STUDY OF VARIABILITY PARAMETER IN KALMEGH

(*Andrographis paniculata* Wall.)

M.Sc. (Ag.) THESIS

By

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INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (C.G.)
2014

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Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)

By

DISHA NAGVANSHI

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science
In
Agriculture

(Genetics & Plant Breeding)

Roll No. 15461 **I.D. No. 112508012**

JULY, 2014

CERTIFICATE – I

This is to certify that the thesis entitled **"STUDY OF VARIABILITY PARAMETER IN KALMEGH (*Andrographis paniculata* Wall)".** Submitted in partial fulfillment of the requirements for the degree of **"MASTER OF SCIENCE IN AGRICULTURE"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur is a record of the bonafide research work carried out by **DISHA NAGVANSHI** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate, awarded etc.) or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by her.

Date- 22/7/14

Dr. Alice Tirkey
(Major Advisor and Chairman)

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman Dr. Alice Tirkey _____

Member Dr. A. K. Geda _____

Member Dr. Zenu Jha _____

Member Dr. R .R .Saxena _____

Member Dr. Y.K. Dewangan _____

CERTIFICATE - II

This is to certify that the thesis entitled **"STUDY OF VARIABILITY PARAMETER IN KALMEGH (*Andrographis paniculata* Wall)".** Submitted by **DISHA NAGVANSHI** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) in partial fulfillment of the requirements for the degree of **"MASTER OF SCIENCE IN AGRICULTURE"** in the **DEPARTMENT OF GENETICS AND PLANT BREEDING** has been approved by the external examiner and Student's Advisory Committee after an oral examination.

Date: 14/8/14

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16 OCT 2014

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ACKNOWLEDGEMENT

Research is creating new knowledge. Research needs the close co-operation of the friends and colleagues and the guidance of experts in the field to achieve something worthwhile with light patience, vigor and dedication of the person.

First of all I would like to thank, and praise almighty "God", the most beneficent and merciful, for all his love and blessings conferred up on mankind."A journey is easier when you travel together; interdependence is certainly more valuable than independence". I bow to Almighty "GOD" who keeps ever burning before my vagrant steps the kindly light of hopes and always showered blessing on me without whose endless benevolence and blessing this tedious task could not have been accomplished.

"Education plays vital role in personal and social development and teacher plays a fundamental role in imparting education. Teachers have crucial role in shaping young people not only to face the further with confidence but also to build up it with aim and responsibility. There is no substitute for teacher pupil relationship".

I take this golden opportunity to express my heartfelt sense of gratitude to those who helped me to make my research possible. These words are small acknowledgement but never fully recomposed for their great help and cooperation.

Most humbly and respectfully I wish to express my profound sense of gratitude to Dr. S.R Patel, Dean, and Dr. O.P Kashyap Ex Dean, College of Agriculture, IGKV, Hon'ble Vice Chancellor, Dr. S.K. Patil, Director of Research Services Dr. J.S. Urkurkar and Dr. S.S Shaw, Director of Instructions, IGKV, Raipur, for providing me the necessary facilities for research work. Raipur, for his excellent guidance, valuable suggestion, memorable advices and encouragement which is the vital source of inspiration in my life. I pay my sincere thanks to Dr. A.K. Sarawgi, Professor and Head, Department of Genetics and Plant Breeding for his excellence guidance during course of investigation and providing necessary facilities.

With a sense of high reverence my sincere and warmest gratitude goes to adorable guide and Chairman of my Advisory Committee, Dr. Alice Tirkey, Scientist, Department of Genetics and Plant Breeding, IGKV, Raipur (C.G.) for her inspiring guidance, constructive criticism, sympathetic attitude during the entire course of her investigation and timely advisement during my thesis work and providing necessary facilities. she always exuded unceasing in my thesis work which always inspired me to work better and better.

With a sense of high resolve and reverence, I would like to express my sincerest thanks to respected members of my advisory committee Dr.A.K Geda,Professor (Department of Plant physiology, Agricultural Biochemistery and herbal Science),Dr. Zenu Jha, Professor (Department

of Molecular biology and biotechnology), Dr. Ravi R. Saxena, Associate Professor (Department of Agricultural Statistics and Social Science L.), Dr. Y.K. Dewangan, Scientist (Department of Agronomy) Raipur, for their critical suggestions, keen co-operation and kind help rendered as and when needed.

I express my sincere thanks to my teachers Dr. H.C. Nanda, Dr. N. K. Rastogi, Dr. N. K. Rastogi, Dr. Rajeev Shrivastava, Dr. P. K. Chandrakar, Smt. Dr. Prabha Rani Choudhry, Dr. Surendra Verma, Dr. Sandeep Bhandarkar, Shri. P. L. Johnson, Shri. Sunil Nag, Dr. (Smt.) Vina R. Saxena, Dr.Mayuri Sahu, Dr.Bhawana Sharma, Mrs.Mangala Parikh, Shri R. K. Sharma, Mr. S.M. Ali Humayun for their encouragement and constant helps throughout the course of my studies.

I would like to express my sincere gratitude to Dr. Madhav Pandey (Librarian, Nehru Library, Raipur) and Shri U.K. Watti for giving me there kind help during my study.

I wish to express thanks to my seniors Madhuri Mam, AKhilesh Sir, Namrata Mam, Jyoti mam, Anju mam, my batch mates Preeti Singh, Arpita, Nidhi ,Neha, Shilpi, Jaspreet, Vandna, Varsha, Pritansha, Laxmi, Aradhana, Preeti, Abhilasha, Kiran, Ishu, Manoj, Bupesh and my Juniors Mukesh, Akash, Chitra for their co-operation during the course of work.

Unforgettable help and assistance throughout the course of this investigation by Mr. Hemanand, Raghu, Citrasen, and others also deserve my sincere thanks.

At last I am short of words to express my feelings and thanks to my father Mr. Khamman Lal Nagvanshi, My mother Mrs. Kashmir Nagvanshi, Grandmother Santi Nagvanshi, my family member Prahad Singh Netam, Jitendra Komra, Vinay Komra, Rakesh Sori, Yogesh Nag whose blind affection, obstinate sacrifice, sincere prayers and blessings, affectionate encouragement, love and support throughout my carrier and especially during this study.

I would like to convey my cordial thanks to all those unmentioned persons who helped me during my thesis course work. I take this golden opportunity to express my heartfelt sense of gratitude to those who helped me to make my research possible. These words are small acknowledgment but never fully recompensed for their great help and co-operation.

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Introduction

CHAPTER-I

INTRODUCTION

Andrographis paniculata Wall. ex Nees, commonly known as Kalmegh, King of bitters which belongs to family Acanthaceae is an annual herb about 30-100 cm height, stem acutely quadrangular with many branches widely used in tropical Asia. *Andrographis paniculata* is probably native to India and it is distributed throughout Thailand, Peninsular Malaysia to Indonesia and in India it is found in the state of Madhya Pradesh, Chhattishgarh, Odisha, Maharashtra, Assam, Bihar, West Bengal, Uttar Pradesh, Tamilnadu, Kerala (Pandey *et al*. 2010). It is placed at 17th position among the 32 prioritized medicinal plants of India with a demand of 2,197.3 tonnes (2005-2006) and annual growth of 3.1% (Mishra *et al*.2001). It has an important place in the Indian pharmacopoeia and is being prominently used in 26 Ayurvedic formulas (Nandkarni 1954). Leaves, stem, flower, seed, root of the plant is being used in various formulation of Indian system of medicine. The leaves and aerial parts of the plant are used in Indian traditional medicine for the treatment of fever, malaria, sone throat (Shanker *et al.* 2012, Chopra 1956, Mishra 1992, Najib 1999), hepatopratective, antioxidant (Lin *et al.* 2009 and Tiwari and Rawal 2001). useful in wounds, ulcers, lepcory, tonsillitis, osteodynea, menstrual and post partum hacmatometra, hypertension (Puri *et al.* 1996), blood purifier, liver tonic, jaundice, dermatological diseases, antimicrobial activity (Singha *et al*. 2003). antityphoidal property, antibiotic properties (Akbarsha *et al.* 1990) , anti hepatotoxic effect (Kapil 1993), Anticancer activity (Kumar, 2004). antidiabetic (Lal *et al.*1986). trail on HIV patient (Calabrese, 2000). and found effective etc.

In view of great demand in phytopharmaceutical industries its commercial production become one of the imporors restricting the large scale production and

development of better varieties is that little information is available about the genetic diversity, inter and intra specific variability and genetic relationship among *Andrographis paniculata*. Therefore attempts are made to analyze possible untapped genetic diversity which is extremely essential for the selection and improvement of medicinal plant. Knowledge of genetic diversity in nature and degree is very much useful for selecting parents from large number of available genotypes.

Genetic parameters of variation and character association provides information about expected response of various character and helps in developing suitable breeding procedure for their improvement, nature and magnitude of variability in the existing plant material and the association among various character are pre requisites for yield and selection of better plant types. Path coefficient analysis permits further facilitate important trait to identify. These parameters however vary with the type of material used and the environmental conditions to which the accession are subjected. Such studies have not been made yet in the state of C.G. The present investigation entitled **" study of variability parameter in Kalmegh (*Andrographis paniculata*)"** was thus, carried out with the following objective:-

1) To study the genetic diversity in Kalmegh (*Andrographis paniculata*).
2) To study PCV, GCV, h^2 or GA.
3) To study correlation and path among ancillary characters and herbage yield in Kalmegh (*Andrographis paniculata*).
4) To study of reproductive behavior in Kalmegh (*Andrographis paniculata*).
5) Assessment of processing in Kalmegh (*Andrographis paniculata*).

Review of Literature

CHAPTER-II

REVIEW OF LITERATURE

A brief review of research work about the variability parameter is summarized under the following heading:

- Genetic diversity
- PCV, GCV, h^2 and GA.
- Coefficient of correlation analysis .
- Path analysis.
- Reproductive behavior in Kalmegh (*Andrographis paniculata*).
- Assessment of processing in Kalmegh (*Andrographis paniculata).*

2.1 GENETIC DIVERSITY

Among several statistical methods developed for measuring divergence between population, multivariate analysis of D^2 statistics has been effectively used for quantitative estimation of genetic variability according to Mahalanobis (1936) D^2 statistics, Which can be effectively used for assessing the genetic divergence between population and helping in desirable parents for crossing programme.

Padmesh *et al*. (1998) determined the intraspecific variability in *Andrographis paniculata*. They identified 5 major groups based on geographical distribution that generally reflected expected trends between the genotypes. Andrographolide showed quantitative variations among the accessions which could not be correlated with allelic variation. The data revealed moderate variation within the species as shown by 61polymorphic RAPD products ranging in size from 310 to 3500 bp out of the 73 products generated (83.56%).

Sabu *et al.* (2001) demonstrated a moderate level of genetic variation among different *Andrographis* accessions from India and other countries of tropical Asia. Product synthesis did not correlate with isozyme pattern or sources of origin. The lower yield of andrographolide content might be related to different genotypes, different growing conditions of the plants and post-harvest treatments of the plant material.

Tongdonae (2002) Studied the genetic diversity of *Andrographis paniculata* using morphological characters and isozyme patterns, and found that all accession were significantly different. Classification based on morphological characters did not correlate with isozyme patterns and sources of origin.

Alireza *et al*. (2004) Studied intra specific hybridization generator of genetic diversification and heterosis in *Andrographis paniculata*.The result revealed that hybridization acted as a power engine for classification of of Andrographis paniculata and it is caused heterosis expression of the studied trait simultaneously.

Sharma *et al*. (2009) Studied at assessment of intra specific variability at morphological, molecular and biochemical level of *Andrographis paniculata*. The study demonstrated that simultaneously morphological, molecular and biochemical analysis are useful for characterizing genetic diversity and defining relationships between Kalmegh germplasm. It also gave possible indications to the phytochemical variation of different genotypes which were due to the genetic differences.

Pandey A.K. and Mandal A.K. (2010) Studied at variation in morphological characteristic and Andrographolide content in *Andrographis paniculata. A. paniculata* collected from 5 location of Madhya Pradesh and chhattishgarh were studied for their morphological characteristic and diterpene content to find out the superior genotype

,and the result indicated that those population are potentially important sources for breeding ,improvement of cultivars and best sources for obtaining higher drug yield

Minz Preeti lata and Koche Vijaya (2012) studied at variation in morphological parameters and Andrographolide content in *Andrographis paniculata* collected from different provenances of Chhattisgarh and the result indicated that quantification of andrographolide was determine by HPLC which revealed that the variation in the andrographolide content is highest in the korba provenances then the plants plant from other provenances. The result indicate that these population are potentially important sources for breeding, improvement of genotype and the best sources for obtaining higher drug yield.

Raina *et al.* (2013) studied at evalution studied on Kalmegh (*Andrographis paniculata*). Results showed that Andrographolide content ranged from 1.30 to 2.51% among 22 collections with mean andrographolide of 1.82%. Promising collections identified were IC342139 (2.51%), IC471916 (2.16%), IC111291 (2.20%) and IC210635 (2.13%). Considering its value as a drug raw material, emphasis should be given for its commercial cultivation to get authentic raw material of known quality.

2.2 PCV, GCV, h^2 & GA

Misra *et al*. (2000) studied at pattern of genetic variation for different trait in collection of kalmegh (*Andrographis paniculata*) genotype. Result that the highest phenotypic and genotypic coefficient of variation were recorded for dry biomass yield, leaf/stem ratio followed by plant height and the lowest for leaf length. Heritability in the broad sense and the corresponding genetic advance as percentage of mean were high for plant height and dry matter yield, indicating the these trait were governed by additive gene effect with low environment effect and thereby offering a

scope for genetic improvement by exercising selection other trait were moderately heritable with moderate to low genetic advance indicating non additive gene effects.

Sharma, M.M. & Singh, O.P. (2012) studied at heritability and genetic advance for different morphological and quality trait in germplasm of Kalmegh and observed that phenotypic coefficients of variations were higher than genotypic coefficient of variations. The highest PCV and GCV were observed for dry weight of herb per plant 20.23% and 19.24% respectively. The moderate PCV and GCV was observed for fresh weight of herbs per plant (18.52 and 18.29) followed by Andrographolide content (16.52 and 16.44), number of primary branches per plant (14.14 and 7.34) and leaf length (11.62 and 9.73). The low PCV and GCV were observed for remaining characters. The high estimates of heritability was observed for the characters Andrographolide content (99.0%) followed by fresh weight of herb per plant (98.0%) and dry weight of herb per plant (90.0%). The moderate heritability in broad sense was recorded for the characters leaf length (70.0%), days to first flowering (67.0%), days to 50% flowering (67.0%) and plant height (54.0%). The high estimates of genetic advance were expressed by the character fresh weight of herb per plant (50.61) and dry weight of herb per plant (18.96). The high expected genetic advance in percent of mean were observed for dry weight of herb per plant (37.67%) followed by fresh weight of herb per plant (37.20%) Andrographolide content (33.70%) and leaf length (16.78%).

2.3 COEFFICIENT OF CORRELATION

Volence (1985) studied at leaf area expension of diverse alfalfa germplasm. This resulted in 74% higher yield per shoot of the rapid SER, plant when compared to slow SER plants. The concentration or number of shoot per plant and were negative correlated with herbage N concentration (r = -3.36 to -0.55).

Patel *et al*. (2002) reported significance correlation for tuber yield plant^{-1} with number of stem plant^{-1} with number of stem and plant was height, tuber dry matter with number of tuber plant^{-1} and number of leaves plant^{-1}. However, the number of tuber plant^{-1} was reported to be negatively associated weight of tubers.

Joseph *et al.* (2005a) reported on the basis of estimated genetic parameters and characters association showed that in the population, tuber yield and average tuber weight could be selected simultaneously without adversely the tuber numbers.

Joseph *et al*. (2005b) revealed that plant height was positively associated with number of leaves and tuber yield with average tuber weight. Tuber yield was not associated with any of foliage character.

Chandraker (2007) reported that tuber yield was positively correlated with number of shoots plant^{-1}, number of leaves plant^{-1}, number of compound leaves plant^{-1}, number of tuber plant^{-1}, tuber weight plant^{-1} and harvest index.

Kubsad *et al*. (2009) analysed the correlation and the result indicated that the harvest index exhibited the highly significant and positive correlation with dry root yield per plant followed by plant height and dry matter per plant.

2.4 PATH ANALYSIS

The path analysis helps in partitioning the correlation coefficient of yield components with seed yield as direct and indirect to ensure the actual contribution of an attribute as well as its influence through other traits. An attempt has been made to review the available literature on this aspect.

Kandalkar *et al.* (1993) studied path coefficient analysis and showed highest positive direct and indirect effect of plant height and stem branches on root yield. Indirect effect of other component characters was high through plant height and stem branches on root yield.

Misra *et al.* (1998) observed that dry root yield was positively associated with all component traits. Root diameter and root length showed the highest level of direct and indirect contributions to root yield.

Chandrakar (2007) recorded that there is no common casual factor that directly influenced the dependent character tuber yield. The direct selection for the traits namely tuber weight plant^{-1}, harvest index percent and number of shoots plant^{-1} could be useful for improvement of tuber yield.

