

Effect of Yellow mosaic virus on yield attributes of Blackgram (*Vigna mungo* L. Hepper)

¹Kakumanu Babu and ²Gorrepati Rosaiah

^{1&2}Department of Botany & Microbiology, Acharya Nagarjuna University, Nagarjunanagar-522510, Guntur, Andhra Pradesh, INDIA.

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ABSTRACT

A field experiment was conducted during Kharif 2018 at Botanical Garden of Acharya Nagarjuna University to determine the effect of Yellow mosaic virus infection on yield attributes of Blackgram (*Vigna mungo* L. Hepper). A total of fifty blackgram varieties were obtained from Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh. The obtained blackgram varieties were cultivated and left to infection of YMV. The data was collected on plant height, days to 50% flowering, clusters per plant, pods per plant, pod length, seeds per pod, 100 seed weight, whole plant dry weight and yield per hectare. Of all the varieties Ku-15-9, TU-18 and PGRU-99-028 found to be potent in producing clusters per plant, pods per plant, pod length, seeds per pod, 100 seed weight along with high whole plant dry weight coupled with high yield content per hectare 1685.45 q/h, 1595.00 q/h and 1280.00 q/h respectively. Based on the performance of the all the varieties, varieties Ku-15-9, TU-18 and PGRU-99-028 should be considered as resistant to yellow mosaic disease.

1. Introduction

Pulses play vital role in dietary proteins of the vegetarians. Blackgram [*Vigna mungo* (L.) Hepper] (2n=22) is indigenous to India or Indo-Burma region, short-duration leguminous crop cultivated extensively in most of the tropical and sub-tropical countries (Biswas *et al.*, 2008). It contains a relatively high proportion of easily digestible good quality protein (24%) with low flatulence and is also rich in iron contents (40-70 ppm), vitamins and other minerals. After chickpea, blackgram occupies prominent role in fulfilling the protein needs of the Indian Sub Continent (Salam *et al.*, 2009).

Worldwide, India is the biggest producer of blackgram, accounts for 3.60 million tons of grains per year in an area about 5.60 million hectares. Nevertheless, the mean yields of blackgram in India is quite unsatisfactory (~546 kg/ha), even lower than most of the other legume crops (Project Coordinators Report-2018). However, the reasons for reduced yield of blackgram are numerous has the crop is attacked by many insects, bacteria and viruses and other abiotic factors. Among the various constraints, yellow mosaic disease (YMD) caused by yellow mosaic virus (YMV) is the most serious disease and major choke point for the blackgram cultivation and production (Malathi and John, 2008; Biswas *et al.*, 2012). Yellow mosaic virus infection results in yellowing of leaves, reduced photosynthetic activity, and reduced pod number, pod size, grain number, grain size which ultimately manifested as severe yield loss (Malathi and John, 2008). Under suitable climatic conditions, YMV disease is widespread and destructive, can cause yield loss 5- 100% annually (Ghafoor *et al.*, 2000; Rathi, 2002). Due to the spread and severity this disease is popularly known as "Yellow plague" (Archana *et al.*, 2018).

Present study was undertaken to identify the potential yield producing Yellow Mosaic Virus (YMV) resistant black gram (*Vigna mungo* L.) genotypes for successful cultivation in

India and to use them in plant breeding experiments to develop YMV resistant blackgram varieties.

2. Materials and Methods

A total of 50 blackgram varieties i.e PU 30, KU 15-19, KU 15-6, P 1070, LBG 777, LBG 775, P 205, SPS 26, KU 15-3, GKU 02-1, KU 15-14, T9, TU 18, TBG 104, PGRU 99-028, VH 85-5, UK 2289, PLU 10-4, LBG 783, KU 15-9, KU 708, KU 15-2, LBG 20, KU 15-10, LBG 752, LBG 708, KU 15-7, LBG 645, KU 15-20, CN 8072, P 726, IPU 10-4, RUG 44, CPS 35, LBG 788, KU 15-13, KU 323, P 728, KU 15-11, LBG 685, UTTARA, KU 15-4, PU 31, LBG 623, LBG 787, LBG 791, KU 15-16 and LBG 722 were obtained from Regional Agricultural Research Station (RARS), Lam, Guntur constitute the experimental material for the present study.

All the 50 entries were planted in 5 replicated rows arranged in a randomized block design and each row measures around 5 m length with arrow to row distance of 30 cm and plant to plant distance of 10 cm. Plots were regularly observed for good agronomic control and proper care was taken to protect from pests and birds. The data on various characters were collected from all the varieties with an interval of 15 days each and continued till to the day of harvest.

