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Correlation and path analysis for yield, yield components and mungbean yellow mosaic virus disease score in blackgram (*Vigna mungo* (L.) Hepper)

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Abstract
Correlation and Path coefficient analysis study were conducted using two hundred and twelve genotypes to screening of Yellow Mosaic Virus Disease. An experimental field were raised with susceptible check in YMV hotspot region of Tamil Nadu. Data were recorded for eleven biometrical traits. Plant height, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, pod length, number of seeds per pod and hundred seed weight had significantly positive association with single plant seed yield. Its indicating the trait single plant seed yield was highly correlated with these independent variables. Days to fifty percent flowering and yellow mosaic virus disease score had significant and negative association with single plant seed yield. Similar outcome were reported by earlier study. In genotypical path coefficient matrix number of pods per plant and number of seeds per pod exhibits maximum low positive direct and indirect effects towards single plant seed yield and most of the component traits. in phenotypical path coefficient matrix, number of pods per plant alone shown low and negligible positive direct and indirect effect towards single plant seed yield and most of its component traits; plant height and days to fifty percent flowering exhibits low negative indirect effect.

Keywords: MYMV, correlation, path analysis, yellow mosaic virus, urdbean

Introduction
Blackgram (*Vigna mungo* (L.) Hepper) is a self-pollinated diploid legume (2n=22) crop belongs to the family of Leguminaceae with size of 560 Mb genome (Arumuganathan and Earle, 1991). a short duration pulse crop largely cultivated in tropical and subtropical regions of Asian countries in different seasons of rainfed and irrigated condition. In India, blackgram is cultivating in 3.06MH with 555 kg/ha of productivity and 1.70MT of production (Anonymous, 2018). Existence of a short duration legume it can able to well fit with different cropping pattern.
Understanding the significance of correlation for traits of economic importance and cause and stimulates of association of yield and yield component traits for the available genotypes are of most important which, assists in preparation the prospect crop improvement programme for heritable development of any crop plant. Narrow genetic diversity is the foremost blockage for improving blackgram. Thus, the selection of diverse parental source for varietal development through hybridization is a essential factors for creating novel heritable variability in blackgram. in addition to that finding the association and path coefficient within a gene pool of significant breeding material can create crop improvement additional effective by the focused build up of preferred alleles. Considering these in the background, the current study aimed to study the, correlation and direct and indirect effect among 212 blackgram genotypes in terms of yield and yield attributing traits for identifying the essential characters which were to be utilize for the prospect of breeding programme.
The production of blackgram in India is very less due to many constraints such as lack of required quality seed of biotic and abiotic stress tolerating high yielding varieties. Therefore, the blackgram needs to be raise the production and productivity through pest and disease resistant crop varieties.
Mungbean Yellow Mosaic Virus is a important biotic stress can cause heavy yield loss in blackgram and also in mungbean. YMV transmitted by *Bemisia tabaci;* its belongs to the genus Begomovirus. Yield loss due to Yellow Mosaic Disease (YMD) vary from five to one hundred percent depends upon virus severity and susceptibility of genotypes and amount of whitefly population. With these background information, the current investigation was carried out to discover correlation among the traits for single plant seed yield, yield components traits and Yellow Mosaic Virus disease score through correlation coefficient and path analysis. Correlation study gives a better understanding of yield and yield component traits that assist a plant breeder during parental selection and crop improvement programme.

Materials and Methods
Experimental materials
The material for the current study comprised of 212 blackgram varieties obtained from the NBPGR, New Delhi, IIPR, Kanpur, NPRC, vamban and other sources.

Experimental site
The experiment was conducted during *kharif* season in Randomized Block design with three replications with susceptible check at MYMV hotspot location tirunelveli of Tamil Nadu. All the recommended cultural practices were followed.

Biometrical Observation
Yellow Mosaic Virus disease occurrences were visual scored and data were recorded for all the genotypes with susceptible check. Disease incidence were recorded

periodically and the yellow mosaic virus disease score was worked out as per suggested by singh *et al.* (1995) [7]. Observation was recorded for eleven characters for determining heritable association of the traits between the traits.