Sangwan *et al.* (2013) evaluated path analysis which revealed that total alkaloid content that highest positive direct effect on fresh root yield plant^{-1} followed by biomass yield at maturity, seed yield plant^{-1}, root diameter and number of berries plant^{-1} which suggested that selection for these would be quite effective ti improve fresh root yield in Ashwagandha.

2.5 Reproductive behavior in Kalmegh

Galen, C. and Plowright, R.C. (1987) revealed that the testing of accuracy of using peroxide activity to indicate stigma receptivity.

Sabu, K.K. (2002) studied at interspecific variation in *Andrographis paniculata.*

Edlund *et al*. (2004) Studied at pollen and stigma structure and function the role of diversity in pollination.

Shivanna, K.R. (2008) studied at pollination biology, breeding system and reproductive success in *Adhatoda vasica*, an important medicinal plant.

Chia, S.H. (2009) studied at reproductive system and genetic diversity of Hempedu Bumi (*Andrographis paniculata*).

Alireza *et al.* (2012) revealed that intraspecific crossability in *Andrographis paniculata*, a barrier against breeding of the species.

Hudedamani, U.B. and Yadav, O.P. (2013) studied at Floral biology of kalmegh (*Andrograhis paniculata*)

2.6 ASSESMENT OF PROCESSING

Techadamrongsin, Y., Dechatiwongse, N. A. T. and Punyarajun, S. (1999) Studied at Harvesting, post- harvesting handling and storage of crude druge.

Bhatnagar, P. and Singh, V.B. 2003 revealed that collection and harvesting and processing and driage percentage of *Andrographis paniculata*.

Materials and Methods

CHAPTER-III

MATERIAL AND METHODS

This chapter deals with the description of the material used and various techniques or methods adopted throughout the course of investigation entitled **"Study of Variability Parameter in Kalmegh (***Andrographis paniculata*) was carried out at Research cum Instructional Farm, Department of Crop Physiology, Agricultural Biochemistry and Herbal Science, College of Agriculture, Raipur (C.G.) during *Kharif* season 2013-14. The materials used and methodologies adopted in investigation are described below:-

3.1 Geographical situation

Raipur is situated nearly in the central part of Chhattisgarh and lies between 21$_o$16' N latitude and 81$_o$36,E longitude with an altitude of 298.60 meters above the mean sea level.

3.2 Climate and weather condition during the crop growth period

The climate of this region is dry, sub-arid. The average annual rainfall ranges from 1200-1400 mm out of which 80-85 percent is received from middle of June to end of September and very little during October and February. The region is also known by the extreme temperature, May is the hottest month of this region and the maximum temperature reach as high as 48$_o$C. December is the coolest month of this region and minimum temperature is 6$_o$C during this month. The atmospheric relative humidity is high from June to October, and wind velocity is high from May to August with its peak in June-July months.

The meteorological data of temperature, rainfall, relative humidity, vapour pressure, wind velocity, evapo - transpiration (PET) and sunshine from June 06, 2013 to January 2014 are furnished in Appendix-I and depicted in fig. 3.1. The

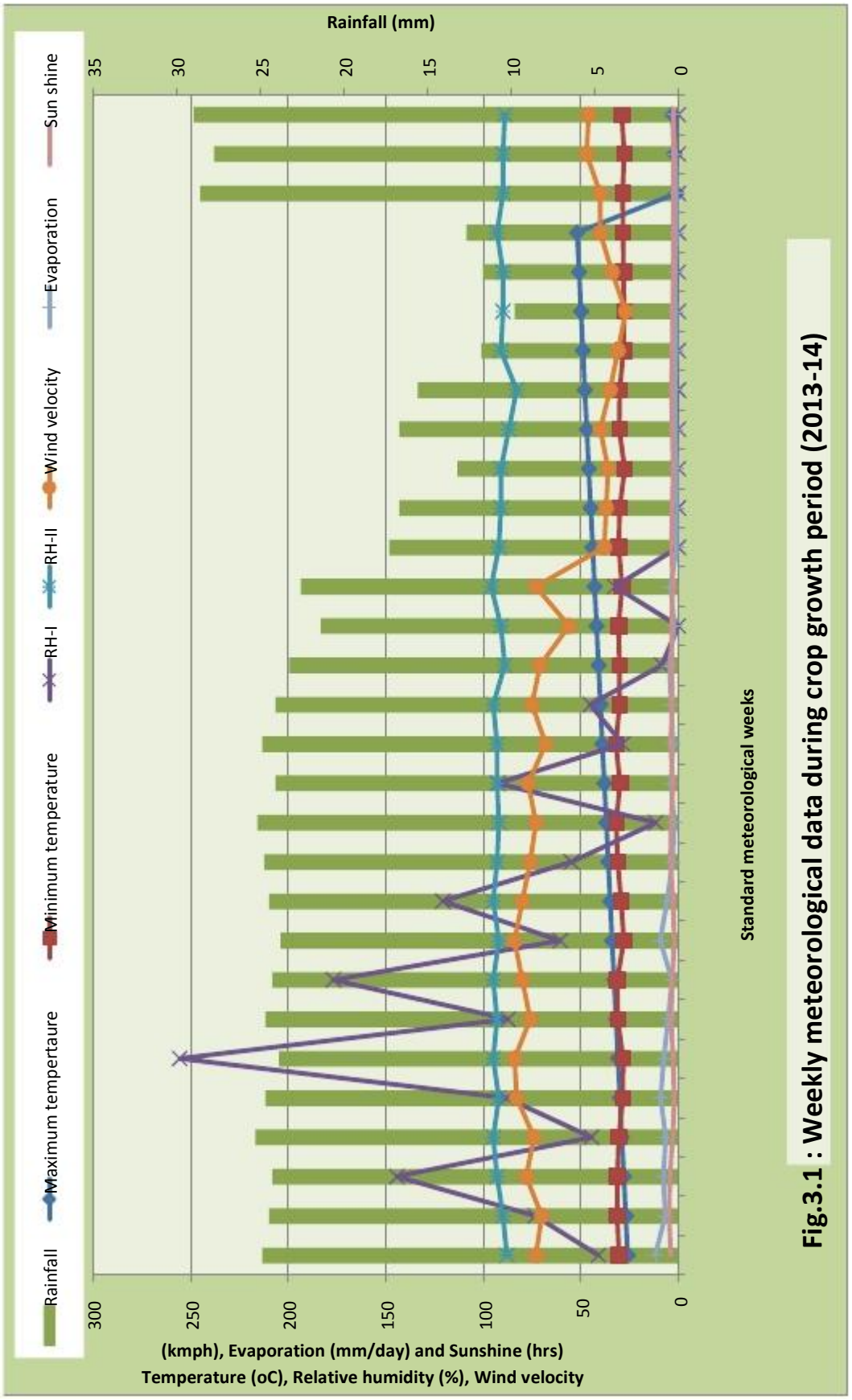

Fig.3.1 : Weekly meteorological data during crop growth period (2013-14)

meteorological data was collected Department of Agricultural Meteorology, Collage of Agriculture, IGKV, Raipur.

3.3 Experimental Materials

In Set-I a total 22 accession of kalmegh representing different districts of C.G with 2 check Anand Kalmegh and Simmegha were used in the present study. The detail of materials used are presented in table-3.1.

Table 3.1:- Set-I List of germplam accessions collected from different district of C.G.

S.NO	Germplasm accession	District of collection	State
1	IKM-1	Raipur	collection from Chhattisgarh
2	IKM-2	Durg	collection from Chhattisgarh
3	IKM-3	Bilaspur	collection from Chhattisgarh
4	IKM-4	Jagdalpur	collection from Chhattisgarh
5	IKM-5	Dhamtari	collection from Chhattisgarh
6	IKM-6	Baster	collection from Chhattisgarh
7	IKM-7	Dantewada	collection from Chhattisgarh
8	IKN-8	Ambikapur	collection from Chhattisgarh
9	IKM-9	Jagdalpur	collection from Chhattisgarh
10	IKM-10	Raipur	collection from Chhattisgarh
11	IKM-11(C)	CMAP Kanpur	CIMAP
12	IKM-12(C)	Anand Gujrat	Anand kalmegh
13	IKM-13	Ambikapur	collection from Chhattisgarh
14	IKM-14	Dhamtari	collection from Chhattisgarh
15	IKM-15	Dantewada	collection from Chhattisgarh
16	IKM-16	Kanker	collection from Chhattisgarh
17	IKM-17	Sarguja	collection from Chhattisgarh
18	IKM-18	Raigarh	collection from Chhattisgarh
19	IKM-19	Korea	collection from Chhattisgarh
20	IKM-20	Surajpur	collection from Chhattisgarh
21	IKM-21	Jashpur	collection from Chhattisgarh
22	IKM-22	Raipur	collection from Chhattisgarh
23	KM-23	Bilaspur	collection from Chhattisgarh
24	IKM-24	Bilaspur	collection from Chhattisgarh

In Set-II a total 257 accession of Kalmegh representing different districts of C.G. The detail of material used are presented in Table-3.2. The collection was made from 14 location of C.G. and the 257 accession has been collected for present study. The number of the accession collected from different district of C.G is given in Table 3.2 and 3.3.

Table 3.2 :- Set-II List of number of germplam accessions collection from different district of C.G

S.NO	District	No. Of accessions
1	Dhamtari	9
2	Kanker	9
3	Raigarh	22
4	Kondagaon	7
5	Dantewada	2
6	Ambikapur	4
7	Jagdalpur	5
8	Durg	35
9	MAPs plot and MAPs office	91
10	Narayanpur	11
11	Raipur	11
12	Korea	10
13	Jashpur	19
14	Baster	22
15	**Total**	**257**

Table 3.3 List of detail of accession of studied

S.No.	S Aaccession	Location of collection from C.G
1	IKM-Dh-1	Dhamtari
2	IKM-Dh-2	
3	IKM-Dh-3	
4	IKM-Dh-4	
5	IKM-Dh-5	
6	IKM-Dh-6	
7	IKM-Dh-7	
8	IKM-Dh-8	
9	IKM-Dh-9	

10	IKM-KK-1	Kanker
11	IKM-KK-2	
12	IKM-KK-3	
13	IKM-KK-4	
14	IKM-KK-5	
15	IKM-KK-6	
16	IKM-KK-7	
17	IKM-KK-8	
18	IKM-KK-9	
19	IKM-RG-1	Raigarh
20	IKM-RG-2	
21	IKM-RG-3	
22	IKM-RG-4	
23	IKM-RG-5	
24	IKM-RG-6	
25	IKM-RG-7	
26	IKM-RG-8	
27	IKM-RG-9	
28	IKM-RG-10	
29	IKM-RG-11	
30	IKM-RG-12	
31	IKM-RG-13	
32	IKM-RG-14	
33	IKM-RG-15	
34	IKM-RG-16	
35	IKM-RG-17	
36	IKM-RG-18	
37	IKM-RG-19	
38	IKM-RG-20	
39	IKM-RG-21	
40	IKM-RG-22	
41	IKM-KG-1	Kondagoan
42	IKM-KG-2	
43	IKM-KG-3	
44	IKM-KG-4	
45	IKM-KG-5	
46	IKM-KG-6	
47	IKM-KG-7	
48	IKM-Jag-1	Jagdalpur
49	IKM-Jag-2	
50	IKM-Jag-3	
51	IKM-Jag-4	
52	IKM-Jag-5	
53	IKM-DG-1	Durg

54	IKM-DG-2	
55	IKM-DG-3	
56	IKM-DG-4	
57	IKM-DG-5	
58	IKM-DG-6	
59	IKM-DG-7	
60	IKM-DG-8	
61	IKM-DG-9	
62	IKM-DG-10	
63	IKM-DG-11	
64	IKM-DG-12	
65	IKM-DG-13	
66	IKM-DG-14	
67	IKM-DG-15	Durg
68	IKM-DG-16	
69	IKM-DG-17	
70	IKM-DG-18	
71	IKM-DG-19	
72	IKM-DG-20	
73	IKM-DG-21	
74	IKM-DG-22	
75	IKM-DG-23	
76	IKM-DG-24	
77	IKM-DG-25	
78	IKM-DG-26	
79	IKM-DG-27	
80	IKM-DG-28	
81	IKM-DG-29	
82	IKM-DG-30	
83	IKM-DG-31	
84	IKM-DG-32	
85	IKM-DG-33	
86	IKM-DG-34	
87	IKM-DG-35	
88	IKM-MO-1	
89	IKM-MO-2	
90	IKM-MO-3	
91	IKM-MO-4	
92	IKM-MO-5	
93	IKM-MO-6	
94	IKM-MO-7	MAPs Office
95	IKM-MO-8	
96	IKM-MO-9	
97	IKM-MO-10	
98	IKM-MO-11	
99	IKM-MO-12	
100	IKM-MO-13	
101	IKM-MO-14	
102	IKM-MO-15	
103	IKM-MO-16	

104	IKM-MO-17	MAPs Office
105	IKM-MO-18	
106	IKM-MO-19	
107	IKM-MO-20	
108	IKM-MO-21	
109	IKM-MO-22	
110	IKM-MO-23	
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112	IKM-MO-25	
113	IKM-MO-26	
114	IKM-MO-27	
115	IKM-MO-28	
116	IKM-MO-29	
117	IKM-MO-30	
118	IKM-MO-31	
119	IKM-MO-32	
120	IKM-MO-33	
121	IKM-MO-34	
122	IKM-MO-35	
123	IKM-MO-36	
124	IKM-MO-37	
125	IKM-MO-38	
126	IKM-MO-39	
127	IKM-MO-40	
128	IKM-MO-41	
129	IKM-MO-42	
130	IKM-MO-43	
131	IKM-MO-44	
132	IKM-MO-45	
133	IKM-MO-46	
134	IKM-MO-47	
135	IKM-MO-48	
136	IKM-MO-49	
137	IKM-MO-50	
138	IKM-MO-51	
139	IKM-MO-52	
140	IKM-MO-53	
141	IKM-MO-54	
142	IKM-MO-55	
143	IKM-MO-56	
144	IKM-MO-57	
145	IKM-MO-58	
146	IKM-MO-59	
147	IKM-MO-60	
148	IKM-MO-61	
149	IKM-MO-62	
150	IKM-MO-63	
151	IKM-MO-64	
152	IKM-MO-65	
153	IKM-MO-66	

154	IKM-MO-67	MAPs Office
155	IKM-MO-68	
156	IKM-MO-69	
157	IKM-MO-60	
158	IKM-MO-71	
159	IKM-MO-72	
160	IKM-MO-73	
161	IKM-MO-74	
162	IKM-MO-75	
163	IKM-MO-76	
164	IKM-MO-77	
165	IKM-MO-78	
166	IKM-MO-79	
167	IKM-MO-80	
168	IKM-MO-81	
169	IKM-MO-82	
170	IKM-MO-83	
171	IKM-MO-84	
172	IKM-MO-85	
173	IKM-MO-86	
174	IKM-MO-87	
175	IKM-MO-88	
176	IKM-MO-89	
177	IKM-MO-90	
178	IKM-MO-91	
179	IKM-NP-1	Narayanpur
180	IKM-NP-2	
181	IKM-NP-3	
182	IKM-NP-4	
183	IKM-NP-5	
184	IKM-NP-6	
185	IKM-NP-7	
186	IKM-NP-8	
187	IKM-NP-9	
188	IKM-NP-10	
189	IKM-NP-11	
190	IKM-RPR-1	Raigarh
191	IKM-RPR-2	
192	IKM-RPR-3	
193	IKM-RPR-4	
194	IKM-RPR-5	
195	IKM-RPR-6	
196	IKM-RPR-7	
197	IKM-RPR-8	
198	IKM-RPR-9	
199	IKM-RPR-10	
200	IKM-RPR-11	
201	IKM-JS-1	
202	IKM-JS-2	
203	IKM-JS-3	

204	IKM-JS-4	Jashpur
205	IKM-JS-5	
206	IKM-JS-6	
207	IKM-JS-7	
208	IKM-JS-8	
209	IKM-JS-9	
210	IKM-JS-10	
211	IKM-JS-11	
212	IKM-JS-12	
213	IKM-JS-13	
214	IKM-JS-14	
215	IKM-JS-15	
216	IKM-JS-16	
217	IKM-JS-17	
218	IKM-JS-18	
219	IKM-JS-19	
220	IKM-BS-1	Baster
221	IKM-BS-2	
222	IKM-BS-3	
223	IKM-BS-4	
224	IKM-BS-5	
225	IKM-BS-6	
226	IKM-BS-7	
227	IKM-BS-8	
228	IKM-BS-9	Baster
229	IKM-BS-10	
230	IKM-BS-11	
231	IKM-BS-12	
232	IKM-BS-13	
233	IKM-BS-14	
234	IKM-BS-15	
235	IKM-BS-16	
236	IKM-BS-17	
237	IKM-BS-18	
238	IKM-BS-19	
239	IKM-BS-20	
240	IKM-BS-21	
241	IKM-BS-22	
242	IKM-AM-1	
243	IKM-AM-2	
244	IKM-AM-3	
245	IKM- AM-4	
246	IKM-Kor-1	Korea
247	IKM-Kor-2	
248	IKM-Kor-3	
249	IKM-Kor-4	
250	IKM-Kor-5	
251	IKM-Kor-6	
252	IKM-Kor-7	
253	IKM-Kor-8	

Plate 3.1 Experimental field view

254	IKM-Kor-9	
255	IKM-Kor-10	
256	IKM-DW-1	Dhantewada
257	IKM-DW-2	

3.4 Methods

The experimental material was comprised in two set viz; in Set I, consist of 22 germplasm accession collected from different district of the C.G. along with 2 check Anand Kalmegh-1 (Directorate of Medicinal and Aromatic Plant Board) and Simmegha (Central Institute of medicinal and aromatic plants) and Set II, consist of 257 germplasm accessions was evaluated. During *Kharif* 13-14, Set-I, 22 accessions and check was shown on 26.6.2013 in Nursery and after 30 days the seedling was planted as single seedling per hill in RBD design in two replication. In Set-II, 257 accessions were planted in raised bed. Each entry was sown in 30 cm row to row spacing and plant to plant distance. FYM was applied during the field preparation. Irrigation was given during dry spell. Confidore @ 2ml in 5l. water was used to control leaf eating catterpiller at nursery stage. Weeding was done when required to raise good crop.