Plant height (cm)

Plant height was recorded by measuring it from the ground level to the growing tip of the main shoot. Measurements were taken from five randomly selected plants in each treatment and the average height was expressed in centimeters.

Days to 50% Flowering

Numbers of plants reached to 50% flowering were measured phenotypically and were tabulated.

Clusters per plant

The total number of pod bearing cluster per plant were counted at the time of harvest.

Pods per plant

Total number of seed bearing pods on each plant was counted on five randomly selected plants at maturity and the average was recorded.

Pod length (cm)

The length of pod measured from the base of the pod up to its tip.

Seeds / pod

Grains produced by the pod of each tagged plant separately counted and arrived the number of grains/pod.

Test weight/100 seed weight (g)

Hundred seeds were counted randomly from each genotype and the weight was recorded in grams.

Whole plant dry weight (g)

Fresh plants were weighed by using digital balance and were immediately transferred to paper bags. These paper bags were placed in hot air oven at a temperature of 70 °C for about 72 hrs or until the plant maintain the constant weight (Afzal *et al.*, 2005). The weight of the plant was measured in grams (g).

Yield/hectare (Kgh⁻¹)

Yield per hectare was measured by using the following formula.

$$\text{Yield/hectare} = \frac{\text{Total yield}}{\text{Plot area}} \times 10000$$

Where plot area is 5.0 m²

YMV screening parameters

The disease was scored on a 1-9 arbitrary scale according to Alice and Nadarajan (2007).

Rating scale for scoring yellow mosaic virus disease (1-9 scale):

1. No visible symptoms on leaves or very minute yellow specks on leaves.
2. Small yellow specks with restricted spread covering 0.1 to 5 % leaf area.
3. Yellow mottling of leaves covering 5.1 to 10 % leaf area.
4. Yellow mottling of leaves covering 10.1 to 15 % leaf area.
5. Yellow mottling and discoloration of 15.1 to 30 % leaf area.
6. Yellow discoloration of 30.1 to 50 % leaf area.
7. Pronounced yellow mottling and discoloration of leaves and pods, reduction in leaf size and stunting of plants covering 50.1 to 75 % foliage.
8. Severe yellow discoloration of leaves covering 75.1 to 90 % of foliage, stunting of plants and reduction in pod size.
9. Severe yellow discoloration of entire leaves covering above 90.1 % of foliage, stunting of plants and no pod formation.

Observations on the disease incidence were taken on randomly selected five plants of each entry and took a mean of each entry to assign the category. The following categories are used in assessing the resistant reaction for yellow mosaic virus disease.

Rating	Reaction
Resistant (R)	1.0 to 2.0
Moderately resistant (MR)	2.1 to 4.0
Moderately susceptible (MS)	4.1 to 5.0
Susceptible (S)	5.1 to 7.0
Highly susceptible (HS)	7.1 to 9.0

Analysis of variance (ANOVA) test appropriate to the random block design (RBD) was carried out using AGRISTAT software. Correlation coefficients between traits were calculated by using MINITAB 16 software.

3. Results

A field experiment comprising of 50 blackgram genotypes was carried out in a completely randomized block design with all recommended agronomic practices during *kharif* 2016 for screening of blackgram cultivars against yellow mosaic disease at field level (Plate 1). Results pertaining to the yield parameters were tabulated in Table 1.

Plant height (cm)

The plant height was found to be non significant both in healthy and YMV infected plants and much difference in plant height was observed in all the genotypes both in healthy and YMV infected plants (Table 1). It was ranged from 15 cm (KU 15-10) to 68.32 cm (SPS 26). Followed by SPS 26 maximum plant height was observed in LBG 777, PGRU 99-028 and KU 15-15 (65.00). In case of YMV infected genotypes the plant height was ranged between 15 cm (KU 15-10) to 68.00 cm (SPS 26).



Plate 1. Field trials of 50 blackgram genotypes against yellow mosaic disease

Days to 50% flowering

All the normal genotypes showed above 50% flowering at 45 DAS whereas in case of YMV infected plants except KU 15-11 (40.00) and LBG 685 (48.97) were recorded below 50% flowering (Table 1). Among all the plants 100% flowering was recorded in genotypes PGRU 99-028 and KU 15-9 in case of healthy plants where as in case of YMV infected plants maximum percent flowering was recorded in PGRU 99-028 (98.87) followed by KU 15-9 (98.21), KU 15-6 (94.20) and TU 18 (81.99).