Statistical Analysis

Correlation coefficient

The phenotypic, genotypic and environmental correlation coefficients were worked out as per AI-jibouri *et al.* (1958) [1]

Path coefficient analysis

The direct and indirect effect of yield attributing traits on seed yield were calculated through the path coefficient analysis was suggested by Wright (1921) [14] and elaborated by Dewey and Lu (1959).

Results and Discussion

Correlation Studies

Correlation coefficient is a statistical technique; it is used to evaluate the degree and direction of association among two or more than two variables. Correlation study is gives a better understanding of yield and yield component traits that assist a plant breeder during parental selection and crop improvement programme (Robinson *et al.*1951 and Johnson *et al*. 1955). Mass selection can be used to improve seed yield in various crops through a indirect selection for extremely heritable characters, which are linked with plant yield. In the current study correlation coefficient have been worked out for eleven characters at genotypic and phenotypic levels. Genotypic correlation denotes the heritable relationship among two or more variables. This kind of correlation may also due to pleitropic genes action or due to linkage or also due to both. Phenotypic correlation coefficient is directly experimental and including genotypic and environmental effects and hence varies under different environmental conditions. Estimates of correlation coefficient on yield and yield contributing traits of blackgram genotypes are presented in the Table 1 & 2 and figure 1 & 2.

The trait days to 50% flowering exhibited number of pods per cluster and single plant seed yield had significant and negative association at both genotypic and phenotypic level.

Plant height had significant positive association with number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, hundred seed weight, yellow mosaic virus disease score and single plant seed yield while number of branches per plant had negative association at phenotypic and genotypic levels.

The number of branches per plant exhibited significant positive association with number of clusters per plant, number of pods per cluster and number of pods per plant at genotypic level and number of clusters per plant and number of pods per plant at phenotypic level.

The trait number of clusters per plant had significant and positive association with number of pods per plant, pod length, hundred seed weight and single plant seed yield had negative association while yellow mosaic virus disease score had significantly negative association with both the level respectively.

Number of pods per cluster had significant positive association with all the traits studied while in Yellow Mosaic Virus disease score alone had negative correlation at both levels.

For the trait number of pods per plant had significant and positive association with number of seeds per pod, hundred seed weight and single plant seed yield while the trait YMV score had negative correlation at both phenotypic and genotypic level. Hundred seed weight had positive and significant association with all the character at both level.

Pod length and number of seeds per pod had significant positive association with all the traits at both level. Yellow Mosaic Virus disease score had negatively significant with single plant seed yield at both phenotypic and genotypic level.

Plant height, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, pod length, number of seeds per pod and hundred seed weight had significantly positive association with single plant seed yield. Its indicating that the trait single plant seed yield was highly correlated with these independent variables. The results were agreed with Vadivel *et al.* (2019).

Days to fifty percent flowering and yellow mosaic virus disease score had significant and negative association with single plant seed yield. Similar outcomes were reported by earlier study Kanimoli Mathivathana *et al*. 2015; Sohel *et al*. (2016); Blessy *et al.* 2018, Vadivel *et al.* (2019).

Table 1: Genotypic correlation among various characters of blackgram genotypes

Character		DFF	PH	NBPP	NCPP	NPPC	NPPP	PL	NSPP	100SW	YMV score	SPSY
DFF	G	1.00	0.0589	0.0048	-0.0127	-0.111*	-0.0262	-0.0655	-0.0261	-0.0008	0.0053	-0.104*
PH	G		1.00	-0.0535	0.087*	0.126*	-0.0679	0.598**	0.374**	0.430**	0.213**	0.201**
NBPP	G			1.00	0.221**	-0.080*	0.160**	-0.113*	-0.0327	-0.122*	0.0654	0.0634
NCPP	G				1.00	0.0283	0.540**	0.114*	0.0691	0.207**	-0.104*	0.415**
NPPC	G					1.00	0.467**	0.153**	0.176**	0.092*	-0.0492	0.413**
NPPP	G						1.00	0.041	0.0689	0.116*	-0.519**	0.665**
PL	G							1.00	0.626**	0.508**	0.173**	0.334**
NSPP	G								1.00	0.157**	0.098*	0.342**
100SW	G									1.00	0.093*	0.269**
YMV score	G										1.00	-0.252**
SPSY	G											1.00

