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Correlation and Path Analysis for Yellow Mosaic Virus Disease Resistance and Yield Improvement in Blackgram [*Vigna mungo* (L.) Hepper]

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Pulses are rich and the cheapest source of delivering protein and also valuable animal feed. Indian has the largest area of about 34% and total production of about 26% of pulses globally. The present investigation was carried out with four parents in Diallel mating design during 2010-2011. The resultant 12 hybrids and four parents were evaluated in a randomized and replicated trial for estimating with regard to seed yield, correlation, path analysis and YMV resistance. The study on association of different traits indicated that single plant yield was highly correlated with plant height, number of branches per plant, number of pods per plant, pod length and number of seeds per pod. Path analysis revealed that pod length followed by number of pods per plant and number of branches per plant will be effective in increasing the yield. The inheritance of YMV was studied with 12 hybrids, among the hybrids, VBN 4 x VBN 2, VBN 2 x VBN 4 and VBN 2 x LBG 17 showed complete resistance against YMV, hence the crosses were recommended for further breeding programme to identify high yielding YMV resistant lines.

Introduction

Blackgram [*Vigna mungo* (L.) Hepper] is an important grain legumes grown in many regions of India and in Asian countries like Pakistan, Bangladesh, Sri Lanka and Myanmar. In the developed countries, grain legumes are an important indirect source of protein. However, for many developing countries, pulses constitute the cheap and readily available source of dietary protein. Therefore, the only practical means of solving the protein malnutrition in developing countries is to increase the production of pulse crops. The pulse crops, in general, give lower yield than the cereal crops. One school of thought believes that, because pulses are rich in protein they require more energy to synthesize protein than carbohydrates. From the comparisons of known energy requirements of various metabolic pathways, one gram of glucose can give rise to 0.8 g carbohydrate but on an average, only about 0.5 g of protein. Besides this, pulse crops are generally cultivated in marginally poor soils, mostly in rainfed conditions which leads to low yield. While considering the area and production, it is found to be in the declining trend. Besides, the pulse crop, especially black gram, is attacked by more number of pests and diseases. Among the diseases, yellow mosaic virus disease (YMV) is the major causing yield loss up to 66.6 per cent (Chand and Verma, 1983). The grain legumes are noted for their low yielding capacities throughout the world. The reason for low yield of pulses is not only due to the reason aforesaid, it may rather be that they have not received enough attention concerning intensive breeding efforts. Of late only, the grain legumes drew the serious attention of plant breeders and many high yielding disease resistant varieties have been released from different states. Even then, still, more research and attempts are to be made to develop high yielding and disease resistant varieties so as to achieve self-sufficiency in pulses, especially in blackgram. In any crop improvement programme, the most important prerequisite is the selection of suitable parents, which could combine well and produce desirable segregants. In crops like blackgram, where hybridization followed by back cross or pedigree method is commonly followed, genetic information especially about the nature of combining ability and type of gene action governing the inheritance of economically important quantitative and qualitative traits like YMV resistance can be of immense help to the breeder in the choice of suitable parents and appropriate breeding procedures. The 'Diallel' analysis helps to find out the combining ability for different yield attributes and also the gene action involved. Yield is a complex character collectively influenced by various components. The correlation coefficients coupled with path coefficient estimates provides information on relative importance of the components of yield. Keeping these points in view, a study was undertaken in the present investigation to understand the complexity of quantitative as well as qualitative traits in blackgram. The materials selected for this study included three high yielding and YMV resistant varieties of blackgram and one is YMV susceptible. Yellow mosaic virus is one of the most important constraints for blackgram production. It was also noted on blackgram under natural condition in India (Williams *et al.*, 1968). The virus is endemic to the South Asia region but occurs sporadically in Southeast Asia such as in Thailand where the virus was reported only from 1977 to 1981. Since it is a severe and widespread viral disease, it has been extensively studied by many investigations (Ahmad, 1975; Sandhu, 1978; Jalaluddin and Sheikh, 1981; Singh *et al.*, 1988). The disease cause serious reduction in the yield of blackgram. It is reported to the extent of 85%, 62% and 43% in case of early mid and late inoculations, respectively. The reduction in yield is contributed by reduction in number of pods per plant, seeds per pod and seed weight (Singh and Srivastava, 1985). Due to YMV, the genetic variability is lost and it is this genetic potential for high yield needs to be regenerated. The state and National programme on the improvement of pulses emphasized the urgency of generating variability for high genetic potential. Investigation on the magnitude of heterosis helps to identify promising hybrid combination and also possible to exploit to new recombinant type for yield and it's attributing traits from segregants.

