International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 2551-2555

Received: 23-03-2018
Accepted: 25-04-2018

Suganthi S
Dept. of Medicinal and Aromatic Crops, HC & RI, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Rajamani K
Dept. of Medicinal and Aromatic Crops, HC & RI, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

John Joel A
Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Suresh J
Dept. of Medicinal and Aromatic Crops, HC & RI, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Renuka R
Centre for Plant Molecular Biology and Bioinformatics, AC & RI, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Correspondence
Suganthi S
Dept. of Medicinal and Aromatic Crops, HC & RI, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Studies on genetic variability analysis in black nightshade (*Solanum nigrum* L. complex)

Suganthi S, Rajamani K, John Joel A, Suresh J and Renuka R

Abstract
The present investigation was conducted to study the genetic parameters such as, variability, heritability, genetic advance, correlation and path coefficient effects on yield and yield attributing characters of fifteen diverse black nightshade (*Solanum nigrum* L. Complex) genotypes. Analysis of variance recorded highly significant variation among the fifteen genotypes for the eleven quantitative characters. The results of the present study revealed that the higher values of genotypic coefficient variation and phenotypic coefficient of variation were obtained for fresh leaf yield per plant (g) and days to fifty per cent flowering. The same trend on fresh leaf yield as well as days to fifty per cent flowering was followed for heritability estimates along with genetic gain. This reveals that the, influence of environment on these characters are limited and also selection of parents can be made based on them. The characters *viz*., number of branches per plant, number of leaves per plant, leaf breadth and total alkaloid content had positive and highly significant correlation with fresh leaf yield per plant. Plant height, number of leaves per plant and days to fifty percent flowering showed maximum direct effects through fresh leaf yield. Based on the above results of genetic components, it is suggested that the characters such as number of branches per plant, number of leaves per plant and leaf breadth may be given priority while expressing a selection strategy for yield improvement of black night shade (*Solanum nigrum* complex L.) genotypes.

Keywords: Black nightshade, *Solanum nigrum*, Manathakkali, evaluation, GCV, PCV, heritability, selection, variability

Introduction
Black nightshade (*Solanum nigrum* L. Complex) is an economically important species belongs to the solanaceous family is a self-pollinating crop with an outcrossing percentage of 10% depending on the genotype and environmental effects (Edmonds, 1979; Edmonds and Chweya, 1997) [10, 11]. It is also known as Makoi in Hindi, Black nightshade in English and Manathakkali in Tamil. It is an underutilized leafy medicinal plant valued for its leaves and matured green berries which contains steroidal glyco-alkaloids. The total alkaloid content of leaf and berry are 0.431 and 0.101 per cent, respectively (Tsuyoshi *et al*., 2000) [35]. Human consumption of leaves and fruits as food is wide spread, particularly in Africa and South East Asia (Schippers, 2000, AVRDC, 2003) [29, 4]. Black nightshades have also been used in the field of medicine in the manufacture of analgesics, ointments and vasodilators. Besides the medicinal properties of this crop, it also has some unique nutritive value as it is a rich source of vitamins and minerals such as riboflavin, vitamin C, niacin, iron and calcium (Ramakrishnappa, 2002) [24].
Existing knowledge on the genetic potential of black nightshade and its related species are limited and scarcely found in India, which hinders the improvement of these species as well as their sustainable conservation. The study of genetic diversity is the prerequisite, for development of suitable black nightshade variety with high yield and other quality parameters as any breeding programme depends upon the extent of genetic variability present in the population (Singh *et al.*, 2002) [30]. There are no varieties have yet been developed through conventional breeding, but local variants or landraces have been used in cultivation of this crop. Also success in a recombination breeding depends on the exploitation of genotypes as parents for obtaining high heterotic crosses and transgressive seggregants. Estimates of heritability and genetic advance can serve to identify the factors which can be used as indicators for high yield during selection.

Keeping these things in view, the study was planned to assess the genetic variability, heritability, genetic advance, correlation and path analysis with respect to various desirable characters in fifteen genotypes of black nightshade (*Solanum nigrum* Complex L.) collected from different locations of India. The study was focused to identify the promising genotypes of black nightshade with higher yield, bold berries and high alkaloid content and utilizing the same in hybridization programmes to explore the yield potential and quality characters.

