Original Research Article

Assessment of Variability for Herbage Yield and Its Component Traits in Genotypes of Kalmegh (*Andrographis paniculata*)

Abstract

The study was conducted during the 2019 *Kharif* with the goals of estimating variability, heritability and genetic advance among all the genotypes in a Randomized Block Design with three replications. Based on variability studies, it could be concluded that the characters *viz.,* plant height (9.93% & 81.81%), leaf breadth (15.06% & 80.05%), leaf area (10.62% & 81.91%), number of secondary branches (17.29% & 56.59%), total length of primary branches per plant (15.19% & 75.81%), canopy spread (12.81% & 75.33%), length of internodes (13.59% & 79.01%), angle of primary branch (66.32% & 94.01%), all the yield parameters except leaf dry matter content (9.33% & 69.82%) and stem dry matter content (6.82% & 59.22%) and all the chemical parameters had sufficient amount of variability, high heritability respectively. Therefore, simple selection methods will be more effective for improvement of these characters.

Key words: Andrographolide, *Andrographis paniculata*, Dry Herbage Yield, Genetic Advance, Fresh Leaf Percent.

Introduction

Andrographis paniculata (Burm. f.) Wall. ex Nees., one of the many medicinal herbs, is a very valuable plant that is also known as green chirayita, Creat, King of Bitters, kalmegh, or kariyatu. It is a member of the common Acanthaceae family on Indian plains. It can also be found in other Asian nations like China, Hong Kong, the Philippines, Malaysia, Indonesia, Thailand, and Sri Lanka, where it is utilised as a regional herbal remedy. Madhya Pradesh, Chhattisgarh, Odisha, Maharashtra, Assam, Bihar, West Bengal, Uttar Pradesh, Tamil Nadu, and Kerala are among the Indian states where it is present. The herbal mixture has historically been employed as a stomachic, tonic, alternate antipyretic, and anthelmintic agent.

Kalmegh's a self-pollinated system causes low genetic variation/diversity and it has been classified as an endangered and red-listed species, but at lower risk (Valdiani*et al*., 2014). Better understanding of genetic diversity is a fundamental component of biodiversity analysis and protection of species. Genetic variability of a species is determined by geographical, seasonal and edaphic factors of the environment. The stability and adaptation of different accession to environmental conditions is directly proportional to amount of genetic diversity present. Therefore, it is essential to analyse the genetic diversity among the available sources based on morphological, yield and chemical parameters (Valdiani *et al*., 2014).

A crucial step in encouraging kalmegh cultivation is the development of high yielding varieties with higher concentrations of therapeutically significant phyto-constituents. Information on the kind and extent of genetic diversity for herbage productivity, chemical quality, and its contributing features is extremely important for

the effective application of the available germplasm for crop development programmes.

Materials and Methods

There were 30 different genotypes of *A. paniculata* in the experimental material. In a randomised block design (RBD) with three replications, the 30 genotypes were assessed. Twelve morphological, twenty-four chemical, and eleven yield parameters were examined for the experimental material. Plant height (cm), leaf length (cm), leaf breadth (cm), leaf area (cm^2), primary node number, primary branch number, secondary branch number per primary branch, length of primary branch (cm), total length of primary branch per plant (cm), length of internodes (cm), angle of primary branch (°) and canopy spread (cm) were among the morphological characteristics. Fresh leaf and stem yields (kg/ha), fresh herb yields (kg/ha), dried leaf and stem yields (kg/ha), leaf portions and fresh and dry stem portions and dry herb yields (kg/ha) were among the yield metrics. Chemical parameters included contents (%) of andrographolide, neo andrographolide, andrographiside and 14-deoxy-11,12 didehydro andrographolide and their yields (kg/ha) in leaf, stem and herbage.

Results and Discussions

Morphological characters

In terms of morphological characteristics, such as plant height, leaf length, leaf breadth, leaf area, number of primary nodes per plant, number of primary branches per plant, number of secondary branches per primary branch, length of primary branches, and primary branch angle, the GCV was found to be almost identical to the PCV (Table.1 & Fig. 1). The morphological features used for investigation showed only very modest changes between PCV and GCV, indicating very little influence of environmental influences on the expression in these characters, and hence may be used to most reliably pick parents based on these qualities.

Interestingly, the GCV and PCV for some traits namely, the length of primary branches and leaf area ranged from 7.26% to 23.40% and 9.77% to 23.90%, respectively (Table. 1). Only leaf area had a high GCV and PCV; leaf length, leaf breadth, number of primary branches per plant, secondary branches per primary branch, total length of primary branches, canopy spread, length of internodes, and angle of primary branch all had moderate GCV and PCV. However, the GCV was low and the PCV was moderate for the traits, which included plant height, the number of primary nodes per plant, and the length of the primary branches per plant, indicating the importance of environmental factors for the expression of these traits and possibly not be included for parental selection in breeding programmes.

With the exception of the length of the primary branch per plant, heritability was high across the board in the current study. It suggested that the features are not greatly influenced by outside forces. The major branch length per plant showed a moderate heritability (Fig.2).