Materials and Methods

The present investigation was conducted at the Agricultural College and Research Institute, Madurai during 2010-2011 at the experimental farm in the Department of Plant Breeding and Genetics. Four varieties of blackgram obtained from National Pulses Research Centre, Vamban, Tamil Nadu. Among the parents, four genotypes *viz.*, Vamban 4, Vamban 2, LBG 17 and CO 5 were used as the materials of the present study. Twelve hybrids were raised during *Rabi*, 2011 in ridges of three meter length with an inter row spacing of 40 cm and intrarow spacing of 20 cm. The hybrids were raised in a Randomized Block Design with three replications. For estimating heterosis, the parents were also raised in adjacent plot with above mentioned spacing in three replications. The recommended agronomic and plant protection practices were followed to maintain healthy stand of the plants. The Yellow Mosaic Virus Disease (YMV) incidence was recorded on all the plants based on the visual scores on 50^{th} day while the susceptible check C0 5 recorded scale 6.9. The classification was made into scales 1 – 9 as follows based on the scale adopted by Singh *et al.,* (1988) (Table 5 and 6). Combining ability analysis of cultivars is thus important to exploit the relevant type of gene action for a breeding programme. Combining ability estimates can be used to evaluate the number of promising lines in F_1 and F_2 generations, which is quite helpful in selecting the potential parents for hybridization. Combining ability study is useful in classifying the parental lines in terms of their hybrid performance (Dhillon, 1975). It also helps in identifying the parents suitable for hybridization programme and deciding suitable breeding methodology.

Results and Discussion

The analysis of variance of RBD for 12 hybrids and four parents separately revealed highly significant difference among the genotypes for 11 traits studied (Table 1 and 2). Since all the traits showed highly significant difference among the genotypes, the combining ability effects of parents and their F_1 hybrids were estimated by the diallel method of analysis.

Correlation studies

The genotypic correlation coefficients between grain yield and its component characters and inter correlation among different traits are presented in Table 3. In the present study, single plant yield expressed significant and positive association with number of branches per plant, pod length, plant height, number of pods per plant, number of seeds per pod, 100 grain weight, number of clusters per plant, days to 50 percent flowering and protein content. This result was in close agreement with those obtained by earlier workers *viz.,* Chauhan *et al.,* (2007), Konda *et al.,* (2008), Mallikarjuna Rao *et al.,* (2006), Haritha and Sekhar (2002), Anbumalarmathi (2002), Vijiyalaxmi and Bhattacharya (2006) Rahim *et al.,* (2010) and Pushpa Reni *et al.,* (2013) for days to 50 per cent flowering, days to maturity and protein content. Single plant yield expressed highly significant and positive association with number of branches per plant (0.858), pod length (0.694), plant height (0.692) number of pods per plant (0.641), number of seeds per pod (0.631). Hundred grain weight (0.554), number of clusters per plant (0.531), days to 50 per cent flowering (0.506) and protein content (0.435) registered significantly positive correlation. Days to 50 per cent flowering showed positive and highly significant correlation with days to maturity (0.804). The remaining characters *viz.,* protein content (0.527), number of pods per plant (0.500), plant height (0.470) and number of branches per plant (0.466) showed positive and significant correlation. The inter correlation between yield contributing characters may affect the selection for component traits either in favourable or unfavourable direction. Hence, the knowledge on inter relationship between yield component traits may facilitate breeders to decide upon the intensity and direction of selection pressure to be given on related traits for the simultaneous improvement of these traits.

Days to maturity had with showed significant and positive correlation pod length (0.676), protein content (0.632), number of seeds per pod (0.615), number of pods per plant (0.604), number of branches per plant (0.594) and plant height (0.580) while with number of cluster per plant (0.483) exhibited significantly positive correlation. Plant height had significant and positive correlation with number of seeds per pod (0.829), pod length (0.806), number of branches per plant (0.773), number of pods per plant (0.712) and 100 grain weight (0.683). There was a positive and significant correlation between plant height with number of branches per plant and all other character except number of clusters per plant and protein content. These results were in close agreement with the findings of Rahim *et al.,* (2010) for number of pods per plant, Sunil kumar *et al.,* (2003) for pod length, Mallikarjuna Rao *et al.,* (2006), Baudh Bharti *et al.,* (2014) for number of seeds per pod.

