in 2005 and 2006, respectively. It was closely followed by TGX 1875-2E which had 67.0% and 72.5% in 2005 and 2006, respectively. There were significant differences ($P < 0.05$) In BPMV disease incidence among the soybean varieties. TGX 1864-25F had the least BPMV disease incidence 10.0% and 7.5% in 2005 and 2006, respectively. It was followed by TGX 1807-19F (12.5%) in 2005 and TGX 1866-7F (12.5%) in 2006.

Severity rating of BPMV disease: Severity rating of BPMV disease varied significantly among the twenty soybean varieties (Table 5). TGX 1875-2E had the highest (3.9) severity rating in both years and was statistically the same with TGX 1884-10E (3.5), TGX 1740-2F (3.4) and TGX 1440-2E (3.1) in both years. TGX 1448-1E (2.2 and 2.3 in 2005 and 2006, respectively) and TGX 1843-3E (2.2 and 2.4 in 2005 and 2006, respectively) had the least severity rating. There was no significant difference ($P<0.05$) between the soybean varieties and year of infection. BPMV disease infection did not influence the days to 50% flowering of the twenty soybean varieties (Table 6) TGX 1853-3E (41.7 and 42.0), TGX 1866-7F (42.0 and 42.7) and TGX 1485-ID (42.3 and 42.3) had the shortest days to 50% flowering for healthy and infected respectively in 2005 and differed significantly from all other varieties. The same trend was maintained in 2006. TGX 1866-5F (56.3 and 56.7); TGX 1864-25F (56.0 and 56.0); TGX 1828-4E (56.3 and 56.0); TGX 1884-10E (56.33 and 55.7); TGX 923-2E (55.7 and 56.0) and TGX 1740-2F (55.7 and 56.0) had the highest number of days to 50% flowering of healthy and infected soybean, respectively. BPMV disease infections reduced the heights of infected soybean varieties. There were significant differences ($P<0.05$) on the effect of BPMV disease infection on the heights of twenty soybean varieties (Table 7). In 2005, the mean height of infected soybean plants (32.5 cm) was significantly different ($P<0.05$) from the mean height of healthy soybean plant (36.8 cm). TGX 1740-2F produced the tallest plants (49.2 cm and 47.3 cm) for healthy and infected, respectively and was significantly different ($P<0.05$) from all the other varieties. TGX 1835-3E produced the shortest infected plant height (25.6 cm) and was significantly different ($P <0.05$) from TGX 1807-19F (33.8 cm) which had the shortest infected plant height (32.8 cm) in year 2006. In 2006, the mean height of infected soybean plant (41.3 cm) was significantly different ($P<0.05$) from the mean height of healthy soybean plant (48.3 cm). TGX 1884-10E produced the tallest healthy soybean plant (67.0 cm) followed by TGX 1866-5F (63.0 cm) and TGX 1864-35F (59.0 cm). TGX 1807-19F produced the shortest infected soybean plant (32.8 cm) and was followed by TGX 1835-3E (33.6 cm). Plants grown in 2006 were generally taller than plants grown in 2005.

BPMV disease infection reduced the number of branches of infected soybean varieties. There were significant differences ($P< 0.05$) on the effect of BPMV disease infection on the number of branches of twenty soybean varieties (Table 8). In 2005, the mean number of branches of infected soybean plants (4.8) was significantly different ($P<0.05$) from the mean number of branches of healthy soybean plants (5.3). TGX 923-2E produced the highest number of branches (8.3) while Samsoy 2 produced the highest number of branches of infected plant (8.1) TGX 1878-30E produced the least number of branches of healthy plant (3.6) while TGX 1807-19F and TGX 1740-2F