Characteristics including leaf breadth, leaf area, number of secondary branches per primary branch, total length of primary branches per plant, canopy spread, length of internodes, and angle of primary branch showed high genetic advance as a percentage of the mean. It stated that selection will be successful because the aforementioned characters are controlled by additive gene activity. Plant height, leaf length, the number of primary nodes per plant, the number of primary

branches per plant, and the length of primary branches all showed moderate genetic advance as a percentage of the mean. Given that these traits are controlled by non-additive gene activity, heterosis breeding may be advantageous depending on them.

Characteristics including leaf breadth, leaf area, number of secondary branches per primary branch, total length of primary branches, canopy spread, length of internodes, and angle of primary branch have strong heritability combined with high genetic advance as percent mean. Plant height, leaf length, the number of primary nodes per plant, the number of primary branches per plant, and the length of primary branches all showed high heritability in conjunction with moderate genetic progress as a percentage of the mean. The more or less similar observations was also reported by the following experiments:

Kumar *et al.,* (2014) found that the parameters like plant height, leaf length and leaf width showed moderate variability.

Devi (2016) observed high heritability along with high expected genetic gain as percent of mean in the character like number of tertiary branches/plant, days to 50 % flowering and plant height.

Disha &Tirkey (2016) observed that GCV was seldom lower than PCV for many traits like plant height, however, high GCV, h^2 and GA was found to be higher for traits like number of tertiary branches per plant.

Yield Parameters

Fresh leaf yield, fresh stem yield, fresh herbage yield, dry leaf yield, dry stem yield, fresh leaf percent, and dry leaf percent all had significant GCV and PCV values (Table 2 & Fig. 3). Due to the low environmental impacts and high genetic variability across the genotypes studied for these traits, the high GCV and PCV together with the lack of any significant variations in their values showed the importance of these qualities for parental selection. Similar to stem dry matter percent and herbage dry matter percent, GCV and PCV were low, indicating that there is little environmental influence on these variables and little genetic variation among the genotypes under study, suggesting that these traits may not be suitable for selection.

Except for stem dry matter content, all the features in the current investigation had high heritability levels. It was discovered that environmental conditions had the least impact on features including fresh leaf yield, fresh stem yield, fresh herbage yield, dry leaf yield, dry herbage yield, leaf dry matter content, herbage dry matter content, fresh leaf percent, and dry leaf percent. In terms of stem dry matter content, heritability was moderate. (Table 2 & Fig. 4).

Characteristics like fresh leaf yield, fresh stem yield, fresh herbage yield, dry leaf yield, dry herbage yield, fresh leaf percent, and dry leaf percent all showed high genetic progress as a percentage of the mean (Table 2). It suggested that because these traits are controlled by additive gene activity, selection will be successful. For leaf dry matter content, stem dry matter content, herbage and dry matter content, there was a moderate genetic progress expressed as a percentage of the mean. Research showed that non-additive gene action controls these qualities, suggesting that heterosis breeding may be useful for enhancing these features.

Characteristics like fresh leaf yield, fresh stem yield, fresh herbage yield, dry leaf yield, dry herbage yield, fresh leaf percent, and dry leaf percent all showed strong heritability along with high genetic progress as a percentage mean. For leaf dry matter

content and herbage dry matter content, high heritability in conjunction with moderate genetic progress as percent mean suggested the presence of both additive and non-additive gene activity. The more or less similar observations was also reported by the following experiments:

Kumar *et al.,* (2014) found that the highest variability was found in fresh and dry herbage yield.

Sharma & Singh (2012) recorded moderate variability and high heritability with high genetic advance for fresh herbage yield.

Devi (2016) found that herbage dry weight exhibited maximum coefficient of variation at both genotypic and phenotypic level. High heritability along with high expected genetic gain as percent of mean was found in herbage dry weight/ plant.

Disha &Tirkey (2016) observed that lowest GCV for many traits like fresh herbage yield however and leaf to stem ratio. Dry herbage yield showed high GCV, h^2 and GA.

Chemical Parameters

Among the genotypes under study, there were no discernible changes in the yields of andrographolide, neo andrographolide, andrographiside, and 14-deoxy-11,12 di dehydro andrographolide between GCV and PCV (Table 3 & Table 4, Fig. 5 & Fig.6). However, the magnitude of GCV and PCV was high in the case of neo andrographolide content in leaf, stem, and herbage, moderate in the case of andrographolide content in leaf, stem, and herbage, as well as low in the case of 14-deoxy-11,12 di dehydro andrographolide yield in herbage and andrographiside in leaf and herbage (Table 3). GCV and PCV were high among the genotypes under study when it came to the yield of these characteristics in leaf, stem and herbage.

All of these chemical quality characteristics showed a high degree of heredity (90.59 to 99.99% for phyto-chemical content and 68.67 to 94.87% for their yield), indicating that these traits might be utilised as selection criteria right away. (Table 3 & Table 4, Fig. 7 & Fig. 8).