Number of branches per plant had significant positive association with pod length (0.838), number of pods per plant (0.795), number of clusters per plant (0.779), number of seeds per pod (0.681), hundred grain weight (0.648) and protein content (0.547).

Number of branches per plant had highly significant and positive correlation with number of clusters per plant, pod length, number of pods per plant, number of seeds per pod, 100 grain weight and protein content. This was supported by Natarajan and Rathinasamy (1999) for number of cluster per plant and Mallikarjuna Rao *et al.,* (2006) for number of pods per plant and number of seeds per pod. Konda *et al.,* (2008), Sheetal *et al.,* (2014) for protein content.

Number of clusters per plant expressed positive and significant correlation with number of pods per plant (0.666), pod length (0.626) and number of seeds per pod (0.508). Number of clusters per plant expressed significantly positive correlation with number of pods per plant, pod length and number of seeds per pod. These results were in close agreement with the findings of Kasundra *et al.,* (1995) for number of seeds per pod, Sunil Kumar *et al.,* (2003) for number of pods per plant, Konda *et al.,* (2008), Kanimoli Mathi Vathana *et al.,* (2015) for pod length.

Pod length showed positive and significant association with number of seeds per pod (0.976), number of pods per plant (0.616) and 100 grain weight (0.459). Pod length had significantly positive association with number of pods per plant, number of seeds per pod and 100 grain weight.

This was earlier found by Gayen and Chattopodhayay (2002) for number of seeds per pod and 100 grain weight. Number of pods per plant showed significantly positive association with plant height, number of seeds per pod and 100 grain weight. This was supported by Santha and Velusamy (1997) for plant height, Sunil Kumar *et al.,* (2003) and Konda *et al.,* (2008) for number of seeds per pod. Number of seeds per pod had registered significant and positive association with 100 seed weight. Number of pods per plant had positive and significant correlation with 100 grain weight (0.843) and number seeds per pod (0.572) showed significantly positive correlation. Number of seeds per pod registered positive and significant association with 100 grain weight (0.506). Hundred grain weights had positive and non-significant correlation with protein content (0.281).

Path coefficient analysis

The direct and indirect effects of 11 characters on single plant yield are presented in Table 4. A brief account on direct and indirect effects on different component traits on grain yield is presented below. The direct effects of characters on the yield are presented in Figure 1.

Table.1 Analysis of variance of RBD for different traits in parents and hybrids

Source	d.f	Mean squares										
		DF	DM	PH	BR	CPP	PL	PPP	SPP	HS	PRT	YLD
Replication	2	18.08	24.33	26.58	1.45	4.59	0.62	22.50	1.13	0.07	15.34	3.70
Parents	3	4.56 **	124.97**	101.81**	0.82**	10.77**	0.39**	132.52**	0.82**	0.98**	9.06**	4.34**
Hybrids	11	1.76**	16.93**	68.06**	0.58**	16.41**	0.51**	144.51**	0.32*	0.73**	9.42**	34.39**
Treatment	15	2.20**	40.83**	94.66**	0.71**	29.94**	0.47**	67.59**	0.40*	0.68*	6.32**	44.22**
Error	30	0.43	0.55	0.21	0.09	0.22	0.67	0.02	0.16	0.10	0.20	0.16

*Significant at 5% level ** Significant at 1% level

DF – Days to 50 per cent flowering
DM – Days to maturity
PH – Plant height
BR – Number of branches per plant
CPP – Number of clusters per plant
PPP – Number of pods per plant
PL – Pod length
SPP – Number of seeds per pod
HS – Hundred seed weight
PRT – Protein content
YLD – Seed yield per plant

Table.2 Analysis of variance of combining ability for different traits

Source of variation	d.f	Mean squares										
		Days to 50 per cent flowering	Days to maturity	Plant height	No. of branches per plant	No. of clusters per plant	No. of pods per plant	Pod length	Number of seeds per pod	100 grain weight	Protein content	Single plant yield
GCA	3	3.08**	38.93**	70.16**	0.25**	3.85**	51.90**	0.27**	0.56	0.19**	1.40**	23.12**
SCA	6	0.23	11.77**	25.17**	0.38**	16.73**	18.36**	0.23**	0.18*	0.21**	2.05**	21.43**
RCA	6	0.065	2.78**	18.63**	0.08*	6.29**	12.00**	0.02*	0.12	0.26**	2.51**	3.85**
Error	30	0.14	0.18	0.07	0.03	0.07	0.22	0.00	0.05	0.03	0.06	0.05