Table 4: Incidence of BPMV disease on 20 Soybean Varieties

Soybean varieties	BPMV disease incidence weeks after planting (WAP)					
	Year 2005			Year 2006		
	4	7	10	4	7	10
TGX 1843-3E	7.5	15.0	40.0	5.0	20.0	42.5
TGX1448-2E	10.0	25.0	40.0	5.0	27.5	47.5
TGX1878-30E	5.0	45.0	55.0	5.0	47.5	60.0
Sam soy 2	5.0	7.5	20.0	7.5	10.0	25.0
TGX1835-3E	5.0	30.0	72.5	5.0	35.0	75.0
TGX1866-7F	0.0	10.0	15.0	2.5	10.0	12.5
TGX923-2E	5.0	20.0	35.0	7.5	22.5	32.5
TGX1866-12E	2.5	27.5	50.0	5.0	25.0	45.0
TGX1440-1E	2.5	17.5	22.5	0.0	15.0	25.0
TGX1828-4E	10.0	45.0	52.5	7.5	42.5	52.5
TGX1864-25F	5.0	10.0	10.0	2.5	7.5	7.5
TGX1866-5F	2.5	10.0	32.5	0.0	7.5	30.0
TGX1884-10E	2.5	17.5	40.0	5.0	20.0	37.5
TGX1875-2E	5.0	22.5	67.0	2.5	22.5	70.0
TGX1829-6E	2.5	5.0	15.0	0.0	7.5	17.7
TGX1485-1D	5.0	25.0	30.0	2.5	15.0	17.5
TGX1807-19F	2.5	5.0	12.5	0.0	2.5	22.5
TGX1448-1E	7.5	12.5	27.5	5.0	10.0	30.0
TGX1740-2F	5.0	12.5	27.5	2.5	12.5	25.0
TGX1440-2E	5.0	25.0	45.0	2.5	22.5	47.5
Mean	5.0	20.0	35.0	2.5	20.0	35.0
FLSD (P <0.05)	2.554	7.590	10.935	2.394	8.119	10.331

FLSD (P<0.05) for comparing (WAP) in each year = 4.25

Table 5: Severity ratings of BPMV disease on 20 soybean varieties

Soybean varieties	Severity Ratings of BPMV Disease	
	Year 2005	Year 2006
TGX 1843-3E	2.2	2.4
TGX1448-2E	2.4	2.8
TGX1878-30E	2.7	2.9
Sam soy 2	2.9	2.9
TGX1835-3E	3.0	3.4
TGX1866-7F	2.9	2.9
TGX923-2E	2.3	2.4
TGX1866-12E	2.9	3.1
TGX1440-1E	2.5	2.4
TGX1828-4E	2.5	2.6
TGX1864-25F	2.4	2.5
TGX1866-5F	2.7	2.7
TGX1884-10E	3.5	3.5
TGX1875-2E	3.9	3.9
TGX1829-6E	2.5	2.5
TGX1485-1D	2.7	2.7
TGX1807-19F	3.0	3.1
TGX1448-1E	2.2	2.3
TGX1740-2F	3.4	3.4
TGX1440-2E	3.1	3.1
Mean	2.8	2.9
FLSD (P <0.05)	0.84	0.88

F-LSD (P<0.05) for comparing soybean varieties X year interaction = NS

produced the least number of branches of infected plant (3.2 each).

In 2006, the mean number of branches of infected soybean plant (2.8) was significantly different (P <0.05) from the mean number of branches of healthy soybean plant (4.7). Samsoy 2 produced the highest number of branches of healthy plant (7.1) while TGX 1485-ID produced the highest number of branches of infected soybean plant (6.0). TGX 1829-6E produced the least number of branches of healthy plants (2.5) while the least number of branches of infected plant (1.2) was produced by TGX 1835-3E.

BPMV disease infection reduced the number of pods of infected soybean varieties. There were significant differences (P<0.05) in the effect of BPMV diseases infection on the number of pods of twenty soybean varieties (Table 9). There were significant differences (P<0.05) on the number of pods of different soybean varieties. In 2005, the mean number of pods of infected soybean plants (42.0) was significantly different (P<0.05) from the mean number of pods of healthy soybean plants (62.8). TGX 1835-3E produced the highest number of pods (117.5) from healthy plants while the highest number of pods (96.4) from infected plant was produced by TGX 1866-7F. TGX 1485-ID produced the smallest number of pods from healthy and infected plants (21.0 and 20.8), respectively. In 2006, the man number of pods of infected soybean plant (42.2) was significantly different (P<0.05) from the mean number of pods of healthy soybean plant (85.4). TGX 1884-10E produced the highest number of pods (134.7) from the healthy plant while the highest number of pods from infected plant (68.9) was produced by TGX 1864-25F. TGX 1866-7F produced the smallest number of pod both from healthy and infected (52.4 and 23.2), respectively. BPMV disease infection reduced the grain yields of infected soybean varieties (Table 10). The grain yield of infected soybean varieties (0.90 t/ha) was significantly different (P<0.05) from the grain yield of healthy soybean varieties (1.56 t/ha).There were significant difference (P<0.05) between the grain yield of the different soybean varieties. TGX 1866-5F produced the highest grain yield (2.51 t/ha) from healthy soybean plants while TGX 1866-7F produced the highest grain yield (1.26 t/ha) from infected soybean plants. TGX 1829-6E produced the least grain yield (0.80 t/ha) from the healthy soybean plants while TGX 1440-IE produced the least grain yield (0.071 t/ha) from the infected soybean plants.