Characters like andrographolide content in leaves, stems, and herbs; neo andrographolide content in leaves, stems, and herbs; andrographiside content in leaves and herbs; and 14-deoxy-11,12 di dehydro andrographolide content in herbs were found to have high genetic advance as a percentage of the mean. In the instance of 14-deoxy-11,12 di dehydro andrographolide in leaf and stem, a moderate genetic advance as a percentage of the mean was observed. (Table 3).

All of the quality characteristics showed high heritability in addition to strong genetic progress as percent mean, indicating that these qualities are controlled by additive gene action and that direct selection based on these variables will be successful in producing superior cultivars.

It showed that non-additive gene action controls these traits, suggesting that heterosis breeding may be beneficial. Nonetheless, as a percentage of the mean, all yield traits displayed strong genetic advance (Table 4). The more or less similar observations was also reported by the following experiments:

Kumar *et al.,* (2014) found that the andrographolide content and the andrographolide yield having highest variability

Sharma & Singh (2012) recorded moderate variability and high heritability with high genetic advance andrographolide content.

Devi (2016) observed that andrographolide content had high heritability along with high expected genetic gain as percent of mean.

Disha &Tirkey (2016) observed that GCV was seldom lower than PCV for andrographolide content.

Conclusion

In conclusion most of the morphological parameters were found to have high estimates of genotypic and phenotypic variations with high heritability and genetic advance, it strongly suggests that the traits are controlled by additive gene action hence simple selection can be employed for the improvement of the traits. The remaining traits, however, including plant height, leaf length, number of primary nodes per plant, number of primary branches per plant, and length of primary branches, showed high heritability along with moderate genetic advance as a percentage mean, indicating high heritability is being caused by dominance variance factors rather than additive genetic variance alone and simple selection. The yield parameters showed considerable genotypic and phenotypic variability with high heritability and genetic advance as per cent of mean except dry herbage and stem matter content. Chemical criteria such as the amounts of neo andrographolide in the leaf, andrographiside in the leaf and stem, and neo andrographolide in the stem and herbage; andrographolide yield in leaf, stem and herbage; neo andrographolide yield in leaf, stem and herbage and 14-deoxy-11,12 didehydo andrographolide yield in leaf, stem and herbage as indicated by high value of GCV, while remaining characters had low to moderate GCV values with high heritability hence, selection may be efficient for directing these traits' genetic improvement in the desired direction.

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Table.1: Showing GCV, PCV and h^2 and genetic advance as per cent of mean for morphological characters

Sr. No.	Characters	σ^2_g	σ^2_p	GCV (%)	PCV (%)	H^2 (b) (%)	GA	GA % of mean
1	Plant height (cm)	45.87	56.07	9.93	10.98	81.81	12.62	18.50
2	Leaf length (cm)	0.77	0.94	10.62	11.73	81.91	1.64	19.80
3	Leaf breadth (cm)	0.11	0.14	15.06	16.83	80.05	0.61	27.75
4	Leaf area (cm^2)	6.12	6.39	23.40	23.90	95.83	4.99	47.18
5	No. of primary nodes	3.31	4.02	9.69	10.68	82.41	3.40	18.13
6	No. of primary branches per plant	11.79	15.21	10.32	11.72	77.53	6.23	18.72
7	No. of secondary branches per primary branch	3.97	4.58	17.29	18.58	86.59	3.82	33.13
8	Length of primary branches (cm)	6.34	11.49	7.26	9.77	55.19	3.85	11.11
9	Total length of primary branches (cm)	7639.95	10077.44	15.19	17.45	75.81	156.78	27.25
10	Canopy spread (cm)	235.31	312.36	12.81	14.76	75.33	27.43	22.91
11	Length of internodes (cm)	0.15	0.19	13.59	15.28	79.01	0.71	24.88
12	Angle of primary branch (°)	66.32	70.55	18.48	19.06	94.01	16.27	36.91

Table.2 Showing GCV, PCV and h^2 and genetic advance as per cent of mean for yield characters

Sr. No.	Characters	σ^2_g	σ^2_p	GCV (%)	PCV (%)	H^2 (b) (%)	GA	GA % of mean
1	Fresh leaf yield (kg/ha)	4543597.18	5934887.75	31.75	36.29	76.56	3842.03	57.24
2	Fresh stem yield (kg/ha)	10073085.22	14082259.94	23.65	27.97	71.53	5529.60	41.21
3	Fresh herbage yield (kg/ha)	18333270.87	27473655.34	21.27	26.04	66.73	7205.25	35.79
4	Dry leaf yield (kg/ha)	360127.25	517602.64	26.41	31.66	69.58	1031.16	45.37