* Significant at 5% level, ** Significant at 1% level

Table.3 Genotypic correlation coefficients between single plant yield and component characters

Characters	Days to 50 per cent flowering	Days to maturity	Plant height	No. of branches per plant	No. of clusters per plant	Pod length	No. of pods per plant	No. of seeds per pod	100 grain weight	Protein content	Single plant yield
Days to 50 per cent flowering	1.000	0.804**	0.470*	0.466*	0.215	0.357	0.500*	0.352	0.420	0.527*	0.506*
Days to maturity		1.000	0.580**	0.594**	0.483*	0.676**	0.604**	0.615**	0.417	0.632**	0.400
Plant height			1.000	0.773**	0.361	0.806**	0.712**	0.829**	0.683**	0.416	0.692**
No. of branches per plant				1.000	0.779**	0.838**	0.795**	0.681**	0.648**	0.547**	0.858**
No. of clusters per plant					1.000	0.626**	0.666**	0.508*	0.224	0.251	0.531*
Pod length						1.000	0.616**	0.976**	0.459*	0.421	0.694**
No. of pods per plant							1.000	0.572*	0.843**	0.362	0.641**
No. of seeds per pod								1.000	0.506*	0.311	0.631**
100 grain weight									1.000	0.281	0.554*
Protein content										1.000	0.435*

* Significant at 5% level, ** Significant at 1% level

Table.4 Direct and indirect effect of different characters on yield

Characters	Days to 50 per cent flowering	Days to maturity	Plant height	No. of branches per plant	No. of clusters per plant	Pod length	No. of pods per plant	No. of seeds per pod	100 grain weight	Protein content	Single plant yield
Days to 50 per cent flowering	**1.014**	-1.064	-0.216	0.228	-0.103	0.466	0.447	-0.046	-0.209	0.088	0.506*
Days to maturity	0.815	**-1.044**	-0.267	0.291	-0.232	0.882	0.540	-0.080	-0.208	0.106	0.400
Plant height	0.476	-0.839	**-0.460**	0.378	-0.173	1.051	0.636	-0.108	-0.340	0.069	0.692**
No. of branches per plant	0.472	-0.860	-0.356	**0.489**	-0.373	1.094	0.711	-0.088	-0.322	0.091	0.858**
No. of clusters per plant	0.218	-0.699	-0.166	0.381	**-0.479**	0.817	0.596	-0.066	-0.111	0.042	0.531*
Pod length	0.362	-0.978	-0.371	0.410	-0.300	**1.034**	0.551	-0.127	-0.228	0.070	0.694**
No. of pods per plant	0.507	-0.874	-0.327	0.389	-0.319	0.803	**0.894**	-0.074	-0.419	0.061	0.641**
No. of seeds per pod	0.357	-0.890	-0.382	0.333	-0.243	1.027	0.511	**-0.130**	-0.251	0.052	0.631**
100 grain weight	0.426	-0.604	-0.314	0.317	-0.107	0.599	0.754	-0.066	-0.497	0.047	0.554*
Protein content	0.535	-0.915	-0.191	0.268	-0.120	0.549	0.324	-0.040	-0.140	**0.106**	0.435*