Number of clusters

Number of clusters for plant was varied significantly in all the genotypes and was ranged from 12.00 to 40.00 (Table 1) in case of healthy plants. Maximum number of clusters were recorded in KU 15-9 (40.00) followed by TU 18, TBG 104 (39.00), PGRU 99-028 (37.00) and KU 15-6 (36.00). Yellow mosaic virus infection showed a maximum effect on the cluster number and cluster number was reduced significantly in all the genotypes (Table 3). Among the YMV infected plants highest number of clusters were reported in KU 15-9 (38.00), TU 18 (36.00), PGRU 99-028 (35.00), and KU 15-6 (32.00).

Number of pods

Pod number was also differed significantly in all the genotypes. Pod number was ranged from 23.00 to 100.00 in healthy plants whereas in case of YMV infected plants pod number was ranged between 17 to 95.00 (Table 1). Among the normal plants maximum number of pods were recorded in KU 15-9 (100.00) followed by PGRU 99-028 (86.00), TU 18 (84.00) and KU 15-6 (79.00). In YMV infected plants highest number of pods per plant was recorded in KU 15-9 (95.00), TU 18 (76.00), KU 15-6 (75.00) and PGRU 99-028 (74.00).

Pod length (cm)

Along with number of clusters, pods/plant YMV infection also affects the pod length and most of the pods were shrunken in size when compared with healthy pods. Pod length was varied between 4.10 cm to 5.80 cm in healthy plants and in case of YMV infected plants pod length was ranged from 3.00 cm to 5.55 cm (Table 1). The varieties such as KU 15-9, TU 18, PGRU 99-028 and KU 15-6 showed higher pod length both in healthy (5.80 cm, 5.50 cm, 5.40 cm and 5.35 cm) and YMV infected plants (5.55 cm, 5.35 cm, 5.25 cm and 5.15 cm).

Seeds / pod

With decreased pod length the number of seeds per pod was reduced greatly particularly in severely infected plants. Seeds per pod was varied between 5 to 9 in healthy plant and from 2 to 8 in diseased plants (Table 1). Among all the healthy plants maximum number of seeds per pod (9.00) was reported in KU 15-9, P 205, KU 15-10, KU 15-7, KU 15-4 and LBG 722 where as under YMV infection maximum number of seeds per pod was reported in KU 15-9 (8.00) followed by KU 15-6, TU 18 (7.00) and PGRU 99-028, KU 15-16, LBG 722 (6.00).

100 seed weight (g)

Measuring the 100 seed weight relatively may the indication yield potentiality of a genotype. In present study 100 seed weight was ranged between 3.52 g to 4.99 g in normal plants whereas in case of YMV infected plants it was varied between 2.10 g to 4.82 g (Table 1). Among all the healthy plants maximum 100 seed weight was reported in KU 15-9 (4.99 g) followed by TU 18 (4.90 g), PGRU 99-028 (4.81 g) and

KU 15-6 (4.66 g). In case of disease infected plants the 100 seed weight was maximum in KU 15-9 (4.82 g), TU 18 (4.80 g), PGRU 99-028 (4.60 g) and KU 15-6 (4.40 g).

Whole plant dry weight (g)

Yellow mosaic virus infection affects the whole plant dry weight in all the genotypes (Table 1). Whole plant dry weight was varied between 3.460 g to 17.575 g in healthy plants and it was between 1.260 g to 16.420 g. Among all the genotypes highest dry weight was recorded in PGRU 99-028 (17.575 g) followed by LBG 20 (17.255 g), KU 15-9 (17.050 g), TU 18 (13.650 g) and KU 15-6 (12.975 g). In case of YMV infected plants highest plant dry weight was reported in KU 15-9 (16.420 g), PGRU 99-028 (16.110 g), TU 18 (13.110 g) and KU 115-6 (11.00 g).

Yield per hectare (Kgh⁻¹)

The effect of yellow mosaic virus on yield was calculated and it is found to be reduced drastically in all the infected plants. Among all the fifty varieties yield per hectare was calculated and it was ranged from 386.88 kgh⁻¹ to 1719.75 kgh⁻¹ in healthy plants whereas in case of YMV infected plants yield per hectare was ranged from 200.40 kgh⁻¹ to 1685.00 kgh⁻¹ (Table 1). Of all the genotypes maximum yield per hectare was reported in varieties such as KU 15-9 (1719.75 kgh⁻¹), TU 18 (1605.63 kgh⁻¹), PGRU 99-028 (1316.20 kgh⁻¹) and KU 15-6 (1281.88 kgh⁻¹). In case of diseased plants also maximum yield per hectare was reported by the KU 15-9 (1685.45 kgh⁻¹), TU 18 (1595.00 kgh⁻¹), PGRU 99-028 (1280.00 kgh⁻¹) and KU 15-6 (1200.00 kgh⁻¹).