5	Dry stem yield (kg/ha)	1239980.40	1724529.30	24.70	29.13	71.90	1945.12	43.15
6	Dry herbage yield (kg/ha)	1767365.36	2761337.52	19.61	24.51	64.00	2190.96	32.31
7	Leaf dry matter content (%)	10.49	15.02	9.33	11.17	69.82	5.58	16.06
8	Stem dry matter content (%)	5.25	8.86	6.82	8.86	59.22	3.63	10.81
9	Herbage dry matter content (%)	5.63	7.72	7.00	8.20	72.91	4.17	12.31
10	Fresh leaf percent (%)	312.84	340.01	33.94	35.38	92.01	34.95	67.06
11	Dry leaf percent (%)	334.01	384.62	33.97	36.45	86.84	35.08	65.21

Table.3 Showing GCV, PCV and h^2 and genetic advance as per cent of mean for chemical content

Sr. No.	**Characters**	**σ^2_g**	**σ^2_p**	**GCV (%)**	**PCV (%)**	**H^2 (%) (b)**	**GA**	**GA % of mean**
1.	Andrographolide content in leaf (%)	0.031	0.031	10.03	10.03	99.99	0.36	20.66
2.	Andrographolide content in stem (%)	0.0203	0.0203	20.00	20.00	99.99	0.29	41.19
3.	Andrographolide content in herbage (%)	0.019	0.0198	11.74	12.00	95.70	0.28	23.66
4.	Neo andrographolide content in leaf (%)	0.047	0.047	27.76	27.76	99.92	0.44	57.17
5.	Neo andrographolide content in stem (%)	0.0024	0.0025	28.85	28.97	99.13	0.10	59.17
6.	Neo andrographolide content in herbage (%)	0.016	0.016	26.53	26.82	97.85	0.25	54.06
7.	Andrographiside content in leaf (%)	0.016	0.016	17.68	17.69	99.91	0.26	36.39
8.	Andrographiside content in stem (%)	0.0011	0.0011	9.49	9.53	99.18	0.067	19.46
9.	Andrographiside content in herbage (%)	0.0048	0.0049	13.68	13.87	97.29	0.14	27.80
10.	14-deoxy-11,12 di dehydro andrographolide content in leaf (%)	0.0023	0.0024	8.15	8.34	95.40	0.097	16.39
11.	14-deoxy-11,12 di dehydro andrographolide content in stem (%)	0.0008	0.0008	9.51	9.99	90.59	0.054	18.65
12.	14-deoxy-11,12 di dehydro andrographolide content in herbage (%)	0.0019	0.002	10.39	10.70	94.15	0.0865	20.76

Table 4.: Showing GCV, PCV and h^2 and genetic advance as per cent of mean for chemical yield

Sr. No.	Characters	σ^2_g	σ^2_p	GCV (%)	PCV (%)	H^2 (b) (%)	GA	GA % of mean
1.	Andrographolide yield in leaf (kg/ha)	512.63	665.19	32.53	37.06	77.07	40.94	58.83
2.	Andrographolide yield in stem (kg/ha)	132.97	147.54	48.81	51.42	90.12	22.55	95.46
3.	Andrographolide yield in herbage (kg/ha)	557.37	777.55	25.33	29.91	71.68	41.18	44.17
4.	Neo andrographolide yield in leaf (kg/ha)	48.04	55.29	48.12	51.63	86.88	13.31	92.40
5.	Neo andrographolide yield in stem (kg/ha)	1.34	1.42	78.57	80.67	94.87	2.33	157.65
6.	Neo andrographolide yield in herbage (kg/ha)	54.77	62.73	46.61	49.88	87.32	14.25	89.73
7.	Andrographiside yield in leaf (kg/ha)	32.38	36.68	45.85	48.79	88.28	11.01	88.73
8.	Andrographiside yield in stem (kg/ha)	3.31	4.04	33.27	36.75	81.98	3.40	62.06
9.	Andrographiside yield in herbage (kg/ha)	38.20	45.11	34.56	37.56	84.69	11.72	65.52
10	14-deoxy-11,12 di dehydro andrographolide yield in leaf (kg/ha)	7.47	9.41	34.14	38.32	79.41	5.02	62.68
11	14-deoxy-11,12 di dehydro andrographolide yield in stem (kg/ha)	1.05	1.52	27.23	32.86	68.67	1.75	46.48
12	14-deoxy-11,12 di dehydro andrographolide yield in herbage (kg/ha)	8.98	12.51	25.48	30.08	71.75	5.23	44.46