Table 2: Phenotypic correlation among various characters of blackgram genotypes

Character		DFF	PH	NBPP	NCPP	NPPC	NPPP	PL	NSPP	100SW	YMV score	SPSY
DFF	P	1.00	0.0432	0.0287	-0.0014	-0.063	-0.011	0.0262	0.0300	0.0486	0.0100	-0.091*
PH	P		1.00	-0.0532	0.0749	0.1194**	-0.0613	0.5034***	0.3208***	0.3919***	0.1992***	0.190**
NBPP	P			1.00	0.1751***	-0.0468	0.1568***	-0.0227	0.0345	-0.0595	0.0657	0.0571
NCPP	P				1.00	0.0176	0.4718***	0.0975*	0.0456	0.1653***	-0.1071**	0.342**
NPPC	P					1.00	0.4430***	0.2112***	0.2210***	0.1413**	-0.0402	0.383**
NPPP	P						1.00	0.0751	0.0927*	0.1379***	-0.5013***	0.650**
PL	P							1.00	0.6546***	0.5542***	0.1527***	0.270**
NSPP	P								1.00	0.2496***	0.0938*	0.280**
100SW	P									1.00	0.0849*	0.240**
YMV score	P										1.00	-0.262**
SPSY	P											1.00

***Significance at 0.1% Level, **Significance at 1% Level *Significance at 5% Level DFF - Days to 50% flowering, PH- Plant height, NBPP- Number of branches per plant, NCPP-Number of clusters per plant, NPPC- Number of pods per cluster, NPPP- Number of pods per plant, PL- Pod length, NSPP-Number of seeds per pod, 100SW-Hundred seed weight, YMV score- Yellow Mosaic Virus disease score, and SPSY - Single pl ant seed yield.