3.5 Observations recorded

The observation were recorded for following traits:-

1. Days to 50 % flowering

It was recorded in number of days from to sowing to the date when inflorescence in 50% plant of each plot were in heading stage.

2. Plant height(cm)

The height of the plant was measure in cm from the ground level to tip of primary branches of physiological matured plant at the time of harvest.

3. Number of secondary branches plant^{-1}

Total no of secondary branches emerging from primary branches in each plant were recorded at the time of harvest.

4. Number of tertiary branches plant^{-1}

Total no of tertiary branches emerging from secondary branches in each plant were recorded at time of harvest.

5. Pod length (cm)

The pod length was measured from each plant at physiological maturity in cm.

6. Seed number

The seed number were counted from each pod at physiological maturity.

7. Leaf length (cm)

The leaf length were measured at the time of flowering in cm.

8. Leaf width (cm)

The leaf width were measured at the time of flowering cm.

9. Petiole length (cm)

Petiole length was recorded at region of the leaf in cm.

10. Collar girth (cm)

The collar girth was recorded at collar region of root in cm.

11. Chlorophyll content

The chlorophyll content of leaf were recorded with the help of SPADE meter.

12. Canopy temperature

The canopy temperature of surrounding of plant was recorded help of infrared gun meter**.**

13. Fresh herbage yield (g)

The fresh herbage yield was recorded as actual weight in gram of total biomass of whole plant

14. Dry herbage yield (g)

The fresh herb of each plant was kept separately in envelop and oven dried at 50^0C for one over night. The dried herb was then weighed in gram of the each plant.

3.5.1 Pollen viability test :-

Pollen viability was tested using acetocarmine stain. The treatments were pollens from different bud stages, including (a) unopened anthers (9mm bud), (b) fresh and mature pollens of unopened anthers (11mm unopened bud), (c) pollens shortly after anther dehiscence (13mm unopened bud), and (d) non-fresh pollens (15mm opened bud). The samples were collected in Petri dishes separately, and pollen grains were placed on a glass slide by squeezing the anthers using forceps. Forceps was dipped in 70% ethanol in the interval in order to prevent pollen contamination of different samples. The grains of pollen were counted to determine viability after a couple of minutes in the acetocarmine medium. Cover slip was then gently placed over the stained pollens to avoid production of air bubbles. The slide was visualized under a light microscope with 10x magnification.

3.5.2 Stigma receptivity test:-

Hydrogen peroxide (peroxide water) assay was used for stigma receptivity test. In tests based on staining the stigma with hydrogen peroxide (peroxide water), it is assumed that the rate of bubble production from the stigmatic surface in hydrogen peroxide is directly related to the level of stigma receptivity. Therefore, if the peroxides enzyme is present, many oxygen bubbles will be released by the chemical reaction of the peroxide with the enzyme. The grading scale of 1–5 was developed to

rank receptivity, so that 1 = no bubble production while 5 = very rapid bubble production.

3.5.3 Pollen germination test:-

Pollen germination was tested using 7% sucrose solution. A drop of sucrose solution was applied over coverslip and pollen was sheded over the drop and was kept for 45 min for 30 min. The pollen grain showing emergence of pollen tube. The emerged pollen tube were recorded as germinated. The observation was recorded using binocular microscope with 5X and 10X magnification.

3.5.4 Drying method :-

Drying of the leaves sample was done for preserving the herbage yield and to fetch good market price. For this three method of dying was done viz; sun drying, shade drying and oven drying.

3.6 Statistical Analysis

3.6.1 Analysis of variance

The data obtained from the individual plant observations from randomizied block design experiment were analyzed statistically as per the procedure given by Cochran and Cox (1957).

Table 3.4 The skeleton of variances for Randomized Complete Block Design (RCBD)

Source	**D..f**	**SS**	**Value**
Replication	(r-1)(t-1)	SSR	SR/MSE
Genotype	r-1)(t-1)	SST	ST/MSE
Error		SSE	
Total	t-1	TSS	

Where,

r = Number of replication. t = number of genotype.

To test the significance of treatment, the calculated value of 'F' was compared with tabular value of 'F' at 5 and 1 per cent levels of probability against error degree of freedom, *i.e.*(r-1)(t-1)

3.6.2 Estimation of genetic parameter of variation

1) Mean

Mean of the character was estimated by summing up of all the observation and dividing the sum by the number of observation.

$\overline{X} = \sum Xi/n$

Where, $\sum Xi$ = Summation of all the observation

n = Number of observation

2) Range

Rang is the differences between the least and the greatest terms of a series of observation and thus provides the information about the variability present in the genotype.

Range=Highest value-Lowest value

3**) Estimation of coefficients of variation**

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated by the method suggested by Burton (1952).

Phenotypic coefficient of variation (PCV)

$$\% \quad \sigma^{2}g \quad 100$$

$$PCV\ \% = \frac{\sqrt{\sigma 2P}}{X} \quad 100$$

Where,

σ^2_p = Phenotypic variance

σ_p = Phenotypic standard deviation

σ^2_g = Genotypic variance

σ_g = Genotypic standard deviation

σ^2_e = Environment variance

$\overline{X}$ = General Mean

The estimates of PCV and GCV were classified as low, moderate and high according to Sivasubramanian and Madhavamenon (1973).

< 10 per cent = Low

10 – 20 per cent = Moderate

> 20 per cent = High

4) Genetic advance

Improvement in the mean genotypic value of selected plants over the parental population is known as genetic advance. The expected advance was calculated by the formula given by Johnson *et al*.(1955) as described below.

$GA = K.h^2.\sigma_p$

Where,

GA = Genetic advance

K = Constant (Standardized selection differential) having value of 2.06 at 5% level of selection intensity.

h^2 = Heritability of the character

$\sqrt{\sigma_p}$ = Phenotypic Standard deviation

The genetic advance as percentage of mean was estimated as per the below formula

h^2 = Heritability

$\sqrt{\sigma_p}$ = Phenotypic standard deviation

The genetic advance as percentage of mean was estimated as per the below formula

$$\text{Genetic advance as percent of mean} \quad \frac{\text{Genetic advance}}{\text{General mean}} \text{ X } 100$$

Range	Category
> 20 percent	High
10-20 percent	Moderate
<10 percent	Low

The magnitude of genetic advance as percent of mean was categorized as high (> 30%), moderate (30%- 10%) and low (<10%)

6) Estimation of heritability

Heritability in broad sense (h^2bs) defined as the proportion of the genotypic variance to the total variance to the total variance (phenotypic) was calculated as per the formula suggested by Burton (1956)

$$h^2 (bs)\% = \frac{\sigma^2 g}{\sigma^2 p} \text{ x } 100$$

where,

h^2 (bs) = Heritability in broad sense

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

The broad sense heritability estimates were classified as low (<50%), moderate (50-70%) and high (>70%) as suggested by Robinson(1966).

3.6.3 Estimation of correlation coefficient

Correlation coefficient analysis measures the mutual relationship between various characters at genotypic (g), phenotypic (p) and environmental levels with the help of formula suggested by Miller *et al*. (1958).

1. Genotypic correlation coefficient character x and y

$$r_{xy\,(g)} = Cov_{xy(g)} / \sqrt{var_{x(g)} \times var_{y(g)}}$$

2. Phenotypic correlation coefficient between character x and y

$$r_{xy(p)} = Cov_{xy(p)} / \sqrt{var_{x(p)} x var_{y(p)}}$$

Where,

$r_{xy(g)}$ = Genotypic correlation coefficient between x and y

$r_{xy(p)}$ = Phenotypic correlation coefficient between x and y

$Cov_{xy(p)}$ = Genotypic covariance between x and y

$Cov_{xy\,(p)}$ = Phenotypic covariance between x and y

$Var_{x(g)}$ = Genotypic variance of x

$Var_{x(p)}$ = Phenotypic variance of x

$Var_{y(p)}$ = Genotypic variance of y

$Var_{y(p)}$ = Phenotypic variances of y

Significance of correlation:

Phenotypic correlation coefficient were tested for their significance following 't' test at n-2 degree of freedom.

$$t_c = r\sqrt{n-2/1-r^2}$$

If 't' calculated (t_c) is ≥ 't' tabulated (t_T) at (n-2) degree of freedom at given probability level, the coefficient of correlation is considered as significant.

3.6.4 Path coefficient analysis

Path analysis was originally developed by Wright (1921) and elaborated by Dewey and Lu (1959). Path coefficient analysis splits the genotypic correlation coefficient into measure of direct and indirect effects. It measures the direct and indirect contribution of independent variables on dependent variable.

The result of path coefficient analysis is interpreted as per the following scale suggested by Lenka and Mishra (1973).

Table.3.5 Scale for path analysis

Value of direct and indirect effects	**Rate/ Scale**
0.00 to 0.09	Negligible
0.10 to 0.19	Low
0.20 to 0.29	Moderate
0.30 to 0.99	High
> 1.00	Very High

3.6.5 Genetic divergence analysis

The D2 statistic was originally developed by Mahalanobis in 1928. Rao, (1952) suggested the application of this technique for the assessment of genetic divergence in plant breeding. The varieties were grouped into a number of clusters as per the standard procedure described By Spark (1973).

Results and Discussion

CHAPTER-IV

RESULTS AND DISCUSSION

Genetic variability is a pre-requisite for breeding programmes and the information on heritability, path and genetic divergence focus on the specific breeding programmes. The results obtained in the present investigation on "Study of variability parameter in Kalmegh (*Andrographis paniculata* Wall.)" are discussed here under following heads:

SET-I

4.1 Mean performance of genotype and Analysis of variance

4.2 Estimation of genetic variability

4.3 Genetic divergence analysis

4.4 Association analysis

4.4.1Correlation coefficient analysis

4.4.2 Path coefficient analysis

4.5 Reproductive behavior in kalmegh

4.6. Assessment of processing

SET-II

4.7. Variability in traits of the collected genotypes from different location.

4.8. Range of yield from different location.

4.9. Genetic divergence analysis.

4.1 Analysis of variance and mean performance of set-I

The average performances of the 24 Kalmegh genotype are shown in the table 4.1. Analysis of variance worked out for fresh herbage yield and its attributing traits along with quality characters indicated that the mean sum of squares due to genotypes were highly significant for all the characters *viz.*, days to 50% flowering plant^{-1}, plant

Table 4.1: Analysis of variance for fresh herbage yield and its components in kalmegh

Source of variation	DF	Days to 50% flowering	Plant height (cm)	No. of secondary branches plant^{-1}	No. tertiary branches plant^{-1}	Internode length (cm)	Pod length (cm)	Seed no pod^{-1}	Leaf length (cm)	Leaf width (cm)	Chlorophyll content	Petiole length (cm)	Canopy temperature	Collar girth (cm)	Fresh herbage yield (g)	Dry herbage yield (g)
Replication	1	15.1	58.29	3	0.015	0.008	0.025	2.08	0.42	0.003	80.3	0.003	0.13	0.13	4.68	9.01
Treatment	23	156.4**	184.9**	27.33**	2048**	0.305	0.046	0.44	0.72	0.31**	15.9	0.037*	0.13	0.13**	77.4**	19.4**
Error	23	8.97	1.22	6.17	12.15	0.417	0.031	0.38	0.46	0.06	8.4	0.014	0.008	0.008	1.05	0.47

DF = degree of freedom

*= Significant at 5% probability level

** = Significant at 1% probability level

Table 4.2 Estimation of genetic parameter for different traits in kalmegh

Character	Mean	Range		GCV (%)	PCV (%)	h_2 (%)	Genetic advance	GA as % of mean
		Min.	Max.					
Days to 50% flowering	153.18	122.00	167.50	5.61	5.94	89.1	16.70	10.90
Plant height (cm)	57.30	43.70	72.50	16.19	17.30	87.5	17.90	31.23
Number of secondary branches	26.08	20.00	32.50	12.47	15.69	63.1	5.32	20.39
Number of tertiary branches	64.18	31.00	159.50	49.72	50.10	98.8	65.35	99.82
Internode length (cm)	3.46	2.60	4.25	0.91	18.69	00.2	0.04	0.09
Pod length (cm)	2.32	2.05	2.70	3.70	8.47	19.1	0.08	3.44
Seed number/pod	10.87	10.50	11.50	1.57	5.94	07.0	0.09	0.82
Leaf length (cm)	8.15	7.10	9.15	4.43	9.43	22.1	0.35	4.29
Leaf width (cm)	2.30	1.75	2.65	15.33	18.66	67.5	0.60	26.08
Chlorophyll content	37.54	32.30	43.45	5.18	9.30	31.0	2.23	5.94
Petiole length (cm)	0.91	0.70	1.15	11.60	17.62	43.4	0.14	73.68
Canopy temperature	30.65	29.00	31.75	0.10	4.33	00.1	0.02	0.08
Collar girth (cm)	1.63	1.35	2.30	15.22	16.23	88.0	0.48	29.44
Fresh herbage yield (g)	16.92	8.15	30.50	36.51	37.01	97.3	12.56	77.53
Dry herbage yield (g)	6.87	3.05	13.60	44.87	45.96	95.3	6.20	90.24

height plant^{-1} (cm), number of secondary branches plant^{-1}, number of tertiary branches plant $^{-1}$, leaf width plant^{-1} (cm), petiol length plant^{-1} (cm), collar girth plant^{-1} (cm), fresh herbage yield of leaf plant^{-1} (g), dry herbage yield of leaf plant^{-1} (g). Whereas, characters internode length plant^{-1} (cm), pod length plant^{-1} (cm), number of seed pod^{-1}, leaf length plant^{-1} (cm), chlorophyll content plant^{-1}, canopy temperature plant^{-1}. Significant mean squares due to herbage yield and attributing characters revealed existence of considerable variability in the material studied for the improvement of various traits and better chances of improvement through selection on the basis of these traits.

4.2 Estimation of genetic variability

Genetic parameters of variation are presented in table 4.2 for all the characters. The overall mean and rang for fresh herbage yield and its components revealed that there are sustainable genetic variability present for most of the characters among the germplasm accession under study. Genetic parameters of variation are discussed character wise.

4.2.1 Character mean and range

4.2.1.1 Days to 50% flowering

Days to 50% flowering ranged from 122 to 161 days with a mean value of 153days. The genotype IKM-15 (167days) recorded as the late flowering accession and IKM-13 (122 days) was as early in flowering accession.

4.2.1.2 Plant height (cm)

The plant height ranged from 43.7 to 72.5 cm with an average plant height 57.3 cm. Among all accession, IKM-18 (72.5 cm) was recorded as tallest and IKM- 5 (43.7) was recorded as the dwarf most genotype.

4.2.1.3 Number of secondary branches / plant

The number of secondary branches per plant ranged between 20 to 32 branches with an average of 26 branches. The maximum number of branches per plant was recorded in IKM -9 (32 branches). Whereas, the lowest number of branches per plant was recorded in IKM-11 (20 branches).

4.2.1.4 Number of tertiary branches

The number of tertiary branches per plant ranged between 31 to 159 branches with an average of 64 branches. The maximum number of branches per plant was recorded in IKM-1 (159 branches). Whereas, the lowest number of branches per plant was recorded in IKM – 16 and IKM -19 (31 branches).

4.2. 1.5 Internode length (cm)

The internode length of plant ranged between 3.1 to 4.2 cm with mean internode length of 3.4 cm. The maximum internode length of plant was recorded in IKM-2 (4.2cm). Whereas, the minimum internode length was recorded in IKM-8 (3.1 cm).

4.2.1.6 Pod length (cm)

The length of pod for accession under study was ranged from 2.0 to 2.7 cm with mean pod length of 2.3 cm. The genotype IKM-24 (2.7 cm) recorded with maximum pod length and IKM- 1 (2.0 cm) with minimum pod length.

4.2. 1.7 Number of seed per pod

The average number of seed/ pod was 10 ranging from 10 to 11 seed/pod. Some accession *viz.* IKM-3, IKM-5, IKM-6, IKM-7, IKM-8, IKM-11(c) , IKM-14, IKM-15, IKM- 16, IKM-18, IKM-19, IKM-20, IKM-21, IKM-22 and IKM- 23 were having maximum number of seed / pod and most of the accession *viz.* IKM-1, IKM-2, IKM-4, IKM-9, IKM-10, IKM-11, IKM-12, IKM-13 and IKM-24 had lowest number of seed/pod.