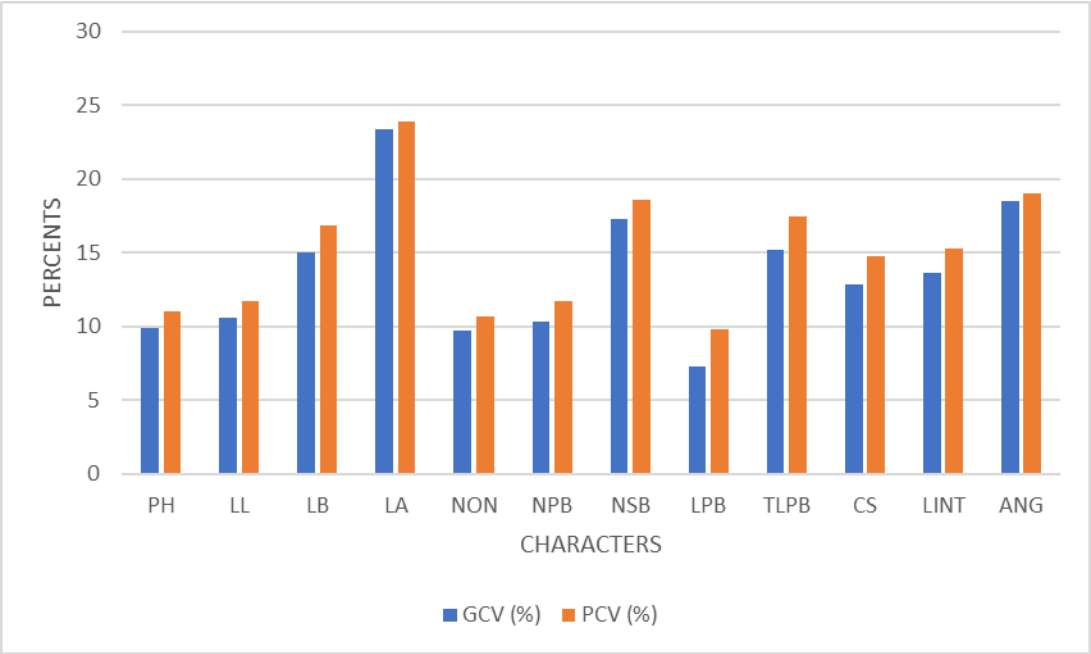

Fig.1 Comparison of GCV and PCV of morphological characters

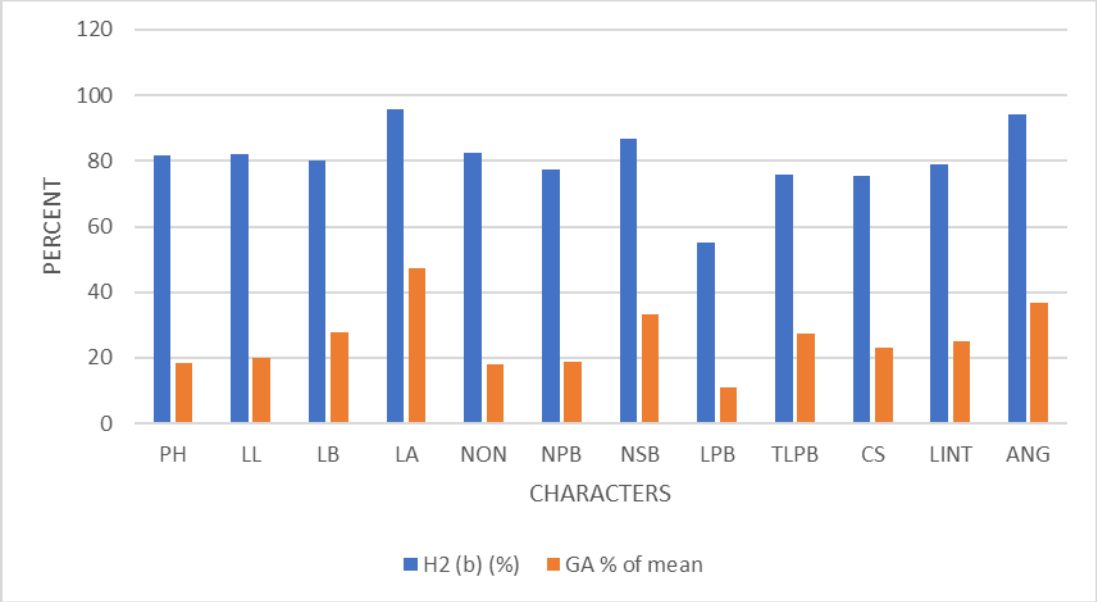

Fig.2 Comparison of H^2 and GA % of mean of morphological characters

PH-Plant Height, LL-Leaf length, LB-Leaf Breadth, LA-Leaf Area, NON-Number of Primary Nodes, NPB-Number of Primary Branches per plant, NSB- Number of Secondary branches per plant, LPB- Length of Primary Branch, TLPB- Total Length of Primary Branch, CS- Canopy Spread, LINT- Length of Internodes, ANG- Angle of primary branch.