Residual effect: 0.16

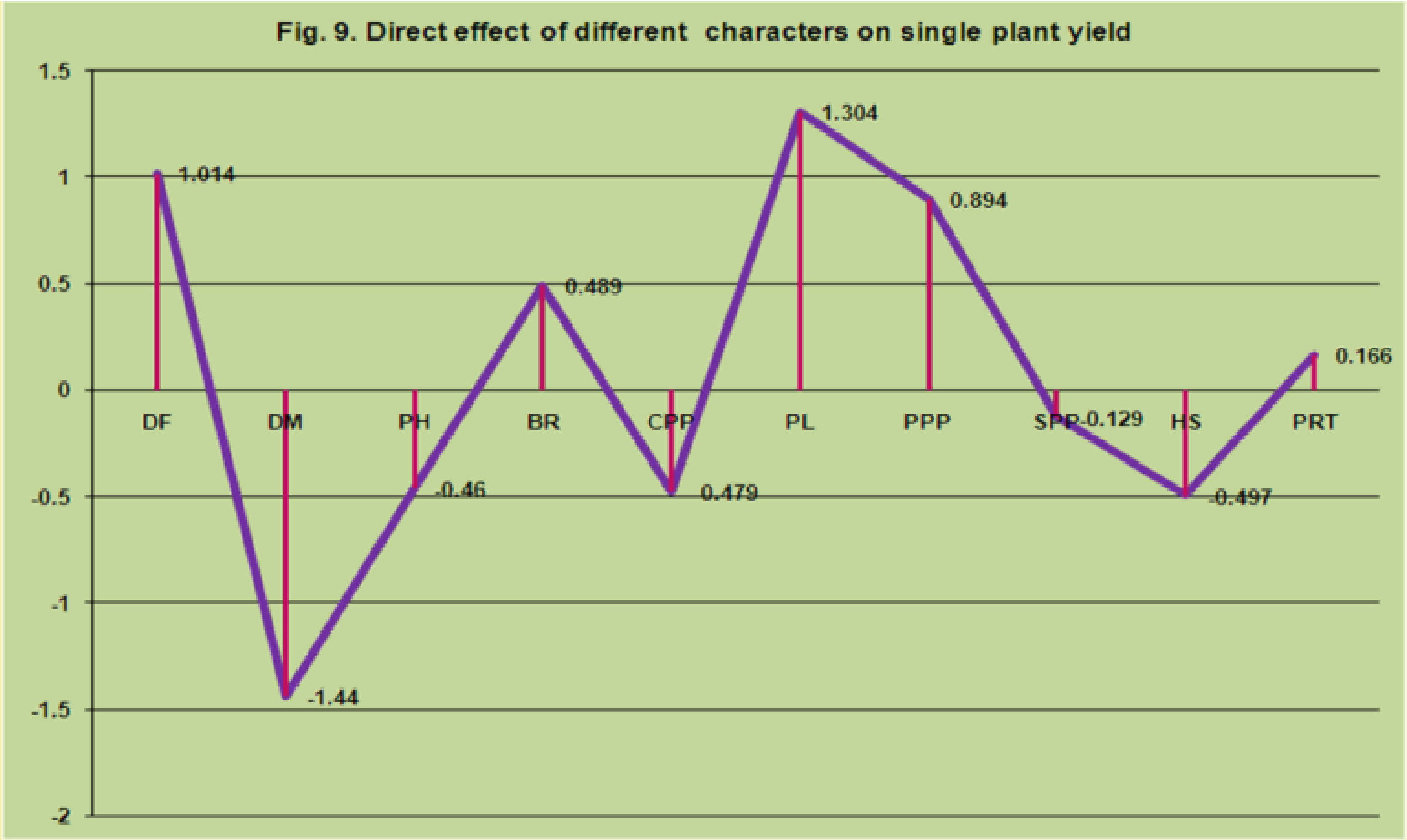
Table.5 Yellow Mosaic Virus disease (YMV)

Scales	Percentage of plant foliage affected	Reaction
1	Mottling of leaves covering 0.1 to 5.0 per cent of the leaf area.	Resistant
3	Mottling of leaves covering 5.1 to 10.0 per cent of the leaf area.	Moderately resistant
5	Mottling and yellow discoloration of 10.1to 25.0 per cent of the leaf area.	Moderately susceptible
7	Mottling and yellow discoloration of 25.1to 50.0 per cent of the leaf area.	Susceptible
9	Severe yellow mottling on more than 50.0 per cent and up to 100 per cent of the leaf area.	Highly susceptible

Table.6 YMV scores in parents and hybrids

Code no.	Genotypes	Mean YMV score	Reaction
P1	Vamban 4	1.0	Resistant
P2	Vamban 2	1.0	Resistant
P3	LBG 17	3.8	Moderately resistant
P4	CO 5	9.0	Highly Susceptible
Hybrids			
P1 x P2	VBN4 x VBN2	1.2	Resistant
P1 X P3	VBN4 X LBG 17	4.3	Moderately resistant
P1X P4	VBN4 X CO 5	3.8	Moderately resistant
P2 X P1	VBN2 X VBN 4	1.8	Resistant
P2 X P3	VBN2 X LBG 17	3.4	Moderately resistant
P2 X P4	VBN2 X CO 5	7.6	Susceptible
P3 X P1	LBG 17 X VBN 4	4.2	Moderately resistant
P3 X P2	LBG 17 X VBN 2	1.5	Resistant
P3 X P4	LBG 17 X CO5	5.8	Moderately susceptible
P4 X P1	CO 5 X VBN4	4.2	Moderately resistant
P4 X P2	CO 5 X VBN 2	4.5	Moderately resistant
P4 X P3	C0 5 X LBG 17	9.2	Highly Susceptible