Percent infection per plant (%)

Percent infection per plant was measured in order to identify the damage to the plant due to YMV infection. All the genotypes were prone to infection but the severity of infection was varied from genotype to genotype (Table 2). Among all the plants the maximum infection of 95.12% was observed in genotype LBG 722 followed by LBG 788 (81.89%) and T9 (80.00%) where as the lowest infection observed in TU 1 (10.29%) followed by KU 15-6 (10.57%), PGRU 99-028 (10.81%) and KU 15-9 (10.96%).

Disease scoring scale

1-9 disease scoring scale was applied to know the severity of infection (Table 2). Among all the 50 genotypes 4 varieties (KU 15-6, TU 18, PGRU 99-028 and KU 15-9) were came under scale 1. Varieties such as UK 2289, LBG 709, KU 15-7, KU 15-16 came under scale 2. Genotypes came under scale 3 are P 205, GKU 02-1, KU 15-14, KU 323. Twelve varieties (PU 30, LBG 775, KU 15-3, VH 85-5, KU 15-2, LBG 20, LBG 752, KU 15-20, P 726, KU 15-13, UTTARA and LBG 623 came under scale 4. Varieties i.e PLU 10-4, LBG 783, IPU 10-4 and KU 15-4 came under scale 5.

Table 1. Variations in photosynthetic and yield attributes both in healthy and yellow mosaic virus infected genotypes