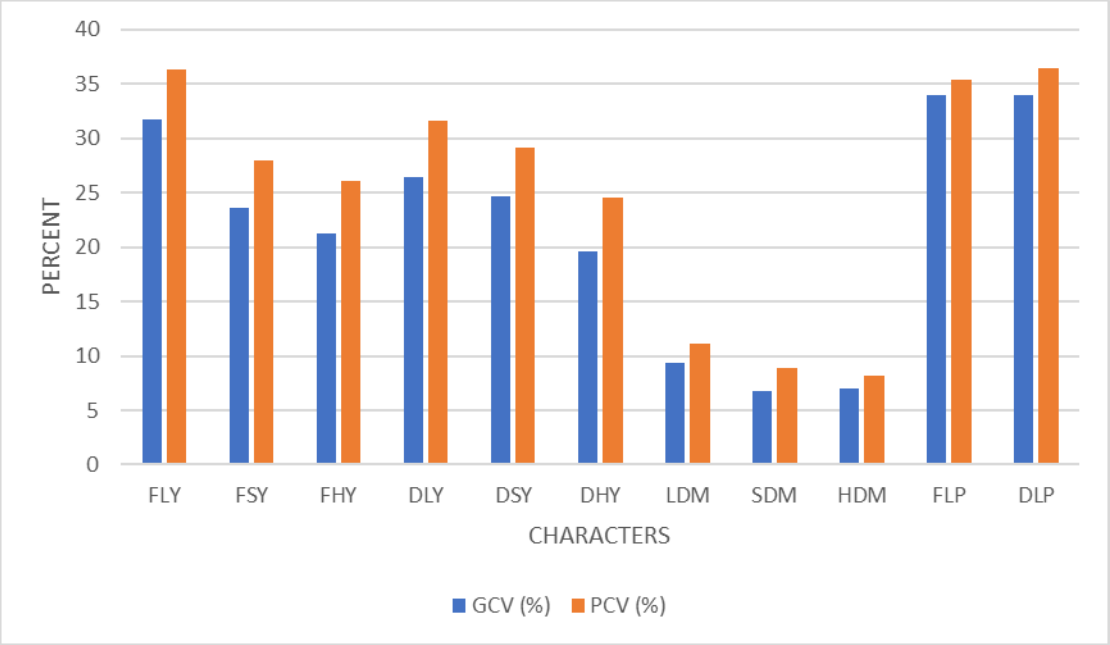

Fig.3 Comparison of GCV and PCV of yield characters

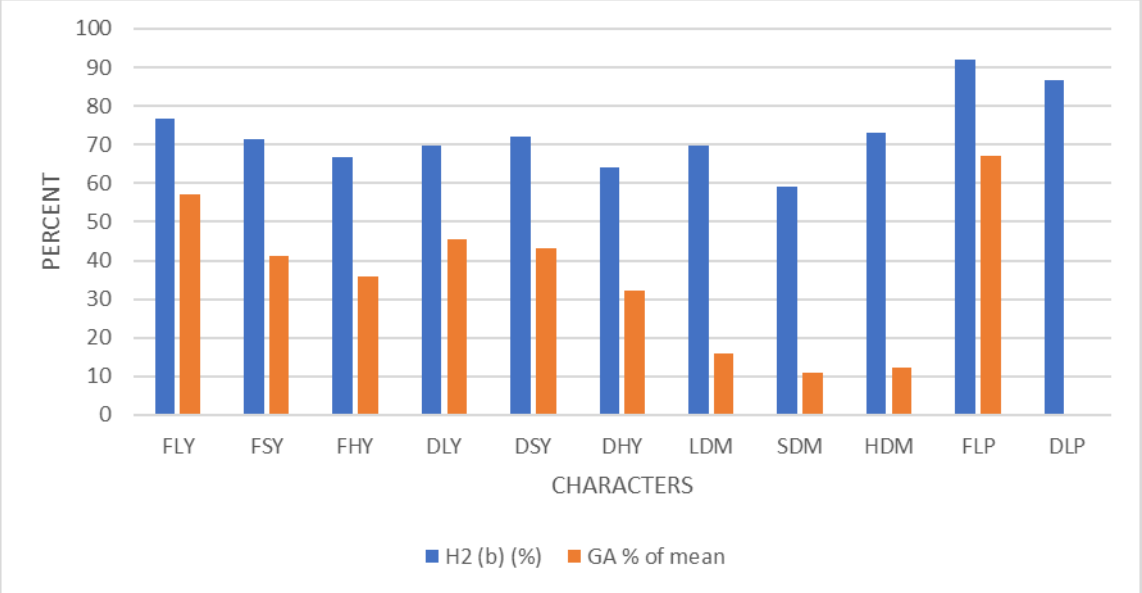

Fig.4 Comparison of H^2 and GA % of mean of yield characters

FLY- Fresh Leaf Yield, FSY- Fresh Stem Yield, FHY- Fresh Herbage Yield, DLY- Dry Leaf Yield, DSY- Dry Stem Yield, DHY- Dry Herbage Yield, LDM- Leaf Dry Matter Content, SDM- Stem Dry Matter Content, HDM- Herbage Dry Matter Content, FLP-Fresh Leaf Percent, DLP-Dry Leaf Percent