4.2.1.8 Leaf length (cm)

The length of leaf for accession ranged from 7.10 to 9.15 cm with mean leaf length of 8.1 cm. The accession IKM-24 (9.15 cm) recorded with maximum leaf length and IKM- 6 (7.10 cm) with minimum leaf length.

4.2.1.9 Leaf width (cm)

The width of leaf for the accession ranged from 1.75 to 3.2 cm with mean leaf width of 2.3 cm. The accession IKM-14 (3.30 cm) recorded with maximum leaf width and IKM-12 and IKM-18 (1.75 cm) with minimum leaf width.

4.2.1.10 Chlorophyll content in leaf

The chlorophyll content in leaf for the accession ranged from 32.3 to 43.4 with mean value of chlorophyll content in leaf of 37.5. The accession IKM-23 (43.4) recorded with highest chlorophyll content and IKM-15 (32.3) with lowest chlorophyll content.

4.2.1.11 Petiole length (cm)

The petiole length for the accession ranged from 0.70 to 1.15 cm with mean petiole length of 0.91 cm. The accession IKM- 2, IKM- 13 (1.15 cm) recorded with highest petiole length and IKM- 6 (0.70 cm) lowest petiole length.

4.2.1.12 Canopy temperature

The canopy temperature for the accession ranged from 29.0 to 32.2 with mean canopy temperature 30.6. The accession IKM-15 (32.2) recorded with maximum canopy temperature and IKM- 21 (29.0) with minimum canopy temperature.

4.2.1.13 Collar girth (cm)

The collar girth for the accession ranged from 1.35 to 2.30 cm with mean collar girth of 1.63 cm. The accession IKM-1 (2.30 cm) recorded with maximum collar girth and IKM-10, IKM-12 (1.35 cm) with minimum collar girth.

4.2.1.14 Fresh herbage yield (g)

The fresh herbage yield for accession ranged from 8.15 to 30.50 g with mean fresh herbage yield of 16.92 g. The accession IKM- 1, IKM-7 (30.50 g) recorded with maximum fresh herbage yield of leaf and IKM - 10 (8.15 g) with minimum fresh herbage yield of leaf.

4.2.1.15 Dry herbage yield (g)

The dry herbage yield of leaf for accession ranged from 3.05 to 13.60 g with mean dry herbage yield 6.87 g. The accession IKM- 1 (13.06 g) recorded with maximum dry herbage yield of leaf and IKM – 10 (3.05 g) with minimum dry herbage yield of leaf.

4.2.2 Genotypic and phenotypic coefficient of variation

Genotypic and phenotypic coefficient of variation are simple measure of variability, these measures are commonly used for the assessment of variability. The relative value of these type of coefficients gives an idea about the magnitude of variability present in a genetic population. Thus, the component of variation such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed. The phenotypic coefficient of variation were marginally higher than the corresponding genotypic coefficient of variation indicated the influence of environment in the expression of the character under study.

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are categorized as low (less than 10%), Moderate (10-20%) and high (more than 20%) as suggested by Sivasubramanian and Madhavamenon (1973).

Among the different herbage yield attributing traits, number of tertiary branches per plant had highest magnitude of GCV (49.72%) and PCV (50.01%). The high magnitude of GCV (44.87%) and GCV (45.96%) was observed for dry herbage

yield per plant followed by fresh herbage yield (36.51% to 37.01%) which is indicative of the genetic variability exists in Kalmeh accession.

The moderate GCV and PCV were observed for plant height (16.19% and 17.30), secondary branches (21.47% and15.69%), chlorophyll content (15.33% and 18.66 %), canopy temperature (11.60% and 17.62%) and collar girth (15.22% and 16.23%).

The low GCV and PCV were observed for number of days to 50% flowering (5.61% and 5.94%), internode length (0.91% and 18.69%), pod length (3.70% and 8.47%), seed no/pod (1.57% and 5.94%), leaf length (4.43% and 9.43%), chlorophyll content (5.18% and 9.30%) and canopy temperature (0.10% and 4.33%).

Similar finding were also reported earlier by Patel and Patel (1998), Venge and Egbe Moses (2009), Mahamad *et al*. (2006), Basavarajaiah *et al*. (2000), Singh (1999), Pansuriya *et al*. (1998), Holker *et al.* (1991), Shoram and Shoram (1985), Bhadru (2010) and Saxena and Kataria(1993).

4.2.3 Heritibility and genetic advance

Heritability governs the resemblance between parents and their progeny whereas, the genetic advance provide the knowledge about expected gain for a particular character after selection. Heritability suggest the relative role of genetic factors in expression of phenotypes and also act as an index of transmissibility of a particular trait to its off springs. However, the knowledge of heritability alone does not help to formulating concrete breeding programme, genetic advance along with heritability help to ascertain the possible genetic control for any particular trait. The nature and extent of the inherent ability of a genotype for a character is an important parameter determining the extent of improvement of any crop species. Heritability and genetic advance are the important genetic parameters for selecting a genotype that

permit greater effectiveness of selection by separating out environmental influence from total variability.

Heritability estimate provide the information regarding the amount of transmissible genetic variation to total variation and determine genetic improvement and response to selection. Heritability estimate along genetic advance are normally more useful in predicting the gain under selection than that of heritability alone. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance (Johnson *et al*. 1955). An attempt has been made in the present investigation to estimate heritability in broad sense and categorized as low (< 50%), moderate (70%) and high (> 70%) as suggested by Robinson (1966).

In the present investigation high magnitude of heritability was recorded for most of characters. The highest heritability was recorded for the character number of tertiary branches per plant (98.8%), fresh herbage yield (97.3%), dry herbage yield (95.3%), days to 50% flowering (89.1%), collar girth (88.0%), plant height (87.5%), leaf width (67.5%), number of secondary branches (63.1%), petiole length (43.4%), Chlorophyll content(31.0%), leaf length (22.1%), pod length (19.1%), seed number/pod (07.0%), internodes length (02.0%) and canopy temperature (01.0%). It indicates that these character is least influenced by the environment or therefore selection of such characters will be rewarded.

The heritability value alone however, provides no indication of the amount of genetic improvement that would that result from selection of superior genotypes. The heritability estimates would be reliable if it is limited in broad sense, additive and non additive gene effect are accompanied with high genetic advance. To facilitate the comparison of progress in various characters of different genotypes genetic advance was calculated as percentage of mean.

The magnitude of genetic advance as percentage of mean easy categorized as high (> 30%), moderate (30% - 10%) and low (< 10%). Genetic advance as percentage of mean was observed high for number of tertiary branches per plant (99.82%) followed by dry herbage yield/ plant (90.24%), fresh herbage yield/plant (77.53%), petiole length (73.68%), plant height/plant (31.23%). It showed that the character is governed by addititive gene and selection will be rewarded for the improvement of such characters.

Genetic advance as percentage mean was recorded as moderate for collar girth/plant (29.44%), leaf width (26.08%), number of secondary branches/ plant (20.39%), Days to 50% flowering (10.90%), and it was low for chlorophyll content (5.94%), leaf length (4.29%), pod length/ plant (3.44%), seed number/pod (0.82%), plant height/plant (87.55) (31.23%). It indicate that these character governed by non additive gene and heterosis breeding may be useful.

High heritability coupled with high genetic advance as percentage of mean was found in the character number of tertiary branches/ plant (98.8%) (99.82%) followed by dry herbage yield /plant (95.3%) (90.24%) and fresh herbage yield (97.3%) (77.53%), plant height /plant (87.5%) (31.23%). It indicates that most likely the h_2 is due to additive gene effect or selection of such character may be effective. Moderate heritability coupled with moderate genetic advance as percentage mean was found in character number of secondary branches (63.1%) (20.29%) followed by leaf width (67.5%) (26.08%). It indicates the existence of additive as well as non additive gene action for the characters. Low heritability coupled with low genetic advance as percentage of mean was found in the character pod length/plant (19.1%) (3.44%), seed number/pod (07.0%) (0.82%), leaf length/plant (22.1%) (4.29%), chlorophyll content (31.0%) (5.94%). It indicates selection of such character is not useful. Days to

Table 4.3 Genotypes of 24 kalmegh included in different clusters

Cluster number	Number of genotype included	Number of genotypes
I	7	IKM-10, IKM-11, IKM-12, IKM-13, IKM-17, IKM-18, IKM-19
II	6	IKM-3, IKM-4, IKM-5, IKM-9, IKM-21, IKM-24
III	4	IKM-8, IKM-14, IKM-15, IKM-16
IV	2	IKM-1, IKM-2
V	5	IKM-6, IKM-7, IKM-20, IKM-22, IKM-23

50% flowering showed high heritability (89.1%) value but moderate genetic advance as percent of mean (10.90%), collar girth showed highly heritability (88.0%) value but moderate genetic advance percent of mean (29.44%), petiole length showed moderate heritability (43.4%) value but high genetic advance as percent mean (73.68%).

4.3 Genetic divergence

The choice of genetically diverse parents for hybridization is an important feature of any crop improvement programme for getting desirable segregant. The multivariate analysis based on Mahalanobis D^2or non- hierarchical Euclidean cluster analysis is used for divergence analysis. The D^2 analysis classifies the genotype into relatively homogeneous groups in such a way that within cluster diversity is minimized and between clusters diversity is maximized. The respective genotypes from divers cluster can be utilized in breeding programme depending upon breeding objectives. The results of earlier studied are relevant only for the material and environmental involved in a particular study and cannot be generalized. Therefore, study on genetic divergence on the available germplasm under the environment where it is to be exploited is essential for successful utilization of available resources.

Genetic diversity is an important factor and also a prerequisite in any hybridization programme. Multivariate analysis by mean of Mahalanobis D^2 statistic is a powerful tool in quantifying the degree of divergence at genotypic level. Vavilov (1926) was the first to emphasize the need for a really broad genetic base for crop improvement. A set of 24 genotypes of Kalmegh were subjected to D^2 analysis for 15 characters based on D^2 values five cluster were formed (Table 4.3). This indicated that substantial diversity existed in the all the genotypes evaluated in the present study. This is an agreement with earlier reports indicating substantial diversity in Kalmegh

Table 4.4 Average intra-cluster (diagonal bold) and intre cluster distance (D values) among the 5 cluster in Kalmegh

Cluster	I	II	III	IV	V
I	**2.833**	3.544	3.601	5.933	3.526
II		**2.952**	4.154	5.219	3.229
III			**2.353**	6.394	3.688
IV				**2.037**	5.545
V					**2.659**

Fig. 4.1 : Average intra-cluster and intre cluster distance (D values) among the 5 cluster in Kalmegh

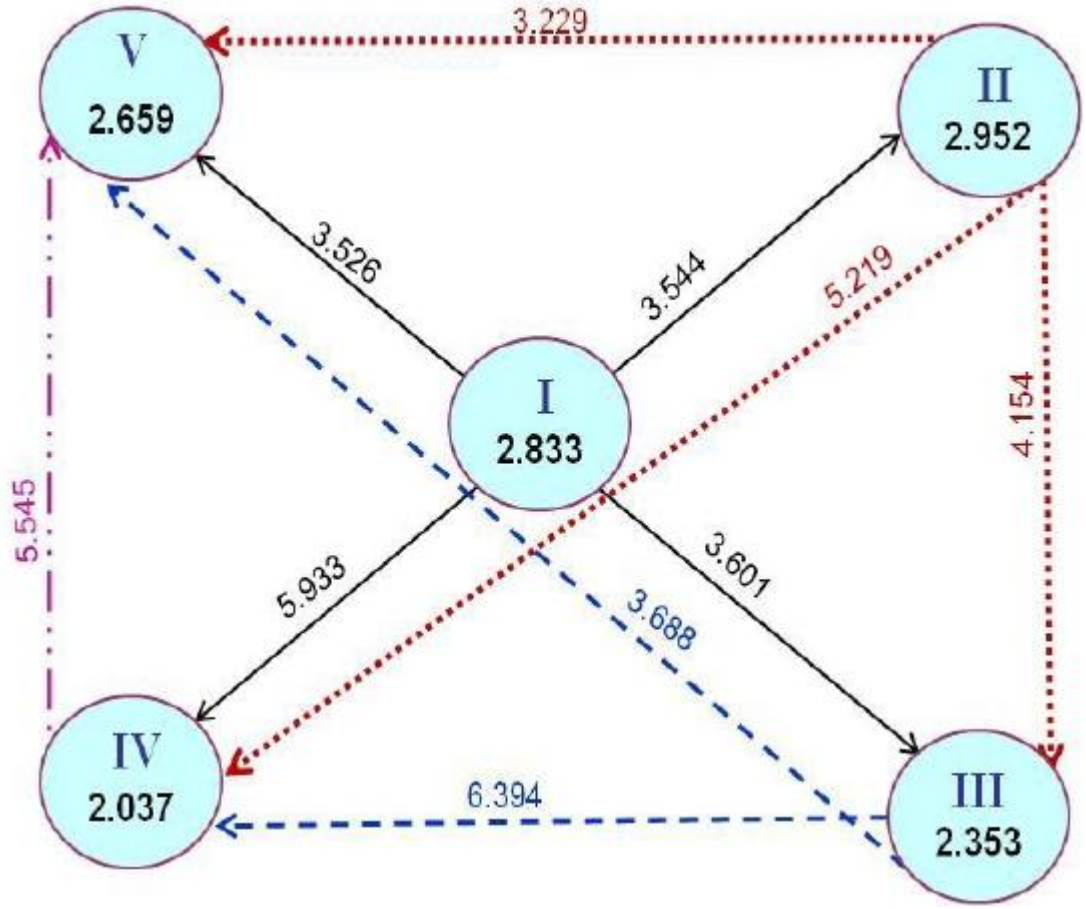

Table 4.5 Mean performance of genotype in individual cluster for different yield traits

Cluster	Character															
	Entries	Days to 50 % flowering	Plant height (cm)	No. secondary branches	No. of tertiary branches	Internode length(cm)	Pod length(cm)	Seed no. pod^{-1}	Leaf length(cm)	Leaf width(cm)	Chlorophyll content	Petiole length (cm)	Canopy temperature	girth Collar	Dry Fresh herbage yield(g)	herbage yield(g)
I	7	150.21	47.93	24	48.14	3.51	2.24	10.71	7.85	2.01	36.31	0.97	30.75	1.56	4.59	13.05
II	6	151.92	65.74	26.42	61.67	3.51	2.52	10.58	8.63	2.33	39.17	0.94	30.09	1.7	6.83	16.03
III	4	160.88	81.71	26.75	74.12	3.12	2.29	11.25	8.26	2.95	35.34	0.87	31.58	1.61	5.4	13.62
IV	2	149	66.57	29.5	131.25	4.2	2.12	10.5	7.9	2.33	38.33	1.03	30.45	2.25	12.27	25.85
V	5	154.4	61.44	26.7	54.9	3.3	2.31	11.3	8.1	2.17	38.76	0.78	30.56	1.44	9.14	22.51

4.6 Desirable genotype based on cluster performance

Character	Cluster				
	I	II	III	IV	V
Days to 50 % flowering	IKM-18, IKM-19	IKM-24	IKM-16	IKM-1	IKM-20
Plant height (cm)	IKM-19	IKM-5	IKM-14	IKM-2	IKM-23
No. secondary branches	IKM-17	IKM-9	IKM-14	IKM-1	IKM-6
No. of tertiary branches	IKM-18	IKM-21	IKM-14	IKM-1	IKM-22
Internode length(cm)	IKM-13	IKM-5	IKM-14	IKM-2	IKM-22
Pod length(cm)	IKM-10, IKM-11	IKM-5, IKM21	IKM-8	IKM-2	IKM-6
Seed no. pod^{-1}	IKM-18	IKM-3,IKM-5,IKM21	IKM-8,IKM-15	IKM-1,IKM2	IKM-6, IKM-7, IKM-20
Leaf length(cm)	IKM-19	IKM-21	IKM-8	IKM-2	IKM-20
Leaf width(cm)	IKM-13	IKM-9	IKM-14	IKM-1	IKM-7,20
Chlorophyll content	IKM-10	IKM-9	IKM-14	IKM-2	IKM-23
Petiole length (cm)	IKM-13	IKM-5	IKM-8,14,15,16	IKM-2	IKM-7,20,22,23
Canopy temperature	IKM-18	IKM-3,IKM-9	IKM-15	IKM-1	IKM-7
Collar girth	IKM-17	IKM-5	IKM-14	IKM-1	IKM-22
Fresh herbage yield (g)	IKM-13	IKM-24	IKM-15	IKM-1	IKM-7
Dry herbage yield(g)	IKM-12	IKM-21	IKM-15	IKM-1	IKM-7

materials. This present study also suggests that, there is no relationship between geographical and genetic diversity as genotype chosen from different eco-geographical regions are grouped in different clusters. The cluster I were the largest which consisted of 7 genotypes, followed by cluster II , V and III (6 ,5 and 4 genotypes respectively) and cluster IV (2 genotypes). From the clustering pattern, it was found that the genotypes from different region were independent of their genetic origin. Hence the genotype studied are reliable enough for hybridization and selection.