Sr. No.	Character → Variety _j	Plant Height (cm)		Days to 80% flowering		No. of Clusters		No. of Pods		Pod Length (cm)		Seeds/ pod		100 seed weight (g)		Whole Plant Dry Weight (g)		Yield/acre (Kgh ⁻¹)	
		H	I	H	I	H	I	H	I	H	I	H	I	H	I	H	I	H	I
		1	PU 30	38.00	37.50	88.46*	64.10	25	12	55	39	4.9	3.10	5	2	3.96	3.00	7.345	4.870
2	KU 15-19	35.00	35.00	84.94	62.17	21	10	58	40	4.8	3.00	6	2	4.16	3.80	3.460	1.260	674.94	480.42
3	KU 15-6	33.00	32.90	96.74*	94.20*	36*	32*	79*	75*	5.35*	5.15*	8*	7*	4.66*	4.40*	12.975*	11.000*	1281.88*	1200.00*
4	P 1070	37.00	36.54	87.93*	60.19	27*	13	71*	54*	4.40	3.10	7	4	4.77*	3.70*	6.550	4.750	740.74	360.00
5	LBG 777	65.00*	64.58*	96.29*	70.41*	30*	20*	66*	42	4.90	4.00	7	3	4.81*	4.00*	5.255	3.251	495.26	310.20
6	LBG 775	52.50	52.00	88.23*	68.92*	22	16	73*	49*	5.00	3.60	8*	4	3.86	3.10	13.605*	6.172*	1020.38*	625.16
7	P 205	55.00	55.00	92.10*	70.16*	22	12	55	36	4.70	4.10	9*	4	4.38*	3.40	5.010	3.214	1117.66*	700.25*
8	SPS 26	68.32*	68.00*	92.43*	76.28*	28*	18*	47	27	4.80	4.10	6	2	4.00	3.20	6.840	3.480	285.95	300.00
9	KU 15-3	60.00*	60.00*	76.36	62.32	25	18*	58	33	4.60	4.00	7	3	4.09	3.60	3.830	2.140	974.73*	680.00*
10	GKU 02-1	25.00	25.00	94.17*	68.10	30*	26*	71*	49*	5.20*	4.20*	8*	4	4.07	3.60	9.025*	4.985	910.79*	720.25*
11	KU 15-14	44.00	43.85	83.47	72.29*	35*	24*	78*	57*	5.30*	4.30*	8*	4	3.72	3.20	8.650*	4.701	988.24*	700.19*
12	T 9	38.00	37.32	96.15*	69.15*	30*	24*	28	18	4.80	4.15*	7	2	3.79	3.00	6.280	3.990	519.46	250.56
13	TU 18	28.00	25.40	98.17*	81.99*	39*	36*	84*	76*	5.50*	5.35*	8*	7*	4.90*	4.80*	13.650*	13.110*	1605.63*	1595.00*
14	TBG 104	39.00	38.50	93.75*	64.09	39*	20*	80*	32	4.90	4.20	7	4	4.26	3.20	4.425	2.980	474.29	260.19
15	PGRU 99-028	65.00*	64.20*	100.00*	98.87*	37*	35*	86*	74*	5.40*	5.25*	8*	6*	4.81*	4.80*	17.575*	16.110*	1316.69*	1280.00*
16	VH 85-5	62.00*	62.00*	85.58	63.04	32*	24*	70*	57*	4.60	4.10	8*	4	4.30	3.10	15.965*	7.860*	874.12	600.19
17	UK 2289	40.00	41.50	90.59*	65.11	39*	26*	69*	54*	5.40*	4.60*	8*	3	4.11	3.10	8.835*	4.181	1136.20*	890.60*
18	PLU 10-4	57.00	56.50	94.89*	80.16*	34*	24*	68	51*	4.30	3.90	7	4	3.91	3.88*	8.800*	4.262	899.13*	590.16
19	LBG 783	65.00*	65.00*	82.02	71.27*	28*	11	58	47*	5.20*	4.50*	7	3	4.33	3.10	13.370*	9.994*	843.12	510.00
20	KU 15-15	65.00*	65.00*	76.40	62.42	36*	14	69*	54*	4.90	4.10	7	3	3.91	3.20	13.060*	8.620*	862.47	375.25
21	LBG 709	40.00	39.50	88.09*	70.14*	25	12	82*	69*	5.20*	4.60*	8*	3	3.99	3.14	6.180	3.125	1120.90*	890.40*
22	KU 15-9	44.00	44.00	100.00*	98.21*	40*	38*	100*	95*	5.80*	5.55*	8*	8*	4.99*	4.82*	17.050*	16.420*	1719.75*	1685.45*
23	KU 708	39.00	38.50	79.51	61.00	24	11	39	20	5.70*	4.80*	8*	5*	4.66*	3.80*	5.965	3.617	973.19*	480.00
24	KU 15-2	49.00	48.30	81.15	62.22	38*	22*	68	46*	4.60	3.20	7	4	4.31	3.10	3.725	1.928	811.72	600.00
25	LBG 20	58.00	57.89	94.50*	69.48*	27*	12	56	37	4.90	4.20*	8*	3	4.53*	3.9*	17.255*	8.110*	905.53*	675.14*
26	KU 15-10	15.00	15.00	93.23*	70.12*	32*	24*	62	50	4.80	4.30*	9*	4	3.97	2.10	5.875	3.010	817.27	320.25
27	LBG 752	55.00	54.80	92.72*	67.09	24	15	57	39	4.90	4.10	7	4	4.77*	3.10	12.640*	7.217*	991.89*	691.90*
28	LBG 708	25.00	25.00	96.74*	62.27	14	6	32	19	4.10	3.10	7	3	4.03	3.80*	5.710	3.180	634.31	410.00
29	KU 15-7	49.00	48.72	83.95	68.10	27*	12	73*	61*	5.40*	4.20*	9*	4	4.74*	3.75*	12.335*	7.421*	1138.30*	890.00*
30	LBG 645	36.20	35.10	85.36	70.41*	27*	14	68	58*	5.40*	4.10	7	4	4.22	3.60	4.975	2.910	513.55	285.00
31	KU 15-20	37.00	36.50	87.20*	69.76*	33*	16	61*	49*	5.10	4.00	8*	4	4.38*	3.10	12.225*	8.017*	1018.27*	665.90
32	CN 8072	45.00	44.80	79.36	68.28	30*	19*	74*	61*	5.00	4.00	8*	3	4.18	3.19	4.150	2.142	762.59	480.10
33	P 726	35.00	35.00	75.34	62.34	29*	16	78*	64*	4.90	4.00	8*	4	4.20	3.60	7.000	4.136	791.57	600.00
34	IPU 10-4	33.00	32.50	89.41*	68.76*	12	5	23	17	4.90	3.90	8*	5*	4.39*	3.18	6.810	3.616	801.20	585.10
35	RUG 44	30.00	29.95	90.09*	70.99*	32*	24*	79*	54*	4.70	3.50	7	3	4.04	3.60	12.255*	7.261*	605.41	325.20
36	CPS 35	38.00	37.50	81.05	62.30	27*	13	69*	52*	4.40	3.20	7	4	4.33	3.62*	7.865*	4.180	512.25	299.00
37	LBG 788	40.00	40.00	89.89*	72.18*	20	9	42	30	5.40*	4.50*	8*	3	4.13	3.24	10.820*	5.119	544.63	278.14
38	KU 15-13	34.00	33.85	78.02	60.56	18	11	57	43*	4.80	3.20	8*	3	4.27	3.10	8.170*	4.621	859.07	680.95
39	KU - 323	50.00	49.50	90.00*	70.96*	26	15	54	36	4.60	3.10	7	4	4.31	3.65*	12.015*	7.197*	1005.65*	700.80*
40	P 728	35.20	34.60	80.00	64.71	15	8	41	27	5.00	4.10	8*	4	4.75*	3.49	0.815	3.106	400.64	280.20
41	KU 15-11	25.00	25.00	65.00	40.00	20	11	43	29	5.10	4.20*	6	3	4.79*	4.15*	1.320	4.217	664.90	440.10
42	LBG 685	23.00	22.50	64.00	50.17	17	10	42	22	4.90	4.00	7	4	4.54*	3.00	3.415	4.326	386.88	200.40
43	UTTARA	30.00	29.30	81.81	64.87	20	9	48	28	4.60	3.80	8*	4	4.52*	3.80*	0.850	4.114	1099.21*	676.69*
44	KU 15-4	37.00	36.85	79.72	61.44	18	10	37	21	5.40*	4.10	9*	2	4.50*	3.10	4.830	2.109	722.77	588.25
45	PU 31	28.00	25.80	87.27*	69.29*	13	6	29	16	5.00	4.00	7	4	4.10	3.20	1.190	4.008	554.66	280.40
46	LBG 623	25.00	25.00	93.10*	76.17*	13	8	37	24	5.30*	3.85	8*	5*	4.83*	4.00*	2.760	4.172	1087.07*	680.00*
47	LBG 787	27.00	26.80	80.00	66.48	20	11	45	28	4.90	4.00	7	4	4.23	3.65*	3.690	6.109*	666.19	418.00
48	LBG 791	41.00	41.00	90.00*	72.19*	22	10	54	31	4.60	3.60	8*	3	4.87*	3.19	1.950	4.126	495.34	281.16
49	KU 15-16	32.00	31.25	94.23*	70.24*	18	7	55	30	4.90	3.80	7	6*	4.14	3.27	2.590	3.981	1129.80*	840.30*
50	LBG 722	16.00	15.90	92.68*	80.11*	23	8	30	19	5.00	4.20*	9*	6*	4.30	3.80*	8.191*	2.990	543.17	290.15
Grand Mean		40.78	40.50	80.63	64.51	25.98	15.84	58.10	42.18	4.98	4.04	7.44	3.90	4.31	3.47	7.28	5.00	839.84	596.00
SEM		0.586	0.520	5.61	3.89	0.628	0.75	0.58	0.54	0.156	0.11	0.08	0.110	0.05	0.165	0.139	0.136	57.45	72.10
CV%		18.52	25.96	6.82	5.66	0.95	0.86	0.90	0.80	2.58	1.62	2.70	1.98	5.64	4.69	2.50	2.48	120.62	95.44