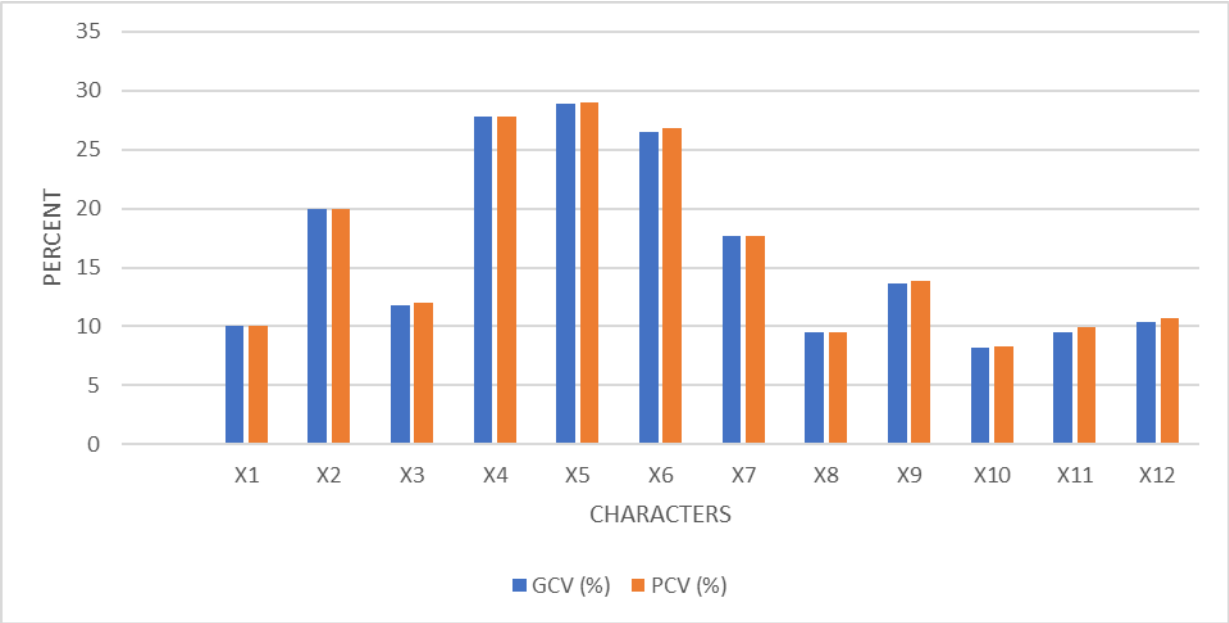

Fig.5 Comparison of GCV and PCV of different chemical content

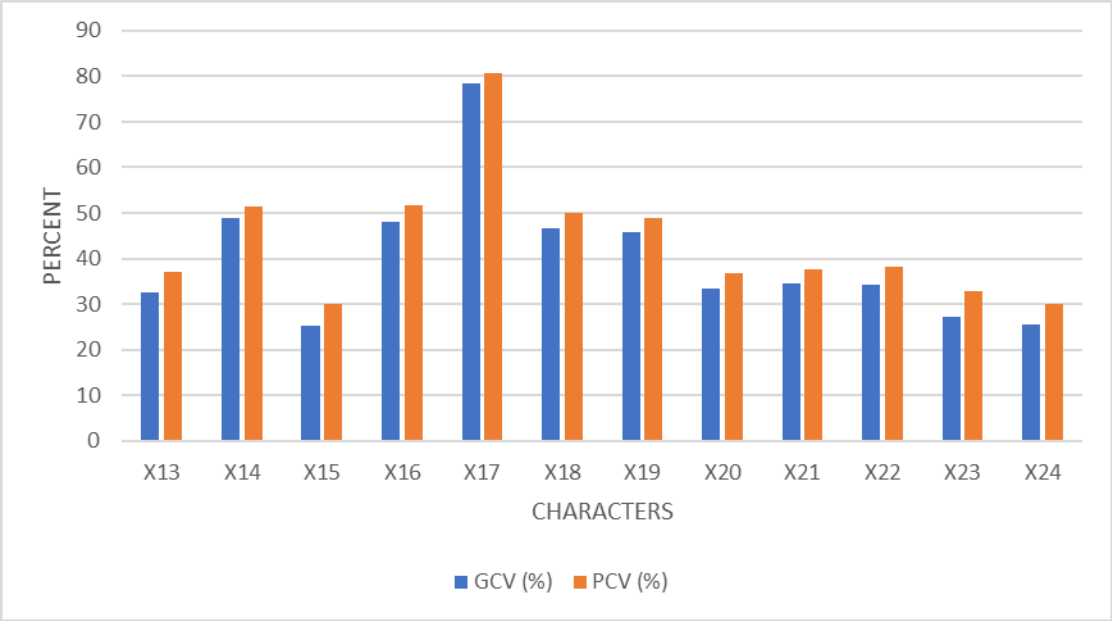

Fig.6 Comparison of GCV and PCV of different chemical yield

X1- Andrographiside Content in Leaf, X2- Andrographolide Content in Leaf, X3- Neo andrographolide Content in Leaf, X4- 14-deoxy-11,12 didehydro andrographolide Content in Leaf, X5- Andrographiside Yield in Leaf, X6- Andrographolide Yield in Leaf, X7- Neo andrographolide Yield in Leaf, X8- 14-deoxy-11,12 didehydro andrographolide Yield in Leaf, X9- Andrographiside Content in Stem, X10- Andrographolide Content in Stem, X11- Neo andrographolide Content in Stem, X12-14-deoxy-11,12 didehydro andrographolide Content in Yield.