The inter and intra cluster distance among the five cluster are presented in table 4.4 and fig 4.1. The maximum inter cluster distance was observed in between cluster III and IV (6.394) followed by cluster IV and V (5.545). This suggested that the hybridization programme involving parents from these cluster is expected to give higher frequency of better segregates or desirable combination for development of useful genetic stocks or varieties. The minimum inter cluster distance was observed in between II and IV (3.229) followed by cluster I and IV (3.526) and cluster I and II (3.544) indicating minimum diversity (differences) for the genes under study.

The maximum intra cluster distance was observed in cluster II (6.952) followed by cluster I (2.833), cluster V (2.659), cluster III (2.353) and cluster IV (2.037).

4.3.1 Cluster mean

The mean values for different character were compared across the cluster and are presented in Table 4.5. Cluster IV having maximum intra cluster distance (divergence) had the highest fresh herbage yield plant $^{-1}$ 25.85 g followed by cluster V (22.51), cluster II (16.03) , cluster III (13.62), and cluster I (13.05).

Overall observation of cluster means indicate that cluster IV having maximum traits and high cluster mean value number of secondary branches plant^{-1} (29.50), number of tertiary branches plant^{-1} (131.25), internode length plant^{-1} (4.20), petiole length plant^{-1} (1.03), collar girth plant^{-1} (2.25), dry herbage yield plant^{-1} (12.27) and fresh herbage yield plant^{-1}(25.85). Cluster III shown higher cluster mean values for days to 50% flowering (160.88), plant height plant^{-1} (81.71), seed no pod^{-1} (11.25), leaf width plant^{-1}(2.95) and canopy (31.58). Cluster IV shown higher cluster mean values for chlorophyll content (38.76). Cluster II shown higher cluster mean values for leaf length plant^{-1} (8.63) and pod length plant^{-1} (2.52).

The above finding clearly showing the wide variation one cluster to another in respect of cluster mean, which indicated that genotypes performance for various character, were separated into different cluster. The five clusters in the aforesaid genetic divergence analysis contained frequently the genotype of heterogeneous origin. Although the genotypes originated in some place or geographic region were also found to be grouped together in some cluster, the instances of grouping of genotypes of different origin or geographic region in same cluster were observed in case of all the five cluster. This suggests lacks of parallelism between genetic and geographic diversity. Therefore, the selection of parental material for hybridization programme, simply based on geographic diversity may not be a successful exercise. The choice of suitable parents based on genetic divergence analysis would be more rewarding than the choice on the basis of geographic diversity advocating lack of definite relationship between genetic and geographic diversity in Kalmegh. Hence, this study suggests that there is a lot of scope for harnessing genetic diversity existing in the improvement of Kalmegh in crop improvement in future.

Results indicated that, the genotypes from most distant clusters may be utilized as parents in crossing programme to isolate desirable segregant for fresh herbage yield plant^{-1}. In present study 24 genotypes shown considerable divergence among the genotypes for different characters. Based on the result obtained from the present study, it is concluded that the mean values of cluster for different character and per se performance of the genotypes grouped in respective cluster could be selected (Table 4.6) for a viable hybridization programme for improving a particular character.

The pattern of distribution of Kalmegh genotypes in various clusters revealed existence of considerable diversity present in the material (Table 4.6). The highest intra cluster distance was observed for cluster II. Hence, genotypes belonging to this cluster *viz.,*IKM-3, IKM-4, IKM-5, IKM-9, IKM-21, IKM-24 may be utilized as parent in future breeding programme with the genotype belonging to cluster I *i.e.,* IKM-10, IKM-11, IKM-12, IKM-13, IKM-17, IKM-18 and IKM-24 as the maximum inter cluster distance was noted between the cluster III and IV. This suggested that the hybridization programme involving parents from these cluster is expected to give higher frequency of better segregats or desirable combination for development useful genetic stocks pipelines or varieties for Chhattisgarh plains.

4.4 Association analysis

4.4.1 Estimation of correlation coefficient

Association analysis is an important approach in breeding program. It gives an idea about relationship among the various characters and determines the component characters, on which selection can be based for genetic improvement in herbage yield. Degree of association also affects the effectiveness of selection process. The degree of association between independent and dependent variables was

TABLE 4.7 Phenotypic (P), Genotypic (G), and Environmental (E) correlation coefficients among different yield traits in Kalmegh (*Andrographis paniculata)*

Characters		Plant height (cm.)	No. of secondary branches plant-1	Number of tertiary branches plant-1	Internode length (cm)	Pod length (cm)	Seed number pod-1	Leaf length (cm)	Leaf width (cm)	Chlorophyll content	Petiole length (cm)	Canopy Temperature	Collar girth(cm)	Dry herbage yield(g)	Fresh herbage yield(g)
Days to 50% flowering	P	-0.036	0.027	-0.065	-0.276	0.067	0.243	0.246	0.079	-0.317	-0.313	0.044	-0.062	0.139	0.060
	G	-0.077	0.066	-0.068	-0.036	0.037	0.804**	0.363	0.100	-0.445*	-0.444*	0.807**	-0.094	0.127	0.047
	E	0.274	-0.110	-0.023	-0.274	0.174	-0.020	0.292	0.010	-0.305	-0.147	0.078	0.182	0.303	0.290
Plant height (cm.)	P		0.393	0.339	0.194	0.175	-0.096	0.271	0.043	0.418*	0.095	-0.188	0.390*	0.410*	0.347
	G		0.511**	0.365	0.634**	0.640**	-0.030	0.478*	0.083	0.864**	0.157	- 0.695**	0.390*	0.472*	0.411*
	E		0.061	-0.030	0.209	-0.273	-0.064	0.197	-0.100	-0.111	-0.006	0.446*	0.388*	-0.274	-0.345
Number of secondary branches plant -1	P			0.670**	0.046	-0.018	-0.041	0.077	0.292	0.140	0.114	0.049	0.327*	0.342	0.261
	G			0.821**	0.620**	-0.203	-0.196	-0.279	0.252	0.675**	0.129	-0.051	0.260	0.475*	0.371
	E			0.335	0.036	0.096	0.000	0.338	0.367	-0.315	0.101	0.177	0.632**	-0.203	-0.296
Number of tertiary branches plant -1	P				0.290	-0.261	-0.162	-0.010	0.287	0.158	0.134	0.098	0.605**	0.347	0.290
	G				0.505**	-0.537**	-0.663**	-0.085	0.353	0.284	0.170	0.768**	0.647**	0.361	0.298
	E				0.409*	-0.280	0.116	0.315	-0.020	0.005	0.269	0.078	0.047	-0.153	-0.138
Internode length(cm)	P					-0.187	-0.219	0.094	-0.152	0.131	0.424*	0.102	0.399	0.223	0.228
	G					-0.515**	-0.618**	-1.000	0.862**	2.546**	4.098**	-0.914**	0.559**	0.763**	0.579**
	E					-0.124	-0.061	0.152	-0.328	0.074	0.388	0.204	0.032	-0.019	-0.195
Pod length (cm)	P						0.036	0.269	0.064	0.122	-0.230	-0.213	-0.107	0.067	-0.028
	G						-0.792**	0.340	-0.385	0.785**	0.088	-0.714**	-0.185	0.050	-0.234
	E						0.146	0.251	0.395	-0.093	-0.377	-0.054	-0.099	0.234	0.497*
Seed number pod-1	P							-0.111	0.065	-0.227	-0.113	0.400	-0.268	0.043	0.127
	G							0.501**	0.241	-0.519**	-0.975**	-0.504**	- 0.855**	0.198	0.473*
	E							-0.349	0.024	0.123	0.077	0.509**	-0.168	-0.039	0.022
Leaf length (cm)	P								0.191	-0.171	0.078	-0.193	0.087	-0.061	-0.044
	G								0.053	0.782**	0.035	0.819**	-0.086	-0.025	-0.045
	E								0.340	-0.313	0.102	-0.255	0.408*	-0.256	-0.160

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Leaf width (cm)	P									0.166	-0.084	0.246	0.136	-0.032	0.015
	G									0.265	0.057	0.801**	0.097	0.006	0.030
	E									-0.094	-0.268	-0.111	0.309	-0.296	-0.100
Chlorophyll content	P										-0.163	-0.167	0.065	0.163	0.068
	G										0.136	-0.822**	0.383	0.285	0.070
	E										-0.340	0.201	-0.468*	0.043	0.222
Petiole length (cm)	P											0.027	0.300	-0.075	-0.071
	G											-0.649**	0.435*	-0.108	-0.062
	E											0.092	0.120	-0.032	-0.256
Canopy Temperatu re	P												0.039	-0.090	-0.010
	G												-0.245	-0.989**	-0.274
	E												0.128	0.012	-0.020
Collar girth(cm)	P													0.428*	0.337
	G													0.499*	0.396
	E													-0.377	-0.519**
Dry herbage yield(g)	P														0.932**
	G														0.942**
	E														0.639**

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

1)Plant height (cm) 2) No. of secondary branches 3) Number of tertiary branches plant $^{-1}$ 4) Internode length (cm)
5) Pod length (cm) 6) Seed number pod^{-1} 7) Leaf length (cm) 8) Leaf width (cm)
9) Chlorophyll content 10) Petiole length 11)Canopy temprature 12) Collar girth (cm)
13)Dry herbage yield(g) 14) Fresh herbage yield(g)

suggested by Galton 1888, its theory was developed by Pearson (1904) and their mathematical utilization at phenotypic and genotypic and environmental levels was described by Searle (1961).

The correlation coefficients analysis is the index of association between two variables. These have been dealt in all possible combination for important characters at phenotypic, genotypic and environmental level and are presented in Table 4.7.

Correlation analysis clearly revealed that the phenotypic and genotypic correlations in general are similar in direction but the magnitude of genotypic correlation was higher than the phenotypic correlations. The low phenotypic results due to masking influence and modifying effect of the environment on the association of character. Pandey and Gritton (1975) have pointed out that no suitable test of significance of genetic correlation is available. Therefore, their primary utility is in strengthening interpretation based on phenotypic correlation and in better predicting correlated responses to selection. Hence, important finding based on phenotypic correlation are discussed here.

4.4.1.1 Correlation of attributing characters with herbage yield

Knowledge about interrelationship between yield and its contributing characters facilitates the choice of efficient breeding method to be adopted. To estimated the association between two characters, correlation coefficient at phenotypic genotypic and environmental levels were worked out in all possible combinations among yield components.

In the present study genotypic correlation coefficient were higher in magnitude for plant height (cm), No. of secondary branches plant^{-1}, no of tertiary branches plant^{-1}, internode length(cm), leaf width(cm), seed no. pod^{-1}, collar girth(cm), dry herbage yield (g). Then corresponding phenotypic correlation

coefficient indicating the depression of phenotypic expression by the environmental factors. The character 50% flowering, pod length(cm) and chlorophyll content showed higher magnitude of environmental correlation coefficient then their corresponding PCV and GCV which indicate that the expression of such character is due to the influence of environment and association of such character may change with locality or change with environment.

Internode length plant-1, dry herbage yield plant-1, plant height plant-1 and collar girth plant-1 exhibited significant and positive correlation with fresh herbage yield plant-1 genotypic and phenotypic level whereas, some characters like collar girth showed negative and significant correlation with fresh herbage yield plant -1 at genotypic level.

At genotypic level the degree of association was highly positive significant between dry herbage yield plant-1(0.932) with fresh herbage yield plant-1(0.579). Which followed by internode length plant-1(0.228), seed number pod (0.473), plant height (0.411), collar girth (0.396) at genotypic level.

Among the significant intense association, plant height had positive correlated with no. of secondary branches plant (0.511) followed internodes length plant -1 (0.634), pod length plant (0.640), leaf length plant (0.478), chlorophyll content (0.864)., At environment level, collar girth (0.390), dry herbage yield (0.472), fresh herbage yield (0.411) it had negative and significant association with canopy temperature (-0.695) at genotypic level.

Number of secondary branches plant-1 had positive and significant association with number of tertiary branches-1(0.670) (0.821), internode length (0.620), chlorophyll content (0.675), collar girth (0.632), dry herbage yield (0.475) at phenotypic, genotypic and environmental level.

Number of tertiary branches plant^{-1} had positive and significant association with internodes length (0.955) (0.409), canopy temperature (0.768) and collar girth (0.605) (0.647) at phenotypic, genotypic and environmental level. Whereas, it had negative and significant association with seed no pod^{-1} (-0.663), pod length (-0.537) at genotypic level.

Internode length plant^{-1} had positive and significant association with collar girth (0.559), fresh herbage yield (0.579), dry herbage yield (0.763), petiole length (0.908), chlorophyll content (0.546) and leaf width (0.862) at genotypic level. Whereas, it had negative and significant association with seed number pod^{-1} (0.618), pod length (-0.515), canopy temperature (0.514) leaf length (-1.000) at genotypic level.

Pod length plant^{-1} was positive and sigficant association with chlorophyll content (0.785) and fresh herbage yield (0.497) at genotypic and environmental level. Whereas it had negative and significant association with seed number pod^{-1} (-0.792), canopy temperature (-0.792) at genotypic level.

Seed number pod^{-1} was positive and significant association with leaf length (0.501) canopy temperature (0.509) and fresh herbage yield (0.473) at genotypic and environmental level. Whereas, it had negative and significant association with petiole length (-0.975), collar girth (-0.855), chlorophyll content (-0.519), canopy temperature (-0.504) at genotypic level.

Chlorophyll content was negative significant association with canopy temperature (-0.822) at genotypic level.

Leaf length was positive and significant association with canopy temperature (0.819), chlorophyll content (0.782) and collar girth (0.408) at genotypic and environmental level.

Leaf width was positive and significant association with canopy temperature (0.801) at genotypic level.

Petiole length had positive and significant association with collar girth (0.435) at genotypic level whereas, it was negative and significance association with days to 50% flowering (-0.444) at genotypic level.Whereas it had negative significant association with canopy temperature (-0.649) at genotypic level.

Canopy temperature was negative significant association with fresh herbage yield (-0.989) at genotypic level.

Collar girth had positive and significant association with dry herbage yield plant^{-1} (0.499) (0.428) at environmental and genotypic level. Whereas it had negative significant association with dry herbage yield (-0.519) at genotypic level.

Dry herbage yield plant^{-1} had positive and significant association with fresh herbage yield plant^{-1} (0.932) (0.942)(0.639) at environmental, genotypic and phenotypic level.

Hence, direct selection for internodes length plant^{-1} and dry herbage yield plant may be advantageous for selecting the high yielding genotype in kalmegh from the available gene pool.

4.4.2 Path coefficient analysis

Path coefficient analysis is simply a standardized partial regression coefficient, which splits the correlation into direct and indirect effect. In other words, it measures the direct and indirect contribution of various independent characters on dependent characters on a dependent character. Following method given by Dewey and Lu (1959) has been used to estimate the magnitude and direction of direct and indirect effect of various yield and yield contributing characters. Correlation coefficients along with path coefficients together provide more reliable information, which can be

Table 4.8 Genotypic path coefficient of variation of various characters influencing seed yield/plant

Character	1	2	3	4	5	6	7	8	9	10	11	12	Genotypic
Days to 50 % flowering	**0.121**	-0.021	0.038	0.073	-0.017	0.018	-0.039	0.003	-0.109	0.098	-0.062	0.025	0.047
Plant Height (cm)	-0.009	**0.268**	0.295	-0.389	-0.286	-0.005	-0.052	0.002	0.212	-0.034	0.258	0.213	0.411*
No. of secondary branches $^{-1}$	0.008	0.137	**0.577**	-0.874	0.091	-0.004	0.030	0.007	0.166	-0.028	0.172	0.192	0.371
No. of tertiary branches $^{-1}$	-0.008	0.098	0.474	**-1.065**	0.240	-0.012	0.009	0.010	0.070	-0.037	0.428	0.155	0.298
Pod Length(cm)	0.005	0.171	-0.117	0.572	**-0.447**	-0.014	-0.037	-0.011	0.192	-0.019	-0.122	-0.121	-0.234
Seed no.pod $^{-1}$	0.121	-0.080	-0.113	0.706	0.354	**0.018**	-0.163	0.007	-0.544	0.214	-0.566	0.245	0.473*
Leaf lengt(cm)	0.044	0.128	-0.616	0.091	-0.152	0.027	**-0.109**	0.002	0.192	-0.008	-0.057	-0.023	-0.045
Leaf width(cm)	0.012	0.022	0.146	-0.376	0.172	0.004	-0.006	**0.030**	-0.065	-0.013	0.065	0.016	0.030
Chlorophyll content	-0.054	0.231	0.390	-0.303	-0.350	-0.040	-0.085	-0.008	**0.245**	-0.030	0.253	0.036	0.070
Petiole length(cm)	-0.54	0.042	0.075	-0.181	-0.039	-0.018	-0.004	0.002	0.033	**-0.220**	0.288	-0.032	-0.062
Collar girth(cm)	-0.011	0.104	0.150	-0.689	0.082	-0.016	0.009	0.003	0.094	-0.096	**0.662**	0.205	0.369
Dry herbage yield(g)	0.006	0.110	0.214	-0.318	0.104	0.009	0.005	0.001	0.017	0.014	0.262	**0.518**	**0.942****

Bold figures diagonal values are direct effect Residual effect =0.0727

1. Days to 50 % flowering
2. Plant Height(cm)
3. No. of secondary branches
4. No. of tertiary branches
5. Pod Length(cm)
6. Seed no.pod $^{-1}$
7. Leaf lengt(cm)
8. Leaf width(cm)
9. Chlorophyll content
10. Petiole length(cm)
11. Collar girth(cm)
12. Dry herbage yield(g)

effectively predicted in crop improvement programme. If the correlation between yield and a character is due to direct effect of a character, it reveals true relationship between them and direct selection for the trait will be rewarding for yield improvement. However, if the correlation coefficient is mainly due to indirect effect of the character through another component trait, indirect selection through such trait will be effective in yield improvement. If the direct effect is positive and high, but such trait should be practiced to reduce the undesirable indirect effect.