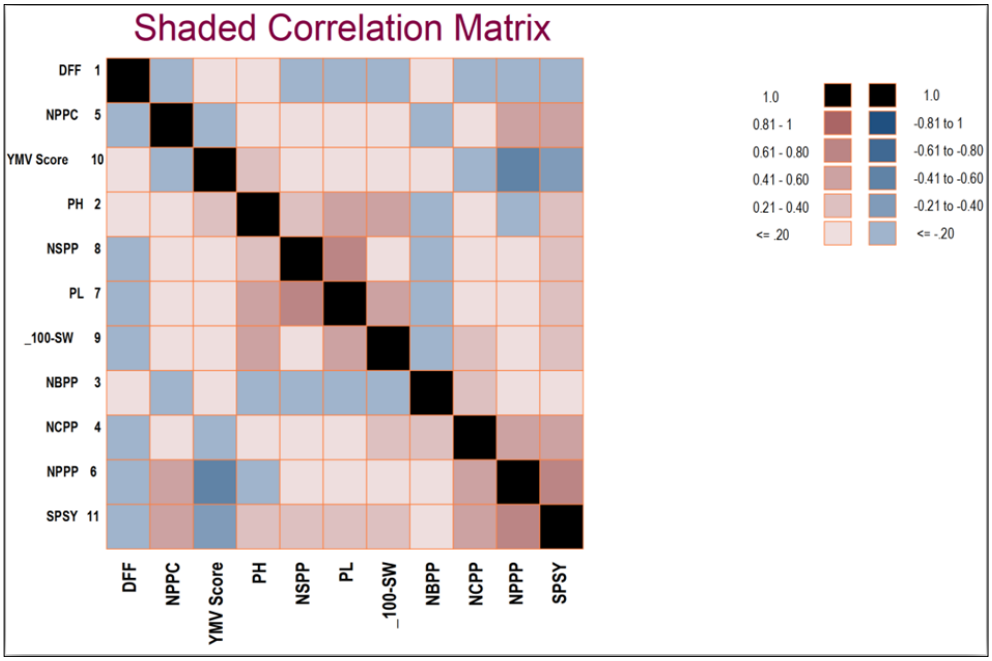

Fig 1: Genotypical shaded correlation matrix

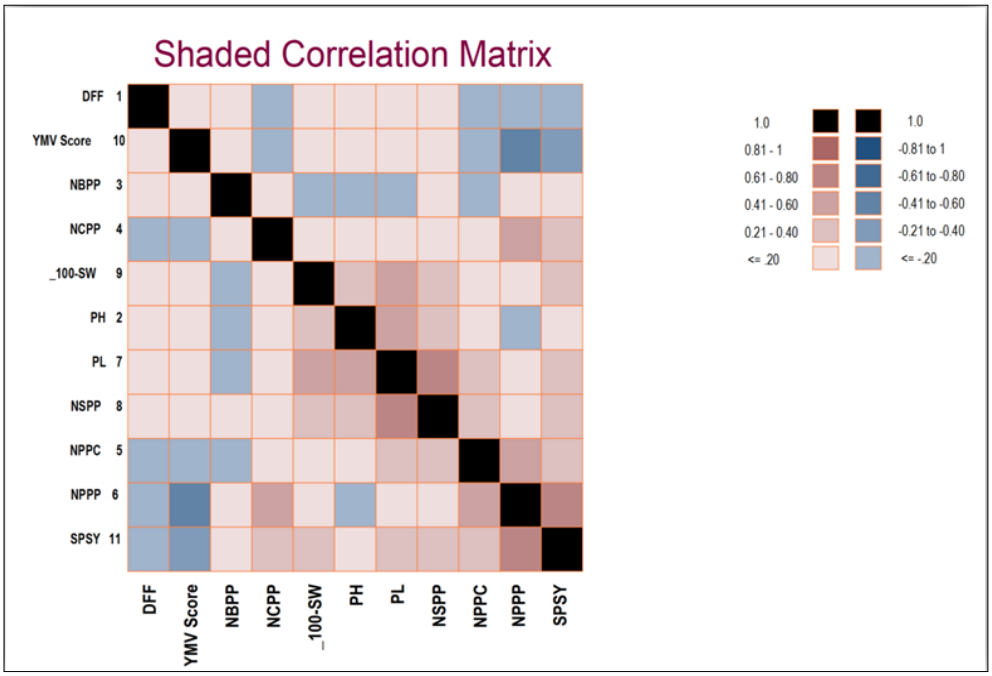

Fig 2: Phenotypical shaded correlation matrix

Path Coefficient Analysis

Simple correlation does not give the precise association among the traits. The whole phenotypic and genotypic correlation coefficients was additional split into direct effect and indirect effects through Path coefficient analysis were carried out at phenotypic and genotypic level, single plant seed yield considered as a dependent trait and the independent traits as follows days to fifty percent flowering, plant height, number of branches per plant, number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, hundred seed weight and Yellow mosaic virus disease score.

Each path constituent has two actions *viz*., direct and indirect effects through constituents which are not shown by correlation study. The direct and indirect effects of genotypic and phenotypic on yield components on single plant seed yield was presented in Table 3-4 and Figure 3-4.

Table 3: Direct and indirect effect of genotypic path coefficient analysis among various characters of blackgram genotypes