* significant at 5% level; H – Healthy: I - Infected

The genotypes such as KU 15-19, KU 708, LBG 708, CN 8072, KU 15-11 and LBG 787 came under scale 6. Five varieties P 1070, LBG 777, SPS 26, KU 15-15, KU 15-10 and RUG 44 came under scale 7. Genotypes viz., T9, TBG 104, LBG 645, CPS 35, LBG 788, P 728, LBG 685, PU 31 and LBG 791 were came under scale 8 and only one variety came under scale 9 is LBG 722.

Grouping of genotypes screened against YMV

Grouping of blackgram genotypes against YMV was done using 1-9 arbitrary scale (Table 3). Varieties KU 15-6, TU 18, PGRU 99-028 and KU 15-9, UK 2289, LBG 709, KU 15-7 and KU 15-16 came under resistant (R) genotypes against YMV (1.0 to 2.0 rating). Blackgram genotypes such as P 205,

GKU 02-1, KU 15-14, KU 323, PU 30, LBG 775, KU 15-3, VH 85-5, KU 15-2, LBG 20, LBG 752, KU 15-20, P 726, KU 15-13, UTTARA and LBG 623 came under 2.1 to 4.0 rating which are moderately resistant (MR). Varieties i.e PLU 10-4, LBG 783, IPU 10-4 and KU 15-4 came under scale 4.1 to 5.0 rating which is moderately susceptible (MS). The genotypes such as KU 15-19, KU 708, LBG 708, CN 8072, KU 15-11 and LBG 787, P 1070, LBG 777, SPS 26, KU 15-15, KU 15-10 and RUG 44 came under scale 5.1 to 7.0 rating and are susceptible (S). Genotypes viz., T9, TBG 104, LBG 645, CPS 35, LBG 788, P 728, LBG 685, PU 31, LBG 791 and LBG 722 came under 7.1 to 9.0 rating and are highly susceptible (HS).

4. Discussion

Identifying a potential yield obtaining blackgram genotypes along with YMV resistance is not an easy task. As field trials prone to uncontrolled environment justifying the existing YMV resistant blackgram varieties under field condition is quite complex one.