Table 6: Effect of BPMV disease infection on days to 50% flowering of twenty soybean varieties grown in 2005 and 2006 cropping seasons

Soybean varieties	BPMV disease incidence weeks after planting (WAP)			
	Year 2005		Year 2006	
	Healthy	Infected	Healthy	Infected
TGX 1843-3E	46.3	46.7	47.7	47.3
TGX1448-2E	47.3	47.0	47.7	47.7
TGX1878-30E	46.7	47.0	47.3	47.0
Sam soy 2	51.3	51.7	52.3	52.7
TGX1835-3E	41.0	41.3	41.7	42.0
TGX1866-7F	42.0	41.3	42.0	42.7
TGX923-2E	55.3	55.3	55.7	56.0
TGX1866-12E	47.7	47.3	48.3	47.3
TGX1440-1E	51.3	51.7	52.7	52.7
TGX1828-4E	55.7	55.3	56.3	56.0
TGX1864-25F	55.3	55.7	56.0	56.3
TGX1866-5F	55.7	55.3	56.3	56.7
TGX1884-10E	55.7	55.3	26.3	55.7
TGX1875-2E	48.0	47.7	48.7	48.3
TGX1829-6E	47.7	47.7	48.7	48.7
TGX1485-1D	41.3	41.7	42.3	42.3
TGX1807-19F	18.3	48.3	48.7	48.7
TGX1448-1E	50.7	51.0	51.7	51.7
TGX1740-2F	55.3	55.7	55.7	52.0
TGX1440-2E	47.7	47.3	48.3	47.7
Mean	**49.5**	**49.5**	**50.2**	**50.2**
FLSD (0.05)			*2005*	*2006*
FLSD (0.05) for comparing any two soybean varieties mean			*0.224*	*0.251*
FLSD (0.05) for comparing any two health condition mean			*NS*	*NS*
FLSD (0.05) for comparing any two state of health			*1.122*	*1.001*

Table 7: Effect of BMPV disease infection on height of twenty soybean varieties grown in 2005 and 2006 cropping seasons

Soybean varieties	Year 2005		Year 2006	
	Healthy	Infected	Healthy	Infected
TGX 1843-3E	28.5	28.6	48.6	38.3
TGX1448-2E	35.7	26.7	48.4	41.1
TGX1878-30E	41.2	36.0	48.0	44.0
Sam soy 2	34.2	28.8	37.6	37.4
TGX1835-3E	34.3	25.6	41.2	33.6
TGX1866-7F	32.5	25.8	40.0	36.3
TGX923-2E	33.9	26.6	46.5	42.1
TGX1866-12E	37.5	30.8	49.7	41.0
TGX1440-1E	31.6	25.8	44.8	37.4
TGX1828-4E	32,0	31.7	50.1	44.6
TGX1864-25F	37.2	36.0	59.0	57.3
TGX1866-5F	36.9	29.2	63.0	51.4
TGX1884-10E	44.0	37.7	67.0	53.0
TGX1875-2E	41.3	36.8	59.0	48.2
TGX1829-6E	31.9	27.6	43.1	34.1
TGX1485-1D	33.1	30.5	37.0	35.5
TGX1807-19F	35.4	33.8	26.0	32.8
TGX1448-1E	44.0	44.0	44.2	42.3
TGX1740-2F	49.2	47.3	46.9	38.2
TGX1440-2E	43.1	40.8	53.3	36.8
Mean	**36.8**	**32.5**	48.3	**41.3**
FLSD (0.05)			*2005*	*2006*
FLSD (0.05) for comparing any two soybean varieties mean			*5.49*	*6.95*
FLSD (0.05) for comparing any two health condition mean			*7.76*	*9.83*
FLSD (0.05) for comparing any two state of health			*1.74*	*2.20*

Discussion

The soil analysis indicated that the soil pH were 4.83 and 4.80 in 2005 and 2006, respectively indicating acidic conditions. This is in line with Enwezor *et al.,* 1989) who reported that southeastern agro-ecological zone of Nigeria is acidic naturally. NAERLS (1994) reported that soybean performs best under a pH range of 5.8-7.0 though can tolerate acid condition. Since the study was being carried out with the local farmers in perspective it was appropriate to grow the crop under the prevailing conditions in their farms. Hence the option of liming was not considered. Also, most of the peasant farmers cannot conveniently afford the purchase of lime if available. The precipitation was concentrated in the months of May, June, July, August, September and October. Thus the soybean varieties were planted late June so as to enable them utilize the abundant moisture then for their physiological and reproductive processes.