Materials and Methods

The experimental field was located at the latitude of 11°North and longitude of 77° East with a maximum and minimum temperatures of 32.33ºC and 22.63ºC respectively and having average rainfall of 135.50 mm. The study was carried out at the Botanical Garden, Department of Medicinal and Aromatic Crops, Horticultural College and Research Institute, TNAU, Coimbatore during 2015-2017. The experimental material consisted of fifteen genotypes which are collected from various local and exotic sources. The details of the genotypes and source of collection is given in Table. 1. The seeds were collected from the genotypes by repeated selfing and sown in nursery beds. Thirty days old seedlings were transplanted in main field at a spacing of 60 x 45 cm in a randomized block design (RBD) with three replications. The quantitative traits such as days to first flowering, days to 50% flowering, plant height (cm), number of branches per plant, plant spread (cm), stem girth (cm), number of leaves per plant, leaf length (cm), leaf breadth (cm), total alkaloid content (%) and fresh leaf yield per plant (g) were recorded.

Analysis of variance in respect of eleven characters studied were estimated according to the formula given by Panse and Sukhatme (1978) [22]. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were computed based on the methods given by Burton (1952) [6]. The co-efficient of variation were categorized as proposed by Sivasubramanian and Madhava Menon (1973) [32]. The heritability was computed based on the method given by Allard (1960) [3]. Genetic advance and genetic advance as percentage of mean were estimated according to the formula given by Johnson *et al.* (1955) [14] and path coefficient analysis was given by Dewey and Lu (1959) [8].

Table 1: Genotypes details of Black nightshade (*Solanum nigrum* L. Complex)

S. No	Name of the genotype	Genotypes/ Treatment Notation	Accession number
1.	Sirugamani Local, Tamil Nadu	Sn 03	IC-0615679
2.	Thagarapudur Local, Tamil Nadu	Sn 04	IC-0615680
3.	Ottampatty Local, Tamil Nadu	Sn 05	IC-0615681
4.	Paiyur Local, Tamil Nadu	Sn 07	IC-0615683
5.	Chinnakalvehalli Local, Tamil Nadu	Sn 08	IC-0615684
6.	Theni Local, Tamil Nadu	Sn 09	IC-0615685
7.	Ooty Local, Tamil Nadu	Sn 10	IC-0615686
8.	E. Patty Local, Tamil Nadu	Sn 11	IC-0615687
9.	Anthiyur Local, Tamil Nadu	Sn 13	IC-0615688
10.	Salem Local, Tamil Nadu	Sn 15	IC-0615690
11.	Kallipalayam Local, Tamil Nadu	Sn 19	IC-0612526
12.	Namakkal Local, Tamil Nadu	Sn 23	IC-0615697
13.	Rahuri Local, Maharastra	Sn 26	IC-0615700
14.	Nalhendra Local, Himachal Pradesh	Sn 44	IC-0615717
15.	Ottampatty-3 Local, Tamil Nadu	Sn 47	IC-0615719

Results and Discussion

The mean performance of fifteen black nightshade genotypes are presented in table 2. The analysis of variance revealed high significant differences among the genotypes for all the studied characters which indicates the presence of ample genetic variability between the fifteen genotypes. The estimates of range, mean, genotypic variance (σ^2g), phenotypic variance (σ^2p), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability (h2), genetic advance (GA) and genetic advance in percent of mean (GA%) for different characters are presented in Table 3. Maximum range was observed in fresh leaf yield per plant (288.55- 1180.82 g) followed by number of leaves per plant (177.41-412.53) and plant spread (47.38-37.13 cm). Higher PCV and GCV were observed for fresh leaf yield per plant at 42.10 and 42.01 followed by days to 50% flowering at 22.23 and 21.38 and days to first flowering at 21.18 and 20.55 that indicates the characters are not as much influenced by environment. The results of present outcomes are in line with the findings of Salvadora *et al*. (2017) [27] in vegetable amaranth green leaf yield per plant. However in some cases higher PCV along with moderate GCV were observed for total alkaloid content of 24.39 and 18.28 followed by leaf breadth (21.12 and 19.25) respectively. Whereas, plant spread recorded the moderate PCV and lowest GCV of 18.05 and 9.69 respectively. Similar results on PCV and GCV estimates have also been reported in Aswagandha (Dubey, 2010; Laxminarayan and Mukund, 2003; Sangwan *et al*., 2013, Manivel *et al.*, 2017) [9, 16, 28, 20] and in Tomato (Adhi Shankar *et al.,* 2013). The minimum magnitudinal differences in PCV and GCV coupled with low Environment coefficient of variation implied that the traits are mostly governed by genetic factors with little role of environment in the phenotypic expression of these characters. Thus, selection of these traits on the basis of phenotypic value may be effective (Oyiga and Uguru, 2011) [21]. Similar findings on variability was also recorded by Ravi *et al*. (2013) [25] in Makoi and Singh *et al.* (2000) [31] in Opium poppy.