The plant height of blackgram over different varieties was differed significantly under YMV infection. The variety Blackgram SPS 26 grew significantly taller (68.00 cm). Followed by SPS 26 maximum plant height was observed in LBG 777, PGRU 99-028 and KU 15-15 (65.00) (Table 2). The overall trend indicated that the progressive increase in height among the varieties was consistent. The significant variations in plant height among the varieties may be due to their genetic variability and the influence of environmental factors. These findings are in accordance with Dharmalingam and Basu (1993); Bhowmick *et al.*, (2008); Anon (2009); Akter (2011); Verma *et al.*, (2011). All the studied varieties showed a conspicuous contrast in case of Days to 1st flowering to 50% flowering and maturity. All the normal genotypes showed above 50% flowering at 45 DAS whereas in case of YMV infected plants except KU 15-11 (40.00) and LBG 685 (48.97) were recorded below 50% flowering (Table 2). The relative early or lateness of flowering might be owing to the genetic potential of varieties rather than the YMV infestation. It is similar with the findings of Anon (2009). Maximum number of clusters were recorded in KU 15-9 (40.00) followed by TU 18, TBG 104 (39.00), PGRU 99-028 (37.00) and KU 15-6 (36.00). Where is in case of YMV infected plants maximum number of clusters were reported in KU 15-9 (38.00), TU 18 (36.00), PGRU 99-028 (35.00), and KU 15-6 (32.00). These results were in accordance with Dharmalingam and Basu (1993); Akter (2011). The formation of a number of pods/plant found to be varied significantly among the blackgram varieties (Table 2). Among the normal plants maximum number of pods were recorded in KU 15-9 (100.00) where as in In YMV infected plants highest number of pods per plant was recorded in KU 15-9 (95.00), TU 18 (76.00), KU 15-6 (75.00) and PGRU 99-028 (74.00). Along with genetic efficiency, soil and climatic condition may also influence the pod number. Venkateswarlu and Rajan (1991); Bhowland and

Bhowmik (2014) reported a variation of the number of pods earlier. The pod length of different blackgram varieties differed significantly (Table 2). The varieties such as KU 15-9, TU 18, PGRU 99-028 showed higher pod length both in healthy (5.80 cm, 5.50 cm, 5.40 cm and 5.35 cm) and YMV infected plants (5.55 cm, 5.35 cm, 5.25 cm and 5.15 cm). Length of the pod is genetically made character under optimal environmental conditions. Here also, all three varieties had been exposed to similar environmental condition; genetic characters express the results. Similar trend of results were reported by Vohra and Beniwal (1979); Babu *et al.*, (1984). The number of grains per pod, varied significantly in different varieties of blackgram (Table 2). Among all the healthy plants maximum number of seeds per pod (9.00) was reported in KU 15-9, P 205, KU 15-10, KU 15-7, KU 15-4 and LBG 722 where as under YMV infection maximum number of seeds per pod was reported in KU 15-9 (8.00) followed by KU 15-6, TU 18 (7.00) and PGRU 99-028, KU 15-16, LBG 722 (6.00). The number of grains/pod was influenced by the genetic potentiality of the genotype. Among the genetic characters, pod length is the primitive parameter deciding the number of grains/pod. Similar results were also reported earlier by Babu *et al.*, (1984); Mahalakshmi *et al.* (2002); and Bhowland and Bhowmik (2014). Measuring the 100 seed weight relatively may the indication yield potentiality of a genotype. Among all the healthy plants maximum 100 seed weight was reported in KU 15-9 (4.99 g) followed by TU 18 (4.90 g), PGRU 99-028 (4.81 g) and KU 15-6 (4.66 g). In case of disease infected plants the 100 seed weight was maximum in KU 15-9 (4.82 g), TU 18 (4.80 g), PGRU 99-028 (4.60 g) and KU 15-6 (4.40 g) (Table 2). These findings are similar to Khattak *et al.*, (2000); Anon (2009). Yellow mosaic virus infection significantly affects the whole plant dry weight in all the genotypes. Among all the genotypes highest dry weight was recorded in PGRU 99-028 (17.575 g) followed by LBG 20 (17.255 g), KU 15-9 (17.050 g), TU 18 (13.650 g) and KU 15-6 (12.975 g). In case of YMV infected plants highest plant dry weight was reported in KU 15-9 (16.420 g), PGRU 99-028 (16.110 g), TU 18 (13.110) and KU 115-6 (11.00 g). It was supposed that, the genetic makeup of the genotypes might cause such variation. This is coinciding with the results of Venkateswarlu and Rajan (1991); Dharmalingam and Basu (1993); Anon (2009); Akter (2011). In present study significant effect of YMV on grain yield was observed (Table 2). Of all the genotypes maximum yield per hectare was reported in varieties such as KU 15-9 (1719.75 kg h^{-1}), TU 18 (1605.63 kg h^{-1}), PGRU 99-028 (1316.20 kg h^{-1}) and KU 15-6 (1281.88 kg h^{-1}). In case of YMV infected plants also maximum yield per hectare was reported by the KU 15-9 (1685.45 kg h^{-1}), TU 18 (1595.00 kg h^{-1}), PGRU 99-028 (1280.00 kg h^{-1}) and KU 15-6 (1200.00 kg h^{-1}). Higher yield potential, suitability to a ricefallow condition in addition to the resistance of yellow mosaic virus might be the reason for higher yield.