Table 8: Effect of BMPV disease infection on number of branches of twenty of twenty soybean varieties grown in 2005 and 2006 cropping seasons

Soybean varieties	Year 2005		Year 2006	
	Healthy	Infected	Healthy	Infected
TGX 1843-3E	4.4	3.7	4.8	2.1
TGX1448-2E	5.1	4.5	5.0	1.8
TGX1878-30E	3.6	4.1	3.1	1.7
Sam soy 2	6.9	8.1	7.1	5.8
TGX1835-3E	6.9	6.6	4.4	1.2
TGX1866-7F	6.8	5.7	3.4	1.8
TGX923-2E	8.3	5.8	5.7	2.8
TGX1866-12E	5.7	4.4	5.0	2.8
TGX1440-1E	5.4	4.1	4.7	3.0
TGX1828-4E	4.6	4.9	3.9	1.6
TGX1864-25F	5.9	5.7	3.9	3.5
TGX1866-5F	6.3	5.6	5.4	2.5
TGX1884-10E	5.7	4.5	5.0	2,8
TGX1875-2E	5.6	4.5	4.8	2.8
TGX1829-6E	4.8	4.2	2.5	1.9
TGX1485-1D	4.0	3.8	4.2	6.0
TGX1807-19F	4.1	3.2	5.0	2.8
TGX1448-1E	4.5	4.2	5.3	4.1
TGX1740-2F	3.7	3.2	4.0	2.0
TGX1440-2E	4.3	5.0	5.9	3.3
Mean	**5.3**	**4.8**	**4.7**	**2.8**
FLSD (0.05)			*2005*	*2006*
FLSD (0.05) for comparing any two soybean varieties mean			*1.76*	*1.00*
FLSD (0.05) for comparing any two health condition mean			*2.49*	*1.41*
FLSD (0.05) for comparing any two state of health			*0.56*	*0.31*

Table 9: Effect of BMPV disease infection on number of pods of twenty of twenty soybean varieties grown in 2005 and 2006 cropping seasons

Soybean varieties	Year 2005		Year 2006	
	Healthy	Infected	Healthy	Infected
TGX 1843-3E	45.3	41.9	119.8	42.0
TGX1448-2E	76.1	27.2	114.0	39.4
TGX1878-30E	48.5	46.4	60.0	31.6
Sam soy 2	58.7	65.4	76.9	51.8
TGX1835-3E	117.5	33.8	69.2	28.9
TGX1866-7F	110.2	96.4	52.4	23.2
TGX923-2E	86.3	62.6	77.0	27.0
TGX1866-12E	59.8	32.2	125.8	53.1
TGX1440-1E	68.8	31.6	94.5	35.3
TGX1828-4E	37.8	35.8	71.3	34.3
TGX1864-25F	68.0	49.1	82.8	68.9
TGX1866-5F	75.4	42.0	85.6	34.3
TGX1884-10E	103.7	38.5	134.7	46.8
TGX1875-2E	64.1	36.3	73.4	49.4
TGX1829-6E	36.4	25.6	53.8	38.1
TGX1485-1D	21.0	20.8	54.5	56.1
TGX1807-19F	33.8	29.2	80.7	49.8
TGX1448-1E	39.8	38.2	82.6	68.3
TGX1740-2F	70.3	57.7	71.9	34.6
TGX1440-2E	33.3	29.3	127.8	50.0
Mean	**62.8**	**42.0**	**85.4**	**43.2**
FLSD (0.05)			*2005*	*2006*
FLSD (0.05) for comparing any two soybean varieties mean			*34.47*	*23.77*
FLSD (0.05) for comparing any two health condition mean			*48.47*	*33.61*
FLSD (0.05) for comparing any two state of health			*10.84*	*7.52*

Fehr *et al*. (1971), Caramete *et al.* (1990) reported that soybean requires sufficient moisture during their vegetative, flowering, podding and pod-filling and seed development stages.