Table 2: Mean performance of fifteen genotypes on yield and yield attributing characters

Genotypes	Days to first flowering	Days to 50 per cent flowering	Plant height (cm)	Number of branches per plant	Plant spread (cm)	Stem girth (cm)	Number of leaves per plant	Leaf length (cm)	Leaf breadth (cm)	Total alkaloid content (%)	Fresh leaf yield per plant (g)
Sn 03	24.00	33.00	56.40	7.53	43.46	1.46	318.08	9.60	5.03	0.401	980.66
Sn 04	35.00	47.00	37.32	6.27	42.33	0.98	215.32	4.60	3.43	0.333	415.84
Sn 05	38.00	57.00	34.91	5.73	37.13	0.92	227.77	7.40	3.43	0.313	288.55
Sn 07	37.00	55.00	38.55	5.27	45.26	1.14	193.52	6.97	3.60	0.337	390.10
Sn 08	37.00	58.00	41.37	4.53	42.21	1.71	211.72	7.67	3.87	0.290	355.83
Sn 09	21.00	36.00	53.29	6.50	51.37	1.58	307.56	9.00	4.93	0.460	733.57
Sn 10	22.00	34.00	60.20	4.80	57.93	2.36	278.53	8.77	4.50	0.523	627.19
Sn 11	27.00	37.00	52.49	7.07	56.71	1.35	251.45	8.70	4.07	0.387	722.70
Sn 13	35.00	54.67	44.85	5.67	53.52	0.68	228.04	6.53	3.30	0.317	496.17
Sn 15	28.00	45.00	51.50	6.33	54.75	1.85	177.41	7.47	4.87	0.403	626.19
Sn 19	30.00	47.00	49.68	6.73	44.28	1.73	252.10	8.03	4.07	0.387	471.94
Sn 23	29.00	50.00	46.75	6.93	43.61	1.96	275.63	9.10	4.70	0.430	551.04
Sn 26	29.00	49.00	48.75	6.87	45.41	0.93	249.66	8.60	5.97	0.437	792.73
Sn 44	40.00	64.00	39.46	5.33	42.79	1.99	208.35	5.63	3.07	0.293	339.70
Sn 47	23.00	33.00	47.86	8.20	49.86	2.09	412.53	7.23	5.27	0.553	1180.82
Mean	30.33	46.64	46.89	6.25	47.38	1.52	253.85	7.69	4.27	0.390	598.20
S.E (d)	1.27	2.32	2.19	0.72	5.89	0.19	29.17	0.55	0.32	0.052	13.46
C.D. at 5%	2.60	4.76	4.50	1.48	12.07	0.39	59.75	1.51	0.66	0.106	27.57

Table 3: Estimates of variability and genetic parameters of Black nightshade (*Solanum nigrum* L. complex) genotypes