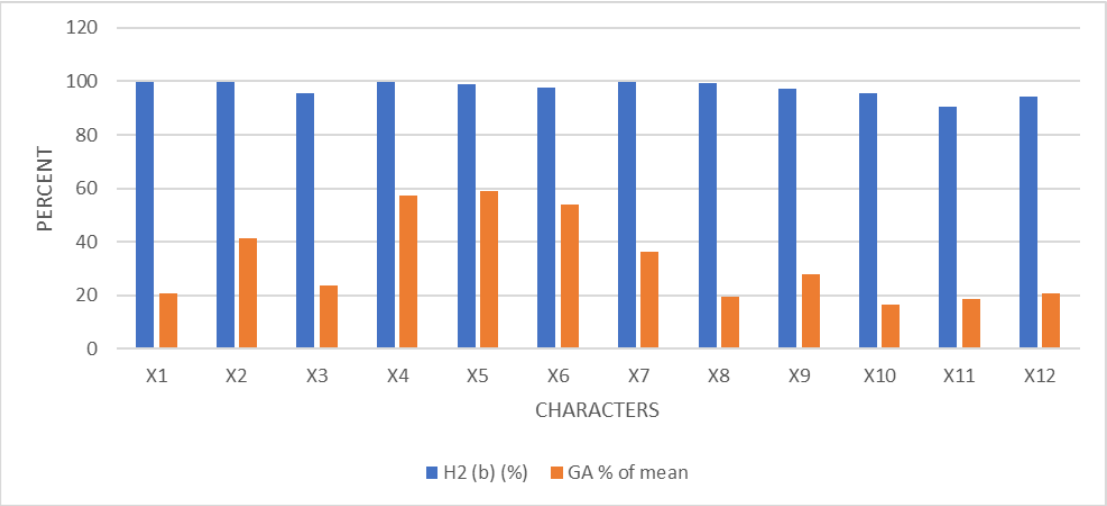

Fig.7 Comparison of H^2 and GA % of mean of different chemical content

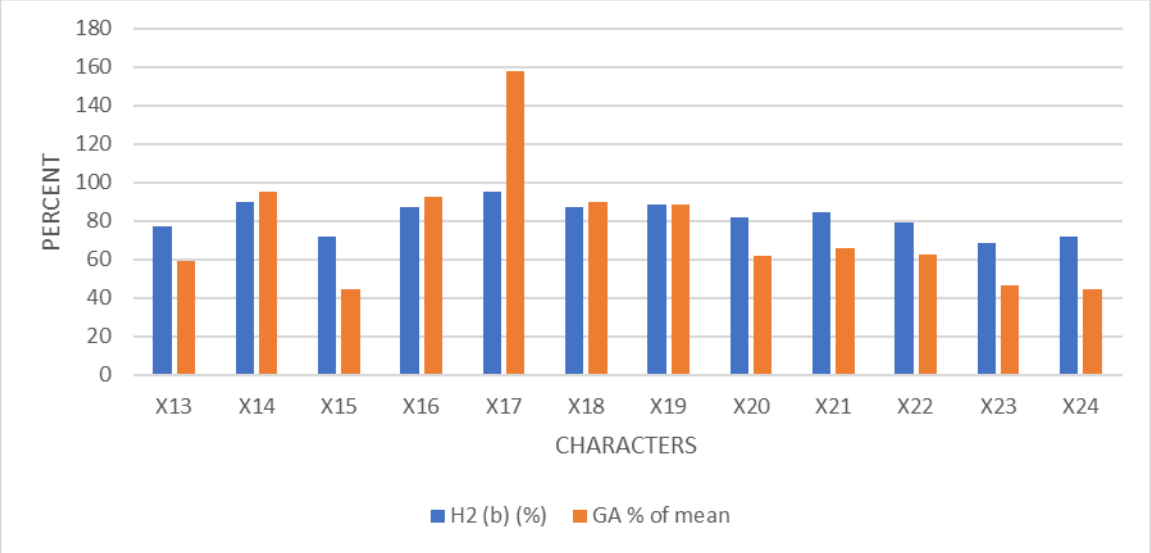

Fig.8 Comparison of H^2 and GA % of mean of different chemical yield

X13- Andrographiside Yield in Stem, X14- Andrographolide Yield in Stem, X15- Neo andrographolide Yield in Stem X16-14-deoxy-11,12 didehydro andrographolide Yield in Stem, X17- Andrographiside Content in Herbage, X18- Andrographolide Content in Herbage, X19- Neo andrographolide Content in Herbage, X20-14-deoxy-11,12 didehydro andrographolide Content in Herbage, X21- Andrographiside Yield in Herbage, X22-Andrographolide Yield in Herbage, X23- Neo andrographolide Yield in Herbage, X24-14-deoxy-11,12 didehydro andrographolide Yield in Herbage