Fig.1 Different effects of different characters on single plant yield



DF – Days to 50 per cent flowering
DM – Days to maturity
PH – Plant height
BR – Number of branches per plant
CPP – Number of clusters per plant
PPP – Number of pods per plant
PL – Pod length
SPP – Number of seeds per pod
HS – Hundred seed weight
PRT – Protein content
YLD – Seed yield per plant

Direct effects

Days to 50 per cent flowering (1.014), pod length (1.304) had positive direct effect on single plant yield. Number of pods per plant (0.894), number of branches per plant (0.489) recorded moderate positive direct effects on single plant yield. In the present study, pod length had high direct effect on seed yield. This was in accordance with earlier findings of Konda *et al.*, (2008), Kousar makeen *et al.*, (2009) and Sunil kumar *et al.*, (2003). Moderate direct effect on seed yield was noticed for number of pods per plant. It was suggested by Srividhya *et al.*, (2005 b), Chauhan *et al.*, (2007), Reena Mehra *et al.*, (2016). Protein content (0.166) showed low positive direct effect on single plant yield. Days to maturity (-1.447), 100 grain weight (-0.497), number of clusters per plant (-0.479) plant height (-0.460) and number of seeds per pod (-0.129) had negative direct effects on single plant yield.

Indirect effects

Days to 50 per cent flowering recorded high negative indirect effect on single plant yield through days to maturity (-1.164). The indirect effects of days to 50 per cent flowering on grain yield was significant and positive through number of pods per plant (0.447), pod length (0.466), number of branches per plant (0.228) and protein content (0.088). Negative indirect effect on yield through plant height (-0.126), number of clusters per plant (-0.103) and 100 grain weight (-0.209). Days to maturity showed negative negligible indirect effect through number of seeds per pod (-0.080). Negative indirect effect through plant height (-0.267), number of cluster per plant (-0.232) and 100 grain weight (-0.208). Positive indirect effect through days to 50 per cent flowering (0.815), number of pods per plant (0.540), number of branches per plant (0.291) and protein content (0.106) and also positive high indirect effect through pod length (0.882) on single plant yield.

Plant height showed high positive indirect effect on single plant yield through pod length (1.051), number of pods per plant (0.636), days to 50 per cent flowering (0.476), number of branches per plant (0.378) and protein content (0.069). Negative indirect effect through days to maturity (-0.839), 100 grain weight (-0.340), number of clusters per plant (-0.173) and number of seeds per pod (-0.108) on single plant yield. Number of branches per plant expressed high and positive indirect effect on yield through pod length (1.094). The indirect effect of number of branches per plant on grain yield was significant and positive through number of pods per plant (0.711) and days to 50 per cent flowering (0.472). Low and positive indirect effect on yield through protein content (0.091) via low and negative indirect effect through days to maturity (-0.860), number of cluster per plant (-0.373), plant height (-0.356) and 100 grain weight (-0.322) on single plant yield. Number of branches per plant showed low positive direct effect on yield. Luman Hakim (2008) found similar results with regard to number of branches per plant. Remaining traits noticed negligible effect on single plant yield.

High positive indirect effect of number of clusters per plant on single plant yield was through pod length (0.817). Low and positive indirect effect on yield through number of pods per plant (0.596), number of branches per plant (0.381), days to 50 percent flowering (0.218) and protein content (0.042). Its indirect effect through days to maturity (-0.699), plant height (-0.166), 100 grain weight (-0.111) and number of seeds per pod (-0.066) was low and negative and through other traits was negligible. Pod length expressed positive and high indirect effect on single plant yield through number of pods per plant (0.551),number of branches per plant (0.410) and days to 50 per cent flowering (0.362) and Moderate and negative indirect effects through days to maturity (-0.978) via rest of the traits with negligible values. The indirect effect of pod length and number of pods per plant on grain yield was positive through number of clusters per plant. The indirect effect of pod length was positive through number of pods per plant. The indirect effect of number of pods per plant and pod length was positive through 100 grain weight. Similar findings were also reported by Veeramani *et al.*, (2005) Pushpa Rani *et al.*, (2013) and Vijay kumar *et al.*, (2015). The remaining traits had negligible effects on seed yield.