In the present study the fresh herbage yield plant^{-1} was considered as dependent variable and rest of the trait as independent variable (Table 4.8)

Path coefficient analysis considering fresh herbage yield plant^{-1} as dependent character revealed that collar girth plant^{-1} (0.662) showed highest positive direct effect followed by number of secondary branch plant^{-1}(0.577) followed by dry herbage yield(0.518), plant height(0.268), chlorophyll content(0.245), days to 50% flowering(0.121), leaf width(0.030), number of seed pod^{-1}(0.018).

The other important character showed only negative direct effect on the fresh herbage yield plant^{-1} were no. of tertiary branches plant^{-1} (-1.065) showed highest negative direct effect followed by pod length plant^{-1}(-0.447), petiole length plant^{-1} (-0.220) and leaf length (-0.109).

Days to 50 % flowering showed positive correlation (0.121) and showed positive direct effect on fresh herbage yield plant^{-1} (0.047) which is due to positive indirect effect *via.*, number of secondary branches plant^{-1} (0.038), number of tertiary branches plant^{-1} (0.073), number of seed pod^{-1} (0.018), leaf width (0.003), petiole length plant^{-1} (0.098).

Plant height had positive correlation with fresh herbage yield plant^{-1} (0.411) and positive direct effect on fresh herbage yield plant^{-1} (0.268) was which is mainly

due to the positive indirect effect *via.*, number of secondary branches plant^{-1} (0.295), leaf width (0.002), chlorophyll content (0.212), collar girth plant^{-1} (0.215)

Number of secondary branches plant^{-1} had positive correlation with fresh herbage yield plant^{-1} (0.371) and its positive direct effect on fresh herbage yield plant^{-1} (0.577) was which is mainly due to the positive indirect effect *via.*, Days to 50 % flowering (0.008), plant height (0.137), pod length (0.091), leaf length (0.030), leaf width (0.007), chlorophyll content (0.166), and collar girth plant^{-1} (0.172).

Number of tertiary branches plant^{-1} had positive correlation with fresh herbage yield plant^{-1} (0.298) and its negative direct effect on fresh herbage yield plant^{-1} (-1.065), which is mainly due to the positive indirect effect *via.*, plant height (0.098), number of secondary branches (0.474), pod length (0.240), leaf length (0.009), leaf width (0.010), chlorophyll content (0.070), collar girth (0.428), fresh weight of leaf plant^{-1} (0.155).

Pod length plant^{-1} had negative correlation with fresh herbage yield plant^{-1} (-0.234) and its negative direct effect on fresh herbage yield plant^{-1} (-0.447) which is mainly due to the positive indirect effect *via.*, days to 50 % flowering (0.005), plant height (0.171), number of secondary branches plant^{-1} (0.572), chlorophyll content (0.192).

Seed number pod^{-1} had positive association with fresh herbage yield plant^{-1} (0.473) and its positive direct effect on fresh herbage yield (0.018), which is mainly due to the positive indirect effect *via.*, days to 50 % flowering (0.121), number of tertiary branches plant^{-1} (0.706), pod length plant^{-1} (0.354), leaf width plant^{-1} (0.007), petiole length plant^{-1} (0.214), fresh weight of leaf plant^{-1} (0.245).

Leaf length plant^{-1} had negative association with fresh herbage yield plant^{-1} (-0.045) and its negative direct effect on fresh herbage yield (-0.109), which is mainly

due to the positive indirect effect *via.*, days to 50 % flowering (0.004), plant height plant^{-1} (0.128), number of tertiary branches plant^{-1} (0.091), seed number pod^{-1} (0.027), leaf width plant^{-1} (0.002), chlorophyll content (0.192).

Leaf width plant^{-1} had positive association with fresh herbage yield plant^{-1} (0.030) and its positive direct effect on fresh herbage yield (0.030), which is mainly due to the positive indirect effect *via.*, days to 50 % flowering (0.012), plant height plant^{-1} (0.022), number of secondary branches plant^{-1} (0.146), pod length plant^{-1} (0.172), seed number pod^{-1} (0.004), collar girth plant^{-1} (0.065) and dry herbage yield plant^{-1} (0.016).

Chlorophyll content had positive association with fresh herbage yield plant^{-1} (0.070) and its positive direct effect on fresh herbage yield (0.245), which is mainly due to the positive indirect effect *via.*, plant height plant^{-1} (0.231), number of secondary branches plant^{-1} (0.390), collar girth plant^{-1} (0.253) and dry herbage yield plant^{-1} (0.036).

Petiole length plant^{-1} had negative association with fresh herbage yield plant^{-1} (-0.062) and its negative direct effect on fresh herbage yield (-0.245), which is mainly due to the positive indirect effect *via.*, plant height plant^{-1} (0.042), number of secondary branches plant^{-1} (0.075), leaf width plant^{-1} (0.002), chlorophyll content (0.033), collar girth plant^{-1} (0.288).

Collar girth plant^{-1} had positive association with fresh herbage yield plant^{-1} (0.369) and its positive direct effect on fresh herbage yield (0.662), which is mainly due to the positive indirect effect *via.*, plant height plant^{-1} (0.104), number of secondary branches plant^{-1} (0.150), pod length plant^{-1} (0.082), leaf length plant^{-1} (0.009), leaf width plant^{-1} (0.003), chlorophyll content (0.094), and dry herbage yield plant^{-1} (0.205).

Dry herbage yield plant^{-1} had positive association with fresh herbage yield plant^{-1} (0.942) and its positive direct effect on fresh herbage yield (0.518), which is mainly due to the positive indirect effect *via.,* plant height plant^{-1} (0.006), number of secondary branches plant^{-1} (0.110), tertiary branches plant^{-1} (0.214), pod length plant^{-1} (0.104), seed number pod^{-1} (0.009), leaf length plant^{-1} (0.005), leaf width plant^{-1} (0.001), chlorophyll content (0.017), petiole length plant^{-1} (0.014) and collar girth plant^{-1} (0.262).

The path analysis in the present investigation revealed that collar girth (cm), no. of sec. branches, dry herbage yield (g), plant height (cm), chlorophyll content, days to 50% flowering , leaf width (cm) and seed number per pod indicate the effect is true and is not affected by the other component character and environment, thus we can conclude that the association was true of such character and direct effect of these character on herbage yield (g) was the major causal factor in determining the various correlation coefficient estimates and the role of indirect effect in counter, balancing the direct effect. Therefore direct selection for this character will be beneficial in improving the herbage yield in *Andrographis paniculata*.

4.5 Reproductive behavior study in kalmegh for genetic improvement.

Stigma with two celled anther (Plate 4.3) and its close proximity structure, stigma receptivity, Pollen fertility test showed that the plant is self pollinated, chasmogamous, protogyne, self compatible, hermaphrodite, and habitual inbreed in nature. The stigma receptivity studied revealed that bubble formation starts when the bud length is 0.4 cm with style length 0.3 cm and was in peak at 0.9 cm bud size with 0.8 cm style length and finally stop when flower bud length is 1.5 cm with 1.4 cm style. Pollen was fertile when the flower bud is 0.9 cm at this stage pollen is spherical, dark red color with acetocarmine stain at this stage size of the pollen was 40 micro meter length and width in size. The pollen was tested for pollen tube formation which

Plate 4.1 Morphological variation in available accessions

(a)

(b)

(c)

(d)

Plate 4.2 a) Flower bud development stage b) Pod development stage

c) Flower stage d) Stigma and anther development stage

(a)

(b)

(c)

(d)

Plate 4.3 a) Bubble formation from stigma surface b) Fertile pollen

c) Pollen tube formation d) Hybridization for genetic improvement

showed that the pollen of bud 0.9 cm form tube thus pollen fertility, viability coincide with stigma receptivity. The time of anthesis was from 8:00 am to 11:00 am the intra specific crosses were attempted using diverse parents having marker character. The flower was emasculated carefully using sterilized forceps and needle before anther dehiscences without damaging pistil. Mannual pollination of pollen grains of dehiscence anther of male flower was dusted over receptive stigma of receptor flower which after pollination covered with thin layer of cotton. The crosses were labeled with male and female parent and date of pollination. The fruit set was high in 0.9 cm bud size with 0.8 cm style length if manually outcross is done between 8.00 am to 11.00 am. Out of 300 crosses only in seven cross the fruit was set. The result was quite poor.

4.6 Assessment of processing

The leaf sample was collected from the plant and equal quantity of leaves was divided into three parts. These samples was shade dried, sun dried and oven dried. In shade dried sample, the color of the leaves was black. In the oven dried sample the color of the leaves was faded green color. The sun dried sample was greenish black in color. In all the three method of drying sun drying method was the best and color and quality of the leaf sample was desirable to fetch good price in the market (Bhatnagar 2003). The dried leaves was than preserved to store for long period in dry place in tight container at room temperature.

SET-II

4.7 Variability in traits of collected accessions from different location

The total 257 accession of kalmegh collected from 14 location of Chhattisgarh was evaluated. The field observation revealed that the highest plant height plant^{-1} ranged between 11(cm) to 97(cm), no. of secondary branches was ranged between 12 to 40, no. of tertiary branches ranged between 20 to 130, pod length plant^{-1} ranged

a) Oven drying b) Sun drying c) Shade drying

Plate 4.4 Method of drying

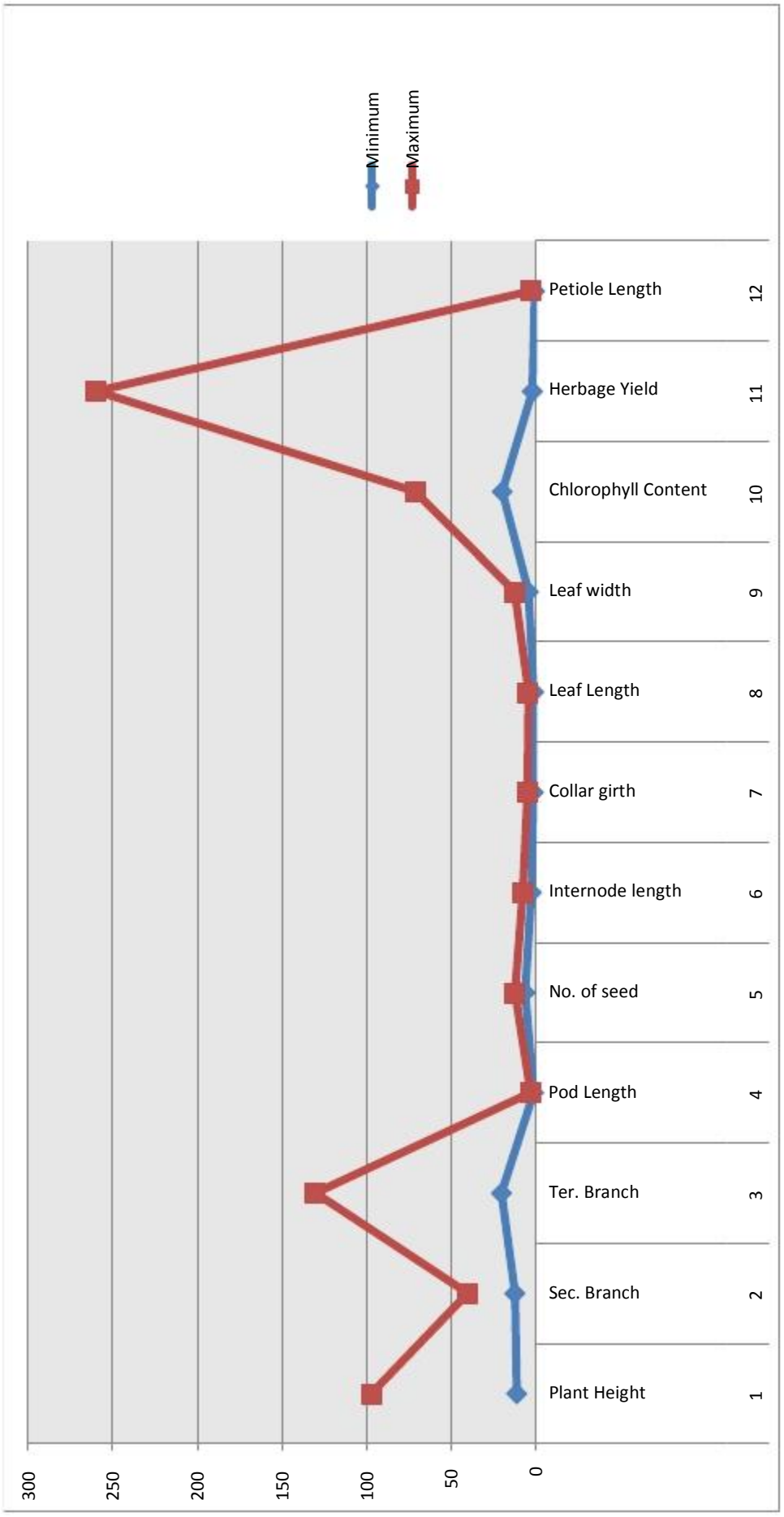

Fig: 4.2 Variability in traits of the collected accession from different location

between 1(cm) to 2.9(cm), no. of seed ranged between 6 to 12, internode length ranged between 2.3 (cm) to 7.5 (cm), collar girth ranged between 1.1 (cm) to 4.7 (cm), leaf length ranged between 4 (cm) to 12.2 (cm), leaf width range between 1 (cm) to 4 (cm), chlorophyll content ranged between 19.5 to 71.2, herbage yield ranged between 1.8 (g) to 259.5 (g) and petiole length ranged between 0.3 (cm) to 2.4 (cm) (Table.4.9; fig4.1).

Table.4.9 Variability in traits of the collected genotypes from different location

S.No.	Traits	Minimum	Maximum
1	Plant Height (cm)	11	97
2	Sec. Branch	12	40
3	Ter. Branch	20	130
4	Pod Length(cm)	1	2.9
5	No. of seed pod^{-1}	6	12
6	Internode length(cm)	2.3	7.5
7	Collar girth(cm)	1.1	4.7
8	Leaf Length(cm)	4	12.2
9	Leaf width(cm)	1	4
10	Chlorophyll Content	19.5	71.2
11	Herbage Yield(g)	1.8	259.5
12	Petiole Length(cm)	0.3	2.4

In the collected accessions maximum variability was found for the traits herbage yield followed by tertiary branches followed by plant height followed by chlorophyll content followed by secondary branches.