Character	DFF	PH	NBPP	NCPP	NPPC	NPPP	PL	NSPP	100SW	YMV score	SPSY
DFF	-0.0747	-0.0044	-0.0004	0.0009	0.0083	0.002	0.0049	0.002	0.0001	-0.0004	-0.104*
PH	0.0045	0.0762	-0.0041	0.0066	0.0096	-0.0052	0.0455	0.0285	0.0328	0.0163	0.201**
NBPP	0.000	0.0004	-0.0076	-0.0017	0.0006	-0.0012	0.0009	0.0002	0.0009	-0.0005	0.0634
NCPP	-0.0006	0.0044	0.0111	0.0502	0.0014	0.0271	0.0057	0.0035	0.0104	-0.0052	0.415**
NPPC	-0.0071	0.0082	-0.0052	0.0018	0.0647	0.0302	0.0099	0.0114	0.006	-0.0032	0.413**
NPPP	-0.0154	-0.0401	0.0941	0.3185	0.2754	0.59	0.0242	0.0407	0.0685	-0.306	0.665**
PL	-0.0054	0.0492	-0.0093	0.0094	0.0126	0.0034	0.0823	0.0515	0.0418	0.0142	0.334**
NSPP	-0.005	0.0718	-0.0063	0.0132	0.0338	0.0132	0.1201	0.1918	0.03	0.0188	0.342**
100SW	-0.0001	0.0336	-0.0095	0.0162	0.0072	0.0091	0.0397	0.0122	0.0781	0.0073	0.269**
YMV score	0.000	0.0014	0.0004	-0.0007	-0.0003	-0.0034	0.0011	0.0006	0.0006	0.0065	-0.252**

Residual Effect = 0.2520 **Significance at 1% level *Significance at 5% level

Table 4: Direct and indirect effect of phenotypic path coefficient analysis among various characters of blackgram genotypes

Character	DFF	PH	NBPP	NCPP	NPPC	NPPP	PL	NSPP	100SW	YMV score	SPSY
DFF	-0.0935	-0.004	-0.0027	0.0001	0.0059	0.001	-0.0025	-0.0028	-0.0045	-0.0009	-0.091*
PH	0.0064	0.1481	-0.0079	0.0111	0.0177	-0.0091	0.0746	0.0475	0.058	0.0295	0.190**
NBPP	-0.001	0.0018	-0.0336	-0.0059	0.0016	-0.0053	0.0008	-0.0012	0.002	-0.0022	0.0571
NCPP	0.000	0.0025	0.0059	0.0339	0.0006	0.016	0.0033	0.0015	0.0056	-0.0036	0.342**
NPPC	-0.0029	0.0054	-0.0021	0.0008	0.0455	0.0202	0.0096	0.0101	0.0064	-0.0018	0.383**
NPPP	-0.0067	-0.0372	0.0953	0.2867	0.2692	0.6077	0.0457	0.0564	0.0838	-0.3046	0.650**
PL	0.0006	0.011	-0.0005	0.0021	0.0046	0.0016	0.0218	0.0143	0.0121	0.0033	0.270**
NSPP	0.0043	0.0461	0.005	0.0066	0.0318	0.0133	0.0941	0.1437	0.0359	0.0135	0.280**
100SW	0.002	0.0158	-0.0024	0.0067	0.0057	0.0056	0.0224	0.0101	0.0403	0.0034	0.240**
YMV score	0.000	0.0004	0.0001	-0.0002	-0.0001	-0.001	0.0003	0.0002	0.0002	0.002	-0.262**