S No.	Characters	Mean	Range		PCV %	GCV %	h^2	GA (% mean)
			Minimum	Maximum				
1.	Days to first flowering	30.33	21	40	21.18	20.55	94.15	41.08
2.	Days to 50% flowering	46.64	33	64	22.23	21.38	92.46	42.35
3.	Plant height (cm)	46.89	34.91	60.20	16.48	15.44	87.86	29.82
4.	Number of branches per plant	6.25	4.53	8.2	20.09	14.23	50.14	20.75
5.	Plant spread (cm)	47.38	37.13	57.93	18.05	9.69	28.82	10.72
6.	Stem girth (cm)	1.52	0.68	2.36	35.47	31.95	81.14	59.29
7.	Number of leaves per plant	253.85	177.41	412.53	26.08	21.96	70.89	38.09
8.	Leaf length	7.69	4.6	9.6	19.25	17.16	79.47	31.52
9.	Leaf breadth	4.27	3.07	5.97	21.12	19.02	81.10	35.29
10.	Total alkaloid content (%)	0.39	0.29	0.55	24.39	18.28	56.18	28.22
11.	Fresh leaf yield per plant (g)	598.20	288.55	1180.82	42.10	42.01	99.57	86.36

The knowledge on heritability of a character is important as it indicates the extent to which improvement is possible through selection (Robinson *et al*., 1949) [26]. A high value of heritability coupled with genetic advance percentage of mean shows that all the characters are under genetic control and attributed to additive gene action. The estimates of heritability (broad sense) was observed for those characters. The trend GCV and PCV estimates were followed in h^2 and genetic advance percentage of mean. The higher heritability of 99.57% along with high genetic gain was observed for fresh leaf yield followed by 94.15% and 41.08% respectively for days to first flowering and days to 50% flowering (92.46% and 42.35% respectively). High estimates of genetic advance coupled with considerable amount of heritability indicates that the selection for desirable characters would results improvement in the positive direction as the characters are governed by additive genes. This predominance of additive gene action in the expression of these traits can be utilized for individual plant selection (Makeen *et al*., 2007) [19]. These results are in corroborate with the findings of Krishnamoorthy and Madalagiri (2002) [15] in Ajowan; Srivastava *et al.* (2003) [33] in Japanese mint and Ravi *et al.* (2013) [25] in Makai. Similar findings of high heritability coupled with high genetic advance over mean for number of leaves per plant, leaf yield per plant and other traits in Aswagandha were observed by Yadav *et al*. (2008) [36] and Manivel *et al*. (2017) [20]. Low heritability coupled with low genetic advance was observed for plant spread of 28.82 and 10.72 respectively. Therefore, such character is said to be more influenced by environment and selection would be ineffective for those traits (Mahesh Sharma *et al*., 2017) [18]. In general, the characters exhibiting high heritability with high genetic advance are genetically controlled by additive genes (Panse, 1957) [23] and can be improved upon through mass selection, family selection or any other modified selection procedures whereas, the characters with low heritability and low genetic advance can be improved through hybridization. While the characters which exhibit high heritability with moderate or low genetic advance can be improved by inter mating the superior genotypes of the segregating population developed from multiple crosses and the desirable genes can be accumulated in the lines (Liang and Walter, 1968) [17].

Simple correlation coefficients estimated for all the traits are presented in Table 4. Significantly positive correlations for fresh leaf yield were found between number of branches (0.782), number of leaves per plant (0.828), leaf breadth (0.792) and total alkaloid content (0.789). The similar trend on total alkaloid content was observed with the findings of

Table 4: Simple Correlation among yield and yield attributing traits of Black nightshade (*Solanum nigrum* L. complex) genotypes

Characters	DFF	DFiF	PH	NOB	PS	SG	NOL	LL	LB	TAC	FLY
DFF	1	0.939**	-0.890**	-0.563	-0.594	-0.433	-0.713*	-0.684*	-0.771**	-0.895**	-0.813**
DiFF		1	-0.803**	-0.594	-0.560	-0.323	-0.711**	-0.541	-0.632*	-0.815**	-0.816**
PH			1	0.333	0.691*	0.465	0.465	0.732*	0.645*	0.715*	0.650*
NOB				1	0.059	0.021	0.672*	0.315	0.604*	0.526	0.782**
PS					1	0.272	0.159	0.253	0.254	0.512	0.398
SG						1	0.356	0.270	0.254	0.526	0.253
NOL							1	0.422	0.566	0.770**	0.828**
LL								1	0.664*	0.518	0.479
LB									1	0.771**	0.792**
TAC										1	0.789**
FLY											1