Table 2. Percent infection per plant and Disease scoring scale of studied blackgram genotypes

S.No	Genotype	Percent infection	Disease scoring scale* (1-9 scale)
1	PU 30	50.19	4
2	KU 15-19	61.18	6
3	KU 15-6	10.57	1
4	P 1070	76.72	7
5	LBG 777	77.77	7
6	LBG 775	43.52	4
7	P 205	34.91	3
8	SPS 26	73.44	7
9	KU 15-3	31.81	4
10	GKU 02-1	30.38	3
11	KU 15-14	35.70	3
12	T 9	80.00	8
13	TU 18	10.29	1
14	TBG 104	78.75	8
15	PGRU 99-028	10.81	1
16	VH 85-5	32.52	4
17	UK 2289	17.94	2
18	PLU 10-4	59.46	5
19	LBG 783	55.84	5
20	KU 15-15	71.56	7
21	LBG 709	22.57	2
22	KU 15-9	10.96	1
23	KU 708	62.89	6
24	KU 15-2	35.64	4
25	LBG 20	45.05	4

S.No	Genotype	Percent infection	Disease scoring scale* (1-9 scale)
26	KU 15-10	21.80	2
27	LBG 752	34.54	4
28	LBG 708	64.39	6
29	KU 15-7	20.61	2
30	LBG 645	79.02	8
31	KU 15-20	35.38	4
32	CN 8072	65.39	6
33	P 726	34.17	4
34	IPU 10-4	51.58	5
35	RUG 44	73.51	7
36	CPS 35	77.89	8
37	LBG 788	81.89	8
38	KU 15-13	36.37	4
39	KU – 323	38.00	3
40	P 728	74.54	8
41	KU 15-11	62.00	6
42	LBG 685	74.00	8
43	UTTARA	42.12	4
44	KU 15-4	52.50	5
45	PU 31	79.00	8
46	LBG 623	32.75	4
47	LBG 787	65.71	6
48	LBG 791	73.33	8
49	KU 15-16	27.60	2
50	LBG 722	95.12	9

Table 3. Grouping of blackgram genotypes screened against YMV basing on morphological, physiological, yield characters and 1-9 arbitrary scale

Rating	Reaction	Genotype
1.0 – 2.0	Resistant (R)	KU 15-6, TU 18, PGRU 99-028 and KU 15-9, UK 2289, LBG 709, KU 15-7, KU 15-16
2.1 – 4.0	Moderately Resistant (MR)	P 205, GKU 02-1, KU 15-14, KU 323, PU 30, LBG 775, KU 15-3, VH 85-5, KU 15-2, LBG 20, LBG 752, KU 15-20, P 726, KU 15-13, UTTARA, LBG 623
4.1 – 5.0	Moderately Susceptible (SC)	PLU 10-4, LBG 783, IPU 10-4, KU 15-4
5.1 – 7.0	Susceptible (S)	KU 15-19, KU 708, LBG 708, CN 8072, KU 15-11 and LBG 787, P 1070, LBG 777, SPS 26, KU 15-15, KU 15-10, RUG 44
7.1 – 9.0	Highly Susceptible (HS)	T9, TBG 104, LBG 645, CPS 35, LBG 788, P 728, LBG 685, PU 31, LBG 791, LBG 722

A higher number of pods/plant in VBN (BG) 6 variety might have directly influenced on grain yield of blackgram. Yield variation over different varieties of blackgram was also recorded earlier (Khattak *et al.*, 2000; Bhowaland and Bhowmik, 2014; and Reddy *et al.*, 2014; Babu *et al.*, 2016, 2017).

5. Conclusion

On the basis analyzed results and disease scoring scale (Table 2 and Table 3) it is concluded that genotypes such

as KU 15-6, KU-15-9, TU 18, PGRU 99-028 found to be relatively more resistant to yellow mosaic disease during *khari* season and these can be useful in developing YMV resistant blackgram varieties.

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