Residual Effect = 0.2970 **Significance at 1% Level *Significance at 5% Level

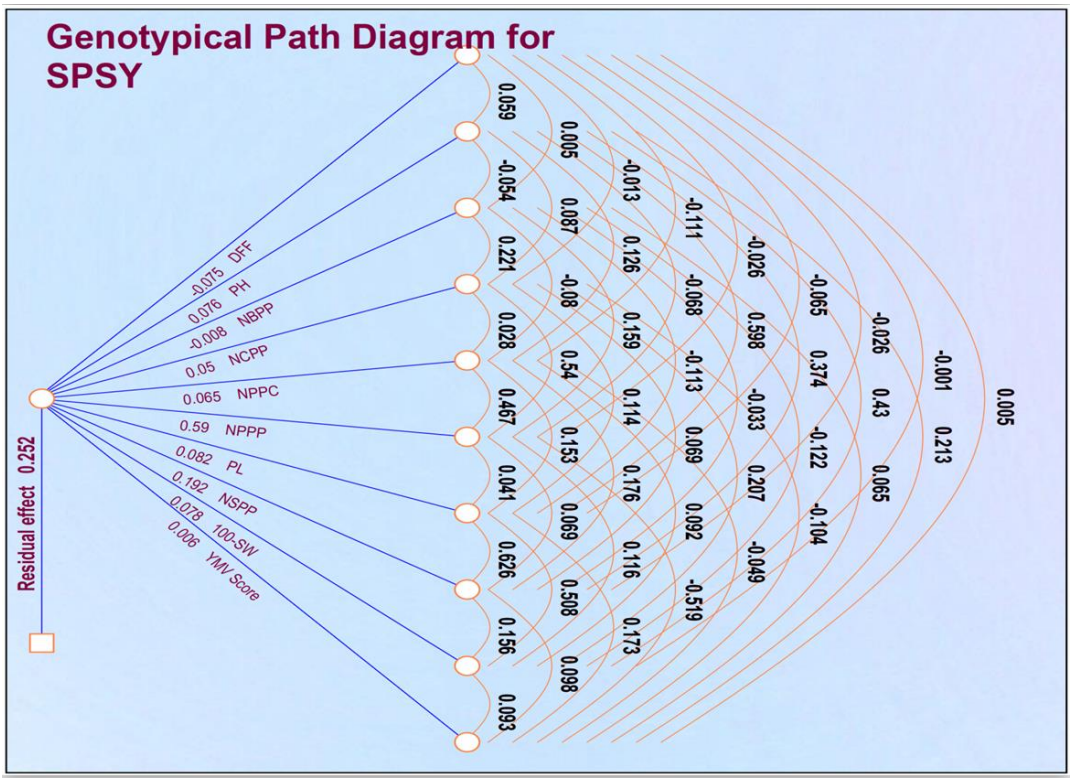

Fig 3: Illustration of direct and indirect effect of genotypical path on single plant seed yield

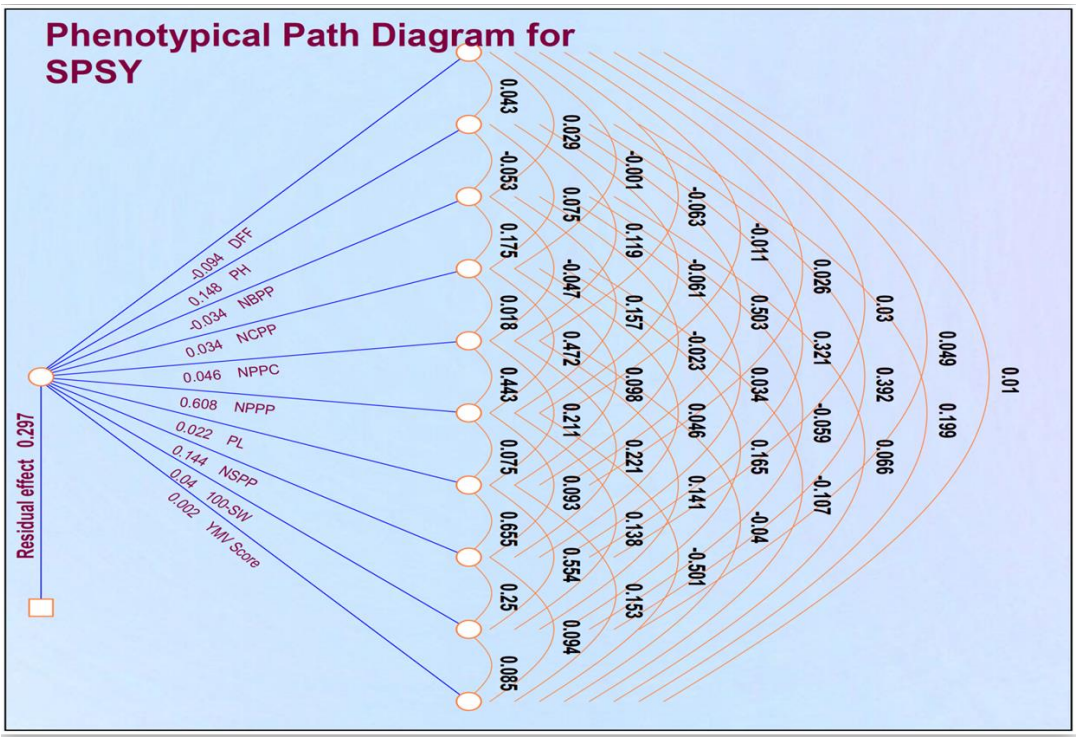

Fig 4: Illustration of direct and indirect effect of phenotypical path on single plant seed yield