*Significant at 5 per cent level **Significant at 1 per cent level

DFF- Days to first flowering, DiFF- Days to 50% flowering, PH- Plant height (cm), NOB- Number of branches per plant, PS- Plant spread (cm^2), SG- Stem girth (cm), NOL- Number of leaves per plant, LL- Leaf length, LB- Leaf breadth, TAC- Total alkaloid content (%),FLY- Fresh leaf yield per plant (g)

Das *et al*. (2011) [7] and Sundesha and Tank (2013) [34] in Aswagandha. For the same trait, significant and negative correlation were found with days to first flowering (-0.813) and days to 50% flowering (-0.816) and hence this indicates the selection early flowering genotypes may affect the fresh herbage yield. Fresh leaf yield was also non-significant with plant spread (0.398), stem girth (0.253) and leaf length (0.479). These findings indicates that the selection of a genotype for higher fresh leaf yield per plant would be accompanied by number of branches per plant, number of leaves per plant and broader leaves. The same results on increased number of branches per plant and number of leaves per plant have showed positive correlation on yield were in agreement with the findings of Ahammed *et al*. (2012) [2] in Stem amaranth.

Path coefficient analysis between fresh leaf yield and its components are presented in Table 5. The estimates of correlation coefficients mostly indicate the inter-relationship of different characters but it does not furnish information on cause and effect. Under such situation, path analysis helps the breeder to identify the index of selection. The residual effect of 0.164 indicates that the choice of characters for path analysis was appropriate and the characters studied contributed 84% towards fresh leaf yield per plant. The highest positive direct effect on fresh leaf yield per plant was observed for plant height (2.016) followed by number of leaves (0.768), days to 50% flowering (0.767) and number of branches (0.384). Similar results of direct and indirect effects on yield was observed in the findings of Haydar *et al*. (2007) [13] in Tomato and Barath Kumar, (2002) [5] in *Solanum trilobatum*. The characters such as days to first flowering (-0.030), plant spread (-0.497), stem girth (-0.402) and leaf length (-1.011) showed negative direct effects for fresh leaf yield per plant. Hasan *et al*. (2013) [12] has reported the negative direct trend on leaf length for marketable yield in Stem amaranth. This high negative direct effects resulting a high total correlation to fresh leaf yield per plant. The traits such as plant spread, total alkaloid content, leaf length and leaf breadth showed positive indirect effects for fresh leaf yield via plant height

Table 5: Direct and indirect effects of different characters on Leaf yield in Black nightshade (*Solanum nigrum* L. Complex) genotypes

Characters	DFF	DFiF	PH	NOB	PS	SG	NOL	LL	LB	TAC
DFF	-0.030	0.740	-1.848	-0.254	0.393	0.186	-0.582	0.721	-0.111	-0.038
DiFF	-0.029	0.767	-1.660	-0.264	0.362	0.137	-0.580	0.563	-0.092	-0.033
PH	0.027	-0.632	2.016	0.155	-0.421	-0.207	0.384	-0.776	0.092	0.031
NOB	0.020	-0.526	0.811	0.384	-0.096	-0.023	0.621	-0.423	0.109	0.023
PS	0.024	-0.559	1.707	0.074	-0.497	-0.186	0.214	-0.301	0.037	0.029
SG	0.014	-0.261	1.039	0.022	-0.230	-0.402	0.310	-0.292	0.041	0.023
NOL	0.023	-0.580	1.007	0.311	-0.139	-0.162	0.768	-0.464	0.086	0.033
LL	0.021	-0.428	1.548	0.161	-0.148	-0.116	0.352	-1.011	0.099	0.022
LB	0.024	-0.512	1.340	0.302	-0.132	-0.120	0.478	-0.726	0.138	0.034
TAC	0.031	-0.690	1.701	0.245	-0.392	-0.249	0.692	-0.619	0.128	0.037