4.8. Range of yield in collected accession from different location

The highest range of yield was recorded in accession of MAPs the ranged between IKM-MO-11 (259.5g) to IKM-MO-37 (52.9 g), followed by accession of Kondagoan ranged between IKM-KG-2(224g) to IKM-KG-5(23.3 g), followed by accession of Raipur ranged between IKM-RPR-6 (148.5g) to IKM-RPR-1 (3.9 g),followed by accession of Durg ranged between IKM-DG-30 (125.7g) to IKM-DG-13 (21.1g), followed by accession of Ambikapur ranged between IKM-AM-1 (123.6g) to IKM-AM-3 (84.5g), followed by accession of Dhamtari ranged between IKM-Dh-118.2 (g) to 11.7 (g), followed by accession of Narayanpur ranged between IKM-NP-1 (88.3g) to IKM-NP-6 (29.1g), followed by accession of Raigarh ranged between IKM-RG-10 (73.3g) to IKM-RG-19 (12.9g), followed by accession of Baster ranged between IKM-BS-18 (66.7g) to IKM-BS- 6 (11.4g), followed by accession of Korea ranged between IKM-Kor-9 (64.7g) to IKM-Kor-2 (16.2 g), followed by accession of Dantewada ranged between IKM-DW-2 (63.8g) to IKM-DW -2 (55.1g) and the lowest yield was recorded in accession of accession of Kanker ranged between 53.3 (g) to 27.1 (g), followed by accession of Jagdalpur ranged between IKM-Jag-4 (49.7g) to IKM-2 (32.2g), followed by accession of Jashpur ranged between IKM-JS-18(21.4 g) to IKM-JS-2 (10g) (Table 4.10;fig.4.3)

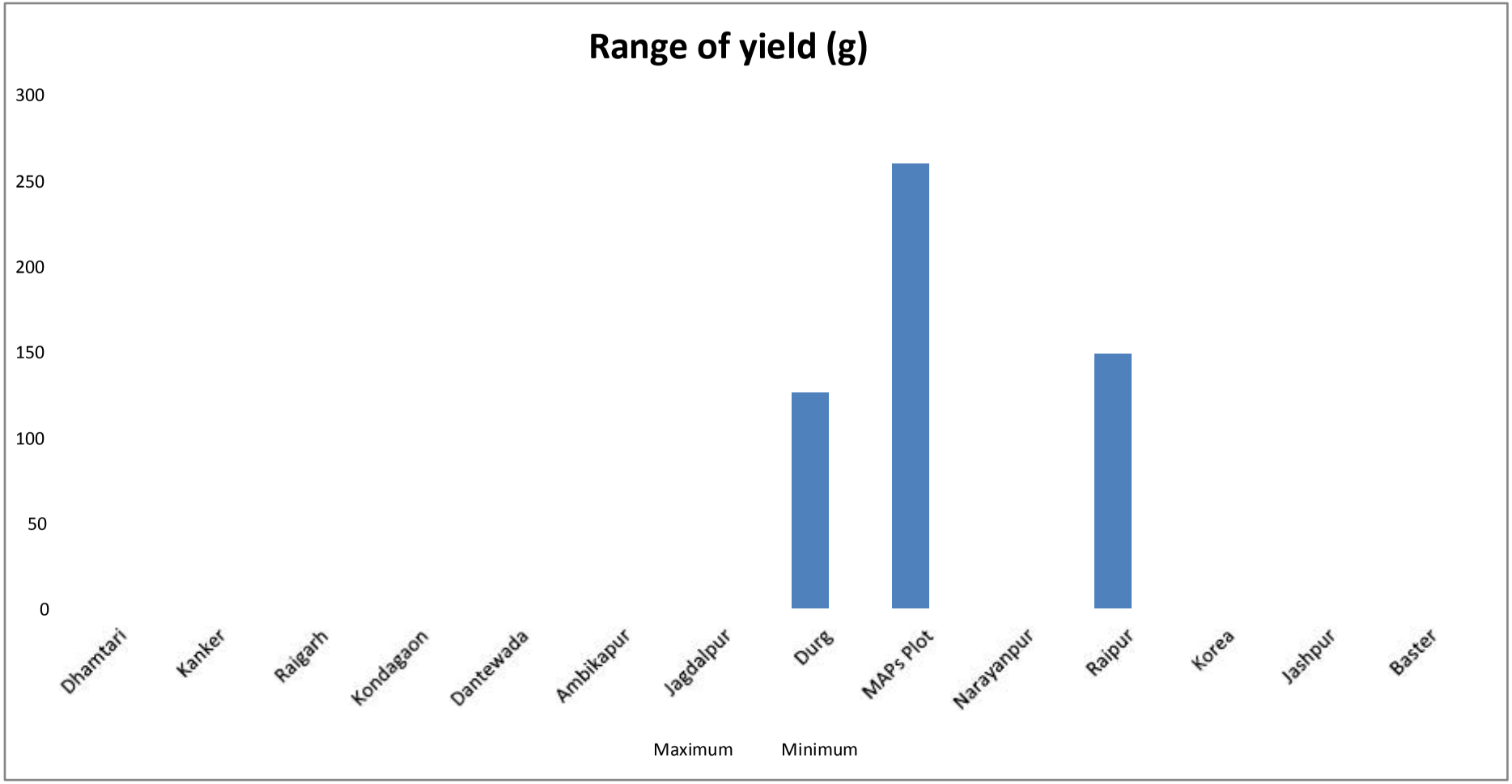

Fig: 4.3 Range of yield from different location

Table 4.10 Range of yield from different location

S.No.	Location	Maximum	Minimum
1	Dhamtari	118.2	11.7
2	Kanker	53.3	27.1
3	Raigarh	73.3	12.9
4	Kondagaon	224	23.3
5	Dantewada	63.8	55.1
6	Ambikapur	123.6	84.5
7	Jagdalpur	49.7	32.2
8	Durg	125.7	21.1
9	MAPs Plot	259.5	52.9
10	Narayanpur	88.3	29.1
11	Raipur	148.5	3.9
12	Korea	64.7	16.2
13	Jashpur	21.4	10
14	Baster	66.7	11.4

4.9 Genetic divergence

The choice of genetically diverse parents for hybridization is an important feature of any crop improvement programme for getting desirable segregant. The multivariate analysis based on Mahalanobis D^2 or non- hierarchical Euclidean cluster analysis is used for divergence analysis. The D^2 analysis classifies the genotype into relatively homogeneous groups in such a way that within cluster diversity is minimized and between clusters diversity is maximized. The respective genotypes from divers cluster can be utilized in breeding programme depending upon breeding objectives. The results of earlier studied are relevant only for the material and environmental involved in a particular study and cannot be generalized. Therefore, study on genetic divergence on the available germplasm under the environment where it is to be exploited is essential for successful utilization of available resources (Katiyar *et al*. 2009).

Genetic diversity is an important factor and also a prerequisite in any hybridization programme. Multivariate analysis by mean of Mahalanobis D^2 statistic is a powerful tool in quantifying the degree of divergence at genotypic level. Vavilov (1926) was the first to emphasize the need for a really broad genetic base for crop improvement. A set of 257 genotypes of Kalmegh were subjected to D^2 analysis for 12 characters based on D^2 values sixteen cluster were formed (Table 4.11). This indicated that substantial diversity existed in the all the genotypes evaluated in the present study. This is an agreement with earlier reports indicating substantial diversity in kalmegh materials. This present study also suggests that, there is no relationship between geographical and genetic diversity as genotype chosen from different eco-geographical regions are groped in different clusters. The cluster III were the largest which consisted of 37 genotypes, followed by cluster IX (29), cluster XV (24), cluster

Table 4.11 Genotypes of 257 kalmegh included in different clusters

Cluster	No. of genotype	Genotype
I	**8**	IKM-DH-11, IKM-DH-12, IKM-RPR-103, IKM-RPR-106, IKM-RPR-107,IKM-RPR-111, IKM-RPR-115, IKM-Kor-121
II	**2**	IKM-MO-93, IKM-MO-94
III	**37**	IKM-Dh-2, IKM-Jag-36, IKM-Jag-37, IKM-DG-38. IKM-DG-39,IKM-DG-43, IKM-DG-46,IKM-DG-50,IKM-DG-51,IKM-DG-52,IKM-DG-55,IKM-DG-56,IKM-DG-57,IKM-DG-59,IKM-DG-60,IKM-DG-60,IKM-DG-61,IKM-69, IKM-DG-70,IKM-DG-71, IKM-NP-77, IKM-NP-78, IKM-NP-81, IKM-Kor-81, IKM-Kor-89, IKM-RG-136, IKM-RG-137, IKM-RG-139, IKM-RG-140, IKM-RG-141, IKM-RG-143, IKM-RG-146, IKM-RG-148, IKM-RG-149, IKM-RG-151, IKM-RG-152, IKM-RG-157, IKM-RG-201, IKM-RG-221
IV	**17**	IKM-DH-1,IKM-DH-3, IKM-DH-7, IKM-MO-187,IKM-MO-209,IKM-MO-210,IKM-MO-211,IKM-MO-212,IKM-MO-213, IKM-MO-229, IKM-230, IKM-MO-231, IKM-MO-232, IKM-MO-233, IKM-MO-242, IKM-MO-254, IKM-MO-255
V	**9**	IKM-BS-95, IKM-BS-96, IKM-BS-105, IKM-BS-109, IKM-BS-112, IKM-BS-114, IKM-JS-119, IKM-JS-127, IKM-JS-129
VI	**3**	IKM-MO-159, IKM-MO-160, IKM-MO-161
VII	**21**	IKM-DH-5, IKM-KG-21, IKM-DG-42,IKM-DG-44, IKM-DG-48, IKM-DG-58, IKM-DG-64, IKM-DG-67, IKM-DG-76, IKM-NP-82, IKM-BS-97, IKM-BS-99, IKM-RG-138, IKM-RG-142, IKM-RG-144, IKM-RG-147, IKM-RG-150, IKM-RG-153, IKM-RG-154, IKM-RG-155, IKM-RG-156
VIII	**21**	IKM-DH-4, IKM-DG-72, IKM-NP-73, IKM-NP-74, IKM-NP-75, IKM-NP-79, IKM-NP-80, IKM-BS-98, IKM-110, IKM-MO-214, IKM- MO-215, IKM-MO-234, IKM-MO-235, IKM-MO-238, IKM-MO-239, IKM-MO-240,IKM-MO-241, IKM-MO-243,IKM-MO-244, IKM-MO-256, IKM-MO-257
IX	**9**	IKM-KK-13, IKM-Kor-85, IKM-BS-100,IKM-BS-101, IKM-BS-102, IKM-BS-104, IKM-BS-113, IKM-JS-120, IKM-JS-124
X	**14**	IKM-DW-28, IKM-AM-29, IKM-Jag-34, IKM-DG-54, IKM-MO-173, IKM-MO-179, IKM-MO-183, IKM-MO-184, IKM-MO-185,IKM-MO-207, IKM-MO-227,IKM-MO-247
XI	**29**	IKM-DH-8, IKM-DH-9, IKM-DH-10, IKM-KK-14, IKM-KK-15, IKM-KK-16,IKM-KK-17,IKM-KK-18, IKM-KG-22, IKM-KG-23,IKM-KG-24,IKM-KG-25,IKM-KG-26, IKM-Jag-33, IKM-Jag-35, IKM-DG-41, IKM-DG-49, IKM-DG-53, IKM-DG-62, IKM-DG-63, IKM-NP-83, IKM-Kor-84, IKM-Kor- 86,, IKM-Kor-87, IKM-Kor-88, IKM-Kor- 90, IKM-Kor- 91,IKM-Kor-92, IKM-RG-145
XII	**22**	IKM-AM-31, IKM-MO-174, IKM-MO-175, IKM-MO- 176,, IKM-MO-177, IKM-MO-178, IKM-MO-181, IKM-MO-182, IKM-MO-192, IKM-MO-194, IKM-MO-206, IKM-MO-208,, IKM-MO-216,IKM-MO-226,,IKM-MO-228, IKM-MO-236,IKM-MO-245,,IKM-MO-248,IKM-MO-249,IKM-MO-250, IKM-MO-251,IKM-MO-253
XIII	**14**	IKM-BS-108, IKM-BS-117, IKM-JS-118, IKM-JS -123,IKM-JS-125, IKM-JS-126, IKM-JS-128, IKM-JS-130, IKM-JS -131, IKM-JS -132, IKM-JS-133, IKM-JS-134, IKM-JS-135
XIV	**9**	IKM-MO- 163, IKM-MO- 170, IKM-MO -193, IKM-MO-198, IKM-MO-202, IKM-MO-218, IKM-MO I- 222, KM-MO -246, IKM-MO-252
XV	**24**	IKM-DH-6, IKM-DH-27, IKM-AM-30, IKM-DG-32, IKM-DG-40, IKM-DG-45, IKM-DG-47, IKM-DG-65, IKM-DG-66, IKM-DG-68,IKM-BS-116, IKM-MO-188, IKM-MO-189, IKM-MO-190, IKM-MO-191, IKM-MO-195, IKM-MO-196, IKM-MO -197,IKM-MO-199, IKM-MO-200, IKM-MO-205, IKM-MO-219, IKM-MO-220, IKM-MO-225
XVI	**18**	IKM-KK-19, IKM-KG-20, IKM-RG-158, IKM-MO- 162, IKM-MO-164, IKM-MO-166, IKM-MO-167, IKM-MO-168, IKM-MO-169, IKM-MO-171, IKM-MO-180, IKM-MO-203, IKM-MO-204, IKM-MO-217, IKM-MO-223, IKM-MO-224, IKM-MO-227,IKM-MO-237

XII (22), cluster VII and VIII (21), cluster XVI (18), cluster IV (17), cluster X and XIII (14), cluster V, XIV and IX (9), cluster I (8), cluster IV (3) and cluster II (2 genotype), respectively. From the clustering pattern, it was found that the genotypes collected from different region were independent of their genetic origin. Hence the genotypes studied are reliable enough for hybridization and selection.

The average inter and intra cluster distance among the five cluster are presented in table (4.12). The maximum inter cluster distance was observed in between cluster II and VI (10.637) followed by cluster II and VII (10.627). This suggested that the hybridization programme involving parents from these cluster is expected to given higher frequency of better segregates or desirable combination for development of useful genetic stocks or varieties. The minimum inter cluster distance was observed in between cluster III and XV (2.096) followed by cluster IV and XII (2.123), and cluster VIII and XII (2.267) indicating minimal diversity (differences) for the gene under study.

The maximum intra cluster distances was observed in cluster IX (2.810) followed by cluster V (2.636). The minimum intra cluster was observed in cluster II (1.093) followed by cluster IV (1.568).

Cluster mean

The mean values for different characters was compared across the cluster and are presented in Table (4.13). Results of the analysis revealed that cluster II was found highest plant height (155.50), number of secondary branches (47.50) whereas, cluster IV exhibited the more number of tertiary branches (72.41). Similarly cluster VIII was found highest pod length (2.38), number of seed (11.48), cluster XII was found highest internode length (5.82), cluster XVI was found highest collar girth (3.87), cluster VI was found highest leaf length (15.73) and leaf width (3.90), cluster

Table 4.12 Average intra cluster (diagonal bold) and inter cluster distance (D values)among the 16 clusters in kalmegh

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	**2.031**	7.893	3.295	4.569	2.785	6.965	3.521	4.152	3.363	4.320	3.427	4.062	3.141	4.289	3.341	5.548
II		**1.093**	9.821	8.920	8.978	10.627	10.637	9.695	8.742	8.854	9.808	8.616	9.522	9.732	9.366	10.751
III			**1.721**	3.095	4.261	6.105	1.799	2.476	3.792	3.385	2.693	3.483	3.850	3.367	2.096	3.897
IV				**1.777**	5.635	5.706	4.646	2.514	5.127	2.585	4.423	2.123	5.340	3.957	3.321	3.221
V					**2.636**	6.132	4.560	4.771	3.277	4.362	4.562	4.356	2.824	4.240	4.603	5.534
VI						**1.568**	7.204	5.355	7.168	5.077	8.258	4.919	6.172	5.456	6.006	4.582
VII							**2.053**	3.478	4.161	4.801	2.710	4.798	3.923	3.975	2.655	5.330
VIII								**1.957**	4.833	3.274	4.200	2.267	4.759	3.296	3.003	3.415
IX									**2.810**	3.564	3.353	4.494	3.104	4.021	3.945	5.588
X										**1.815**	4.280	1.891	4.332	2.729	3.241	2.765
XI											**2.293**	4.613	4.235	4.076	3.347	5.443
XII												**1.710**	4.727	2.987	3.414	2.928
XIII													**2.292**	4.114	3.830	5.812
XIV														**1.962**	2.395	3.145
XV															**2.143**	3.770
XVI																**2.199**

Table 4.13 Mean performance of genotype in individual cluster for different yield traits

Cluster	Entry	Plant height(cm)	No. of secndary branches	No of tertiary branches	Pod length(cm)	No. of seed pod^{-1}	Internode length(cm)	Collar girth(cm)	Leaf length(cm)	Leaf width(cm)	Petiole length(cm)	Chlorophyll content	Herbage yield(g)
I	8	63.11	22.62	40.25	1.70	11.25	4.51	1.82	9.28	1.64	1.19	39.15	23.46
II	2	155.50	47.50	22.50	1.45	9.50	3.45	1.40	7.90	2.10	2.10	33.90	33.90
III	37	45.49	25.05	42.97	2.16	11.0	4.40	2.58	9.51	2.11	0.82	54.63	61.46
IV	17	61.25	34.94	72.41	2.19	11.06	4.36	2.99	8.45	2.48	1.13	52.72	97.71
V	9	57.34	23.22	38.33	1.50	10.00	5.76	1.86	10.73	2.04	0.84	28.51	26.93
VI	3	61.67	30.33	60.00	1.97	10.67	6.10	3.07	15.13	3.90	1.13	40.03	127.77
VII	21	35.43	17.52	33.10	2.21	11.33	4.62	2.05	9.10	1.90	0.80	56.77	38.78
VIII	21	58.79	28.67	57.10	2.38	11.48	5.38	2.62	9.09	2.42	0.95	49.36	74.72
IX	9	52.28	23.00	39.11	1.91	7.78	4.46	1.97	9.23	1.79	1.01	36.67	28.30
X	14	53.89	32.50	62.21	1.94	8.86	5.06	3.00	9.21	2.52	1.11	45.12	100.48
XI	29	41.83	23.31	39.14	1.97	10.07	4.14	2.23	6.18	1.62	0.74	50.87	43.72
XII	22	65.28	32.95	69.55	1.99	10.41	5.82	2.73	8.94	2.50	1.15	45.28	92.72
XIII	14	13.95	5.55	8.09	0.16	10.18	0.72	0.25	1.28	0.40	0.21	5.31	3.41
XIV	9	13.07	3.91	12.66	0.08	10.53	0.66	0.48	0.65	0.29	0.14	10.16	26.15
XV	24	43.81	21.00	37.92	2.07	10.71	4.72	2.71	8.80	2.33	1.28	25.47	83.97
XVI	18	58.72	29.78	55.44	2.02	10.33	5.52	3.87	10.06	2.59	0.96	49.56	180.12