DFF - Days to fifty percent flowering, PH- Plant height, NBPP-Number of branches per plant, NCPP-Number of clusters per plant, NPPC- Number of pods per cluster, NPPP- Number of pods per plant, PL- Pod length, NSPP-Number of seeds per pod, 100SW-Hundred seed weight, YMV score-yellow mosaic virus disease score and SPSY - Single plant seed yield.

Direct effect at genotypic path

number of pods per plant (0.5900) alone shown high positive direct effect, the trait number of seeds per pod alone shows low positive direct effects and pod length, hundred seed weight plant height, number of pods per cluster, Number of clusters per plant had low positive effect and days to fifty percent flowering and number of branches per plant had negligible negative effect towards single plant seed yield at genotypic path.

Direct effect at phenotypic path

at phenotypic level the trait number of pods per plant (0.6077) exhibited a high positive direct effect towards single plant seed yield per plant. Plant height (0.1481) and number of seeds per pod (0.1437) exhibited low positive direct effect, number of pods per cluster, hundred seed weight, number of clusters per plant, pod length, yellow mosaic virus disease score expressed a negligible positive direct effect; days to fifty percent flowering and number of branches per plant exhibited low negative direct effect towards single plant seed yield at phenotypic level.

Direct and indirect effect of Yellow Mosaic virus disease score (YMV Score)

This trait Yellow Mosaic Virus disease score (0.0065) showed negligible positive direct effect on single plant seed yield while number of seeds per pod (0.0188), plant height (0.0163), pod length (0.0142) and hundred seed weight (0.0073) shown negligible positive indirect effect while the remaining traits were revealed negligible negative effects. However this number of pods per plant (-0.3060) shows high negative indirect effect at genotypic level.

Yellow mosaic virus disease score had negligible positive direct effect (0.0020) towards single plant seed yield. Number of pods per plant (0.3046) had high negative indirect effect and it had negligible negative indirect effect via days to fifty percent flowering, number of branches per plant, number of clusters per plant, number of pods per cluster and number of pods per plant while plant height, pod length, number of seeds per pod and hundred seed weight had negligible positive indirect effect towards single plant seed yield at phenotypic level.

In genotypical path coefficient matrix number of pods per plant and number of seeds per pod exhibits maximum low positive direct and indirect effects towards single plant seed yield and most of the component traits. in phenotypical path coefficient matrix the trait number of pods per plant alone shown low and negligible positive direct and indirect effect towards single plant seed yield and most of its component traits; plant height and days to fifty percent flowering exhibits low negative indirect effect.

Among the different traits studied for genotypic and phenotypic path analysis, a trait number of pods per plant alone shown high positive direct effect towards single plant seed yield, the results are in agreed with previous workers (Sathya *et al.* 2018; Sowmyasree *et al.* 2018; Sathees *et al.* 2019) [12, 13, 11]. For hundred seed weight, number of clusters per plant and number of seeds per pod had negligible positive direct effect on single plant seed yield (Sathya *et al.* 2018) [12], for days to fifty percent flowering and plant height had negative direct effect reported by Blessy *et al.* 2018 at both genotypic and phenotypic path.

Based on the results of path and correlation analysis the traits number of clusters per plant, number of pods per cluster, number of pods per plant, pod length and hundred seed weight had positively correlated with single plant seed yield at both genotypic and phenotypic level. In path analysis number of pods per plant and number of seeds per

pod had positive effects towards single plant seed yield and its component traits. The traits yellow mosaic virus disease score negatively correlated with yield and most of it contributing characters and the direct and indirect effects were also revealed negative effect in yellow mosaic virus disease score. Hence selection of traits which highly associated to yield and component traits such as number of pods per plant, number of pods per cluster pod length and yellow mosaic virus (YMV) disease resistant and tolerant plants may creates considerable tolerant effects to yield improvement.

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