Residual Effect = 0.164

DFF- Days to first flowering, DFiF- Days to 50% flowering, PH- Plant height (cm), NOB- Number of branches per plant, PS- Plant spread (cm^2), SG- Stem girth (cm), NOL- Number of leaves per plant, LL- Leaf length, LB- Leaf breadth, TAC- Total alkaloid content (%),FLY- Fresh leaf yield per plant (g)

Conclusion

According to this study the characters such as, number of branches, number of leaves per plant, plant spread, and plant height and leaf breadth are considered as yield contributing characters. More emphasis should be given for these characters during selection and improvement of the superior genotypes for better yield. Promising chemotypes of black nightshade can be developed for solasodine production with high levels of alkaloids accompanied with high fresh leaf yield. Hence, high yielding elite genotypes like Sn 47, Sn 10, Sn 03, Sn 11, Sn 26, and Sn 09 can be utilized in the future breeding programme for genetic enhancement of this crop.

References

1. Adhi Shankar RVS, Reddy K, Sujatha M, Pratap M. Genetic variability studies in F1 generation of tomato (*Solanum lycopersicum* L.). IOSR Journal of Agriculture and veterinary Sci. 2013; 4(5):31-34.
2. Ahammed AU, Rahman MM, Mian MAK. Genetic Variability, Heritability and Correlation in Stem

Amaranth (*Amaranthus tricolor*). Bangladesh Journal of Plant Breeding and Genetics. 2012; 25(2):25-32.