Positive and high indirect effect of number of pods per plant was noticed through pod length (0.803). Positive and moderate indirect effect days to 50 per cent flowering (0.507) and number of branches per plant (0.389). Negative and high indirect effect through days to maturity (-0.874), 100 grain weight (-0.419), plant height (-0.327) and other traits showed negligible indirect effect on single plant yield. Number of seeds per pod expressed positive and high indirect effect on single plant yield through pod length (1.027).Positive and moderate indirect effect number of pods per plant (0.511), days to 50 percent flowering (0.357) and number of branches per plant (0.333). Negative indirect effect on yield through days to maturity (-0.890) and negligible through rest of the traits. Hundred grain weight recorded positive and high indirect effect on single plant yield through number of pods per plant (0.754), pod length (0.599) and days to 50 percent flowering (0.426). Negative and low indirect effect on yield through days to maturity (-0.604) via rest of the traits with negligible values. The indirect effect of protein content on single plant yield was high and positive effect through pod length (0.549), days to 50 percent flowering (0.535), number of pods per plant (0.324) and number of branches per plant (0.268). Negative and moderate indirect effect through days to maturity (-0.915). Plant height (-0.191), 100 grain weight (-0.140) and number of cluster per plant (-0.120) shows low and negative indirect effect. The study on association of different traits indicated that single plant yield was highly correlated with plant height, number of branches per plant, number of pods per plant, pod length and number of seeds per pod. Path analysis revealed that pod length followed by number of pods per plant and number of branches per plant will be effective in increasing the yield.

Yellow mosaic virus disease (YMV) resistance

According to the classification, scale 1-9 i.e. resistant, moderately resistant, moderately susceptible, susceptible, highly susceptible are discussed hereunder: Among the 12 crosses, three hybrids showed complete resistance against YMV with high yield performace. The hybrids are VBN 4 x VBN 2, VBN 2 x VBN 4 and VBN 2 x LBG 17. So the segregants from these crosses may be utilized for recombination breeding for hybridization and YMV resistant. Four hybrids reacted as moderately resistant to YMV such as VBN 4 x LBG 17, VBN 2 x CO 5, LBG 17 x VBN 4 and CO 5 x VBN 2. Moderately susceptible reactions recorded by the hybrids were VBN 4 x CO5, LBG 17 x CO 5 and CO 5 x VBN 4. The hybrids *viz.*, LBG 17 x VBN 2 and CO 5 x LBG 17 was the two crosses showing susceptible reaction against YMV. Screening of parents and hybrids for reaction against yellow mosaic virus is presented in Table 5. Similar results were also reported by Shamim *et al.*, (2014) and Peeta *et al.*, (2016). Among the parents P_1 and P_2 were resistance to YMV P_3 is moderately resistance and P_4 is susceptible to YMV. Experimental results clearly indicated that the crosses were rated as resistant to highly susceptible by using mean YMV score value. Out of 12 crosses, three crosses *viz.*, P_1 x P_2, P_2 x P_1 and P_2 x P_3 showed resistance against YMV disease which gives more yield. Four hybrids reacted against YMV as moderately resistant which also gave more yield when compared to susceptible crosses. The crosses were P_1 x P_3, P_2 x P_4, P_3 x P_1 and P_4 x P_2. Similar result was reported by Prasanthi *et al.,* (2013). Moderately susceptible reaction was recorded by the hybrids *viz.,* P_1 x P_4, P_3 x P_4 and P_4 x P_1. Two crosses showed susceptible reaction against YMV by comparing mean score value, *viz.*, P_3 x P_2 and P_4 x P_3. The inheritance of YMV was studied with 12 hybrids, among the hybrids, VBN 4 x VBN 2, VBN 2 x VBN 4 and VBN 2 x LBG 17 showed complete resistance against YMV, hence the crosses were recommended for further breeding programme to identify high yielding YMV resistant lines.

Yellow Mosaic Virus disease (YMV)

The Yellow Mosaic Virus Disease (YMV) incidence was recorded on all the plants based on the visual scores on 50th day while the susceptible check C05 recorded scale 6.9. The classification was made into scales 1 – 9 as follows based on the scale adopted by Singh *et al.*, (1988).

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