PBMV disease infection of the soybean varieties did not influence their days to 50% flowering. Days to 50% flowering was slightly influenced by year of planting. In 2005 cropping seasons, both healthy and infected soybean had 49.5 days to 50% flowering while in 2006 cropping season, the soybean varieties had 50.2 days to 50% flowering. These suggest that infection of the soybean varieties by BPMV did not influence the gene action responsible for initiation of flowering of soybean varieties and that seasonal variation may influence the action of gene responsible for initiation of flowering. The early maturity varieties differed statistically in their agronomic and production potentials from the medium and late maturing varieties. The relative short flowering time of the early maturing varieties is indicative of their short grain filling period that may have affected their grain

Table 10: Effect of BMPV disease infection on grain yield (g/ha) of twenty soybean varieties

Soybean varieties	Health Conditions		
	Healthy	Infected	Mean
TGX 1843-3E	1.74	0.88	1.31
TGX1448-2E	2.00	0.73	1.37
TGX1878-30E	1.14	0.82	0.98
Sam soy 2	1.43	1.24	1.33
TGX1835-3E	1.97	0.66	1.31
TGX1866-7F	1.71	1.26	1.49
TGX923-2E	1.72	0.94	1.33
TGX1866-12E	1.96	0.90	1.43
TGX1440-1E	1.72	0.71	1.21
TGX1828-4E	1.15	0.74	0.94
TGX1864-25F	1.70	0.80	1.25
TGX1866-5F	2.51	0.90	1.71
TGX1884-10E	1.45	0.91	1.18
TGX1875-2E	0.95	0.67	0.81
TGX1829-6E	0.80	0.81	0.80
TGX1485-1D	1.21	0.83	1.02
TGX1807-19F	1.29	1.12	1.21
TGX1448-1E	1.59	1.24	1.42
TGX1740-2F	1.50	0.97	1.24
TGX1440-2E	1.70	0.84	1.27
Mean	**1.56**	**0.90**	**1.23**

FLSD (0.05) for comparing any two soybean varieties mean = 0.70
FLSD (0.05) for comparing any two state of health condition mean = 0.220
FLSD (0.05) for comparing soybean x health condition mean = 0.983

yields (Whigham 1983). Whigham (1983) also, reported that flower initiation on soybean plants vary with genotype and environmental factors and is dependent on their interaction.

BPMV disease infection significantly ($P<0.05$) reduced the growth and yield of soybean varieties. The significant differences in plant height, number of branches, number of pods and grain yield were due to the reduction in plant vigour by BPMV. Virus competes with plant for its protein, nucleic acid and energy components. Also, plants that were not infected make more efficient use of the soil and solar radiation in obtaining and synthesizing food substrate. BPMV infection of any of the twenty soybean varieties caused systemic symptom of venial chlorosis, which adversely affects the growth and yield of soybean plant. Reports have shown that Okra mosaic virus infection causes failure of cell chloroplast to produce chlorophyll, which adversely affects the growth and yield of Okra plants (Atiri and Ibidapo, 1989; Marchie, 1993). There were significant difference ($P<0.05$) in the effect of BPMV disease on the reduction of the number of pods, of all the soybean varieties. Infected soybean varieties gave the pod yield of 42.0 and 43.2 pods per plant in 2005 and 2006 respectively as against the healthy soybean varieties which gave pod yield of 62.8 and 85.4 pods, respectively. This suggests that BPMV may have affected the initiation, retention of flower buds and the photosynthetic rate and did not affect the days to 50% flowering. It might also have affected the filling and development of those flower buds hence they recorded high reduction in grain yield. Infected soybean varieties gave grain yield of 0.90 t/ha while healthy soybean varieties gave 1.56t/ha. The reduction in the yield could also have resulted from the reduction in the plant height and number of branches caused by the BPMV on the soybean varieties. Infected soybean varieties continuously recorded reduced plant height and smaller number of branches when compared to healthy plants in all the experiments.

There were significant differences ($P<0.05$) in the plant height, number of branches, number of pods and grain yield of all the soybean varieties. These could be due to the varieties in the gene(s) inherent in those varieties and their differences in reacting to the interaction of infection of BPMV and the environment under study. There were variations in performances of soybean varieties in the different years of study in all the parameters measured. It was observed that some soybean varieties were not infected early with BPMV in the field. The delay in the infection of some soybean varieties with BPMV could have enabled them grow older than others before infection, there by tolerating the infection of BPMV disease more than others. Atiri and Verma (1983) reported that Okra plants inoculated earlier in the rainy (planting) season with OKMV had lower yields than those inoculated later.

Conclusion: Bean Pod Mottle Virus disease is an important disease of soybean plant in humid tropical region of Nigeria because it causes reduction in growth and soybean grain yield loss of about 42.3%. TGX 1866-5F and TGX 1866-7F are recommended for farmers growing soybean in humid tropical zone of Nigeria.

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