3. Allard RW. Principles of plant breeding. John Willey and Sons, Inc. New York (USA), 1960.
4. AVRDC. The World Vegetable Center. AVRDC Report AVRDC Publication Number 03-563. Shanhua, Taiwan: AVRDC-the World Vegetable Center. 2002, 2003; 38-42.
5. Barathkumar TR. Studies on genetic variability and standardisation of horticultural techniques for Tuduvalai (*Solanum trilobatum* L.). Ph.D. (Hort.,) thesis, TNAU, Coimbatore, 2002.
6. Burton GW. Quantitative inheritance in grasses. Proc. 6th Int. Grassland Congress. 1952; 1:277.
7. Das A, Datta AK, Ghose S, Bhattacharya A. Genetic analysis in Poshita and Jawahar 22 varieties of *Withania somnifera* (L.) Dunal. Plant Arch. 2011; 11:59-62.
8. Dewey DH, Lu KH. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 1959; 51:515-518.
9. Dubey RB. Genetic variability, correlation and path analysis in ashwagandha (*Withania somnifera)*. J Med. & Aromatic Plant Sci. 2010; 32(3):202-205.
10. Edmonds JM, Chweya JA. Black nightshades: *Solanum nigrum* L. and related species. Bioversity International, 1997; 15:1-115.
11. Edmonds JM. Biosystematics of *Solanum* L. section Solanum (Maurella). In: Hawkes JG, Lester RN, Skelding AD (Eds) The Biology and Taxonomy of the Solanaceae, Academic Press, London, UK, 1979, 529-548.
12. Hasan M, Akther A, Raihan MS. Genetic variability, correlation and path analysis in Stem Amaranth (*Amaranthus tricolor* L.) genotypes. The agriculturists. 2013; 11(1):1-7.
13. Haydar A, Mandal MA, Ahmed MB, Hannan MM, Karim R, Razvy MA *et al.* Studies on genetic variability and interrelationship among the different traits in Tomato (*Lycopersicon esculentum* Mill.). Middle-East Journal of Scientific Research. 2007; 2(3, 4):139-142.
14. Johnson HW, Robinson HF, Comstock RE. Estimates of genetic and environmental variability in soybean. Agron. J. 1955; 47(7):314-318.
15. Krishnamoorthy V, Madalageri MB. Variability and correlation studies in Ajowan (*Trachyspermum ammi*). J Med. Arom. Pl. Sci. 2002; 24:364-370.
16. Laxminarayan H, Mukund S. Genetic variability in ashwagandha (*Withania somnifera*) In: National seminar on new perspectives in spices, medicinal and aromatic plants. 2003; 19:27-29.
17. Liang GHL, Walter TL. Heritability estimates and gene effect for agronomic traits in grain Sorghum. Crop Science. 1968; 8:77-80.
18. Mahesh Sharma, PP Sharma, Hemalata Sharma, Deva Ram, Meghwal. Genetic variability in cowpea (*Vigna unguiculata* L. Walp.) germplasm lines. Journal of pharmacognosy and Phytochemistry. 2017; 6(4):1384-1387.
19. Makeen KA, Garad J, Arif J, Singh KA. Genetic variability and correlations studies on yield and its components in mungbean (*Vigna radiata* L. Wilezek). Journal of Agronomy. 2007; 6:216-218.
20. Manivel P, Nagaraja Reddy RR, Deore HB. Genetic diversity for root yield and its component traits in aswagandha (*Withania somnifera* (L) Dunal) pure lines derived from JA 134 population. Int. J Curr. Microbiol. App. Sci. 2017; 6(4):1694-1710.
21. Oyiga BC, Uguru MI. Genetic variation and contributions of some floral traits to pod yield in Bambra Groundnut (*Vigna subterranean* L. Verdc) under two cropping seasons in the derived savannah of the South-East Nigeria. International Journal of Plant Breeding. 2011; 5(1):58-63.
22. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 3rdEdn. ICAR Publication. New Delhi, India, 1978.
23. Panse VG. Genetics of qualitative characters in relation to plant breeding. Indian Journal of Genetics. 1957; 17:318-328.
24. Ramakrishnappa K. Impact of cultivation and gathering of medicinal plants on Biodiversity – Case study from India. In: Biodiversity and Ecosystems approach in Agriculture, Forestry, and Fisheries, 2002.
25. Ravi CS, Sreeramu BS, Mallikarjuna Gowda AP, Smitha GR. Evaluation of Makoi (*Solanum nigrum* L.) germplasm for growth, yield and quality. Journal of Applied Horticulture. 2013; 15(2):133-137.
26. Robinson HF, Comstock RE, Harvey VH. Estimates of heritability and degree of dominance in corn. Agron. J., 1949; 41:353-359.
27. Salvadora B, Saraswathi T, Ramalingam J. Genetic basis of yield and quality variations in Vegetable amaranth (*A. tricolor*) to identify the promising genotypes. Int. J Curr. Microbio. App. Sci. 2017; 6(4):2104-2111.
28. Sangwan O, Ram Avtar, Amit Singh. Genetic variability, character association and path analysis in ashwagandha [*Withania somnifera* (L.) Dunal] under rainfed conditions. Research in Plant Biology. 2013; 3(2):32-36.
29. Schippers RR. African indigenous vegetables: an overview of the cultivated species. Natural Resources Institute / ACP-EU Technical Centre for Agricultural and rural Cooperation. Chatham, UK, 2000, 214.
30. Singh AK, Singh KP. Induced mutation in okra by gamma rays and ethyl methane sulphonate. Veg. Sci., 2002; 29(1):30-33.
31. Singh OP, Singh TP, Yadav AL, Yadav PN. Genetic variability, genotypic and phenotypic correlation in germplasm of opium poppy (*Papaver somniferum* L.). Adv. plant Sci. 2000; 13:69-73.
32. Sivasubramanian S, Madhava Menon P. Genetic analysis of quantitative characters in rice through diallel crosses. Madras Agric. J. 1973; 60:1097-1102.
33. Srivastava NK, Misra A, Sharma S. Variation among commercial cultivars of Japanese mint (*Mentha arvensis* L.) in the morphological and metabolite characters associated with essential oil yield. The Jour Hort. Sci. Biotech., 2003; 78(2):154-160.
34. Sundesha DL, Tank CJ. Genetic variability, heritability and expected genetic gain for dry root yield in ashwagandha [*Withania somnifera* (L.) Dunal]. Asian J Hort. 2013, 475-477.
35. Tsuyoshi IT, Hidetsuyu, Toshihiro N. Steroidal oligo glucosides from *Solanum nigrum* L. Chemical and Pharmaceutical Bulletin. 2000; 48(7):1062-1064.
36. Yadav OP, Kumar Y, Verma PK. Genetic diversity, association among metric traits and path coefficient analysis in ashwagandha (*Withania somnifera*). Haryana J Hort., 2008; 38(1, 2):23-26.