SET-II **Table 4.14 Desirble genotypes based on cluster performance**

Character	Cluster															
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
Plant height(cm)	IKM- Ac KK -8		IKM-MO-80	IKM-Dh- 2	IKM-BS-10	IKM-RG-21	IKM-Dh- 3	IKM-Dh-3	IKM-KG-3	IKM-DW-2	IKM-KK-3	IKM-JG-3	IKM-BS-11	IKM-MO-41	IKM-KK-8	IKM-KG-5
No. of Secondary branches	IKM- Ac BS-10		IKM-MO-20	IKM-KK-8	IKM-BS-18	IKM-MO-3	IKM-KG-3	IKM-Dg-34	IKM-KG-3	IKM-DW-2	IKM-KK-4	IKM-JG-4	IKM-BS-13	IKM-MO-32	IKM-KG-9	IKM-MO-44
No. of tertiary branches	IKM- Ac JS-15		IKM-DG-25	IKM-Mo-52	IKM-BS-18	IKM-MO-3	IKM-DG-4	IKM-Dg-36	IKM-Kor-2	IKM-Mo-60	IKM-KK-5	IKM-MO-67	IKM-BS-14	IKM-MO-22	IKM-MO -68	IKM-MO-44
Pod length (cm)	IKM- Ac BS- 13		IKM-DG-44	IKM-MO-91	IKM-Kor-10	IKM-MO-4	IKM-RG-3	IKM-Dg-38	IKM-Kor-2	IKM-MO-57	IKM-4	IKM-MO-19	IKM-BS-14	IKM-MO-23	IKM-MO-68	IKM-MO-33
No. of seed pod [1]	IKM- Ac JS- 9		IKM-DG-35	IKM-KK-8	IKM-BS-18	IKM-MO-3	IKM-RG-4	IKM-Mo-45	IKM-R22	IKM-MO-56	IKM-AM-4	IKM-MO-20	IKM-RG-13	IKM-MO-41	IKM-MO-61	IKM-MO-34
Internode length(cm)	IKM- 10-c BS-9		IKM-DG-3	IKM-Mo-52	IKM-MO-85	IKM-MO-4	IKM-RG-4	IKM-MO-46	IKM-JS-	IKM-Mo-60	IKM-AM-4	IKM-MO-67	IKM-RG-14	IKM-MO-32	IKM-MO-62	IKM-KG-5
Collar girth (cm)	IKM- 10-c KK- 3		IKM-MO-82	IKM-Dh- 2	IKM-Js-10	IKM-MO-3	IKM-Dh- 3	IKM-MO-46	IKM-KG-3	IKM-MO-57	IKM-AM-3	IKM-MO-19	IKM-RG -14	IKM-MO-22	IKM-KG-9	IKM-MO-44
Leaf length(cm)	IKM- 10-c BS-17		IKM-MO-77	IKM-MO-88	IKM-BS-1	IKM-RG-21	IKM-Dh- 3	IKM-Mo-45	IKM-Kor-2	IKM-MO-56	IKM-DG-28	IKM-MO-20	IKM-BS-13	IKM-MO-23	IKM-MO -68	IKM-MO-44
Leaf width (cm)	IKM- 10-c KK-4		IKM-RPR-3	IKM-Mo-82	IKM-BS-18	IKM-MO-3	IKM-KG-3	IKM-MO-46	IKM-KG-3	IKM-MO-57	IKM-RPR-4	IKM-JG-4	IKM-BS-14	IKM-MO-41	IKM-MO-68	IKM-MO-33
Petiole length(cm)	IKM- 10-c KK-19		IKM-MO-80	IKM-MO-82	IKM-MO-85	IKM-MO-3	IKM-DG-4	IKM-Dh-3	IKM-KG-3	IKM-MO-56	IKM-RPR-6	IKM-MO-67	IKM-BS-14	IKM-MO-22	IKM-MO-61	IKM-MO-44
Chlorophyll content	IKM- Ac BS-17		IKM-RPR-10	IKM-MO-83	IKM-Js-10	IKM-MO-4	IKM-Dh- 3	IKM-Dg-34	IKM-Kor-2	IKM-Mo-60	IKM-AM-4	IKM-MO-19	IKM-RG-13	IKM-MO-23	IKM-MO-62	IKM-MO-44
Herbage yield(g)	IKM- Ac JS-21		IKM-MO-90	IKM-MO-91	IKM-MO-85	IKM-RG-21	IKM-Mo-77	IKM-Dg-36	IKM-RG-22	IKM-M0-50	IKM-AM-4	IKM-MO-20	IKM-RG-14	IKM-MO-41	IKM-MO-63	IKM-MO-33

II was found highest petiole length (2.10), cluster VII was found highest chlorophyll content (56.77) and cluster XIV was found highest herbage yield in (180.22).

The pattern of distribution of kalmegh genotypes in various cluster revealed existence of considerable diversity present in material (Table 4.14). The highest intra cluster distance was observed for the cluster IX. Hence, genotypes belonging to this cluster *viz.,* IKM-KK-13, IKM-Kor-85, IKM-BS-100, IKM-BS-101, IKM-BS-102, IKM-BS-104, IKM-BS-113, IKM-JS-120 and IKM-JS-124 may be utilized as parent in future breeding programms with genotype belonging to cluster II *i.e.,* IKM-MO-93 and IKM-MO-94as maximum inter cluster distance was noted between cluster II and cluster VII.

This suggest that the hybridization programme involing divers parent is expected to given high frequency of of better segregants or desirable combination for development useful genetic stock pipeline or varieties for the state of. C.G.

The experimental finding of cluster analysis are in general agreement with the finding of Sharma and Roy (1994), Nandan *et al.* (1996), Basawarajaiah *et al.* (2000), Gohil (2006), Mahamad *et al.* (2006).

Summary, Conclusions and Suggestions for Future Research Work

CHPTER-V

SUMMARY, CONCLUSION AND SUGGESTION FOR FUTURE RESEARCH WORK

Summary

The present investigation entitled **"Study of variability parameter in Kalmegh (*Andrographis paniculata*)"** was carried out at Research cum Instructional Farm, Department of Crop Physiology, Agricultural Biochemistry and Herbal Science, College of Agriculture, Raipur (C.G.) during *Kharif* season 2013-14. The experiment was conducted in a Randomized Block Design with two set viz; in Set I, 22 germplasm accession collected from different district of the C.G. along with 2 check in Anand Kalmegh-1 (Directorate of Medicinal and Aromatic Plant Board) and Simmegha (Central Institute of medicinal and aromatic plants) and in Set II, 257 germplasm accessions was evaluated for estimation of genetic variability, coefficient of correlation, path analysis and cluster analysis. Metric observation was recorded on three randomly selected competitive plants.

Observation was recorded for visual traits and for metric traits. Under visual traits, days to 50% flowering plant^{-1}, plant height plant^{-1}(cm), number of secondary branches plant^{-1}, number of tertiary branches plant $^{-1}$, leaf width plant^{-1} (cm), petiol length plant^{-1} (cm), collar girth plant^{-1}(cm), fresh herbage yield of leaf plant^{-1}(g), dry herbage yield of leaf plant^{-1} (g). Whereas, characters internodes length plant^{-1} (cm), pod length plant^{-1} (cm), number of seed pod^{-1}, leaf length plant^{-1} (cm), chlorophyll content plant^{-1}, canopy temperature plant^{-1}. Significant mean squares due to herbage yield and attributing characters revealed existence of considerable variability in the material studied for the improvement of various traits and better chances of improvement through selection on the basis of these traits.

High heritability coupled with high genetic advance as percentage of mean was found in the character number of tertiary branches/ plant followed by dry herbage yield /plant and fresh herbage yield plant height /plant. It indicate that most likely the h^2 is due to additive gene effect or selection of such character may be effective. Rest of the traits showed moderate heritability coupled with moderate genetic advance as percentage mean indicate the role of additive as well as non additive gene action for the characters in their expression.

The GCV and PCV was observed highest for tertiary branches per plant^{-1}, dry herbage yield plant^{-1}, herbage yield plant^{-1} and moderate GCV was recorded for most of the character *viz.*, plant height plant^{-1}, no. of secondary branches plant^{-1}, chlorophyll content , canopy temperature and collar girth plant^{-1} whereas, the low GCV days to 50% flowering, internode length plant^{-1}, pod length plant^{-1}, seed no/pod, leaf length plant^{-1}, chlorophyll content and canopy temperature . The GCV for average tertiary branches per plant, dry herbage yield plant^{-1}, herbage yield plant^{-1} recorded high which shows considerable scope for yield improvement in present kalmegh gene pool.

Correlation study revealed that dry herbage yield plant^{-1} had positive and significant association with fresh herbage yield plant followed by internode length plant^{-1}, seed number pod $^{-1}$, plant height plant^{-1} whereas collar girth plant^{-1} having negative significant correlation with herbage yield. Moreover, plant height plant^{-1}, no. of secondary branches plant^{-1}, internode length plant^{-1}, collar girth was positive significant correlated with dry herbage yield plant^{-1}. Hence direct selection for dry herbage yield plant^{-1} plant height plant^{-1}, no. of secondary branches plant^{-1}, internode length plant^{-1}, collar girth plant^{-1} may be advantageous or selecting the high yielding genotypes in kalmegh from available germplasm accession.

Path coefficient analysis showed that collar girth plant^{-1} had the highest positive direct effect with fresh herbage yield plant^{-1} followed by number of secondary branch plant^{-1} followed by dry herbage yield, plant height, chlorophyll content, days to 50% flowering, leaf width, number of seed pod^{-1}. Moreover, other important character such as no of tertiary branches plant^{-1} observed high but negative direct effect on the fresh herbage yield plant^{-1} followed by pod length plant^{-1}, petiole length plant^{-1} and leaf length plant^{-1}.

Cluster analysis of Set-I showed existence of considerable diversity in kalmegh germplasm accession. The maximum intra cluster distance was observed in cluster II. Hence, genotype belonging to this cluster *viz.,* IKM-3, IKM-4, IKM-5, IKM-9, IKM-21 and IKM-24 may be utilized as parent in future breeding programmes with the genotype belonging to cluster IV *i.e.,* IKM-1, IKM-2 as the maximum inter cluster distance was noted between the cluster III and cluster IV.

The stigma receptivity studied revealed that bubble formation starts when the bud length is 0.4 cm with style length 0.3 cm and was in peak at 0.9 cm bud size with 0.8 cm style length and finally stop when flower bud length is 1.5 cm with 1.4 cm style. Pollen was fertile when the flower bud is 0.9 cm. The fruit set was high in 0.9 cm bud size with 0.8 cm style length if manually outcross is done between 8.00 am to 11.00 am. Out of 300 crosses only in seven cross the fruit was set. The result was quite poor.

The leaf sample was collected from the plant and equal quantity of leaves was divided into three parts. This sample was shade dried, sun dried and oven dried. In shade dried sample, the color of the leaves was black. In the oven dried sample the color of the leaves was faded green color. The sun dried sample was greenish black in

color. In all the three method of drying sun drying method was the best and color and quality of the leaf sample was desirable to fetch good price.

In Set-II, in 257 collected accessions from 14 location of C.G, maximum variability was found for the traits herbage yield followed by tertiary branches followed by plant height followed by chlorophyll content followed by secondary branches. The highest range of yield was recorded in accession of MAPs the ranged between IKM-MO-11 (259.5g) to IKM-MO-37 (52.9 g), followed by accession of Kondagoan ranged between IKM-KG-2 (224g) to IKM-KG-5 (23.3 g), followed by accession of Raipur ranged between IKM-RPR-6 (148.5g) to IKM-RPR-1(3.9 g),followed by accession of Durg ranged between IKM-DG-30 (125.7g) to IKM-DG-13 (21.1g), followed by accession of Ambikapur ranged between IKM-AM-1 (123.6g) to IKM-AM-3 (84.5g), followed by accession of Dhamtari ranged between IKM-Dh-118.2 (g) to 11.7 (g), followed by accession of Narayanpur ranged between IKM-NP-1 (88.3g) to IKM-NP-6 (29.1g), followed by accession of Raigarh ranged between IKM-RG-10 (73.3g) to IKM-RG-19 (12.9g), followed by accession of Baster ranged between IKM-BS-18 (66.7g) to IKM-BS- 6 (11.4g), followed by accession of Korea ranged between IKM-Kor-9 (64.7g) to IKM-Kor-2 (16.2 g), followed by accession of Dantewada ranged between IKM-DW-2 (63.8g) to IKM-DW -2 (55.1g) and the lowest yield was recorded in accession of accession of Kanker ranged between 53.3 (g) to 27.1 (g), followed by accession of Jagdalpur ranged between IKM-Jag-4 (49.7g) to IKM-2 (32.2g), followed by accession of Jashpur ranged between IKM-JS-18(21.4 g) to IKM-JS-2 (10g).

Whereas, in cluster analysis of Set-II, the maximum intra cluster distances was observed in cluster IX. Hence, genotype belonging to this cluster *viz.*, IKM-KK-13, IKM-Kor-85, IKM-BS-100,IKM-BS-101, IKM-BS-102, IKM-BS-104, IKM-BS-113,

IKM-JS-120 and IKM-JS-124 may be utilized as parent in future breeding program with the genotype belonging to cluster II IKM-MO-93, IKM-MO-94 as the maximum inter cluster distance was noted between cluster II and VI followed by cluster II and VII. This suggested that the hybridization program involving parents from these cluster is expected to give higher frequency to better segregates or desirable combination for development of useful genetic stock or varieties. The highest variability in trait of collected genotype from different collection was found in herbage yield (259.5 g) followed by number of tertiary branches (130 branches to 20 branches) followed by plant height (97cm) chlorophyll content (71.2) followed by secondary branches (40 branches).

The different accession of kalmegh collected from different location of chhattishgarh and in field observation the highest range of yield was recorded in accession of MAPs the ranged between IKM-MO-11 (259.5g) to IKM-MO- 37 (52.9 g). followed by Kondagaon (224 to23.3g) followed by Raipur (148.5 to 3.9) followed by Dhamtari (118.2 to 11.7).

Conclusion

Overall observations on variability, correlation coefficient, path coefficient and cluster analysis for fresh herbage yield plant^{-1} and its attributes in kalmegh germplasm accessions indicated presence of maximum variability was observes for no. of tertiary branches plant^{-1}, Plant Height (cm), Chlorophyll Content, No of Sec. Branch, Leaf Length (cm), No. of seed pod^{-1}, Internode length (cm),Leaf width (cm), Collar girth (cm), Pod Length (cm), Petiole Length (cm).

The correlation coefficient studies indicated that the fresh herbage yield plant^{-1} showed positive and significant association with plant height plant^{-1},internode length

plant-1, seed no. pod-1 and dry herbage yield, whereas collar girth having negative significant correlation with fresh herbage yield plant-1.

The path coefficient analysis showed that collar girth plant-1 had the highest positive direct effect with significant association on fresh herbage yield plant-1 whereas, the lowest positive direct effect had noted for no of tertiary branches plant-1 observed high but negative direct effect had noted for pod length plant-1. Other important character such as petiole length plant-1 and leaf length plant-1 observed high negative direct effect with fresh herbage yield-1.

Cluster analysis of Set-I revealed that the 24 genotype of kalmegh were grouped in five clusters. Considerable amount of genetic divergence was present among 24 genotype. The maximum intra cluster distance was observed in cluster II followed cluster I, cluster V, cluster III and cluster IV. Hence, genotype belonging to cluster II may be utilized as parent breeding programmes with the genotype to cluster IV(IKM-1, IKM-2) as the maximum inter cluster distance were noted between the cluster III(IKM-8, IKM-14, IKM-15, IKM-16) and cluster IV(IKM-1, IKM-2). In Set-II the maximum intra cluster distances was observed in cluster IX and cluster V. Hence, genotype of belonging cluster IX may be utilized as parent breeding programmes with the genotype to cluster V as the maximum inter cluster distance were noted between the cluster II (IKM-MO-93, IKM-MO-94) and VI(IKM-MO-159, IKM-MO-160, IKM-MO-161). This suggested that the hybridization programme involving parents from these cluster is expected to give higher frequency of better segregates or desirable combination for development of useful genetic stocks or pipeline or varieties for Chhattishgarh.

The stigma receptivity studied revealed that bubble formation starts when the bud length is 0.4 cm with style length 0.3 cm and was in peak at 0.9 cm bud size with

0.8 cm style length and finally stop when flower bud length is 1.5 cm with 1.4 cm style. Pollen was fertile when the flower bud is 0.9 cm. The fruit set was high in 0.9 cm bud size with 0.8 cm style length if manually outcross is done between 8.00 am to 11.00 am. Out of 300 crosses only in seven cross the fruit was set. The result was quite poor.

The leaf sample was collected from the plant and equal quantity of leaves was divided into three parts. This sample was shade dried, sun dried and oven dried. In shade dried sample, the color of the leaves was black. In the oven dried sample the color of the leaves was faded green color. The sun dried sample was greenish black in color. In all the three method of drying sun drying method was the best and color and quality of the leaf sample was desirable to fetch good price.

In Set-II, in the collected accessions maximum variability was found for the traits herbage yield followed by tertiary branches followed by plant height followed by chlorophyll content followed by secondary branches. The highest range of yield was recorded in accession of MAPs the ranged between IKM-MO-11 (259.5g) to IKM-MO-37 (52.9 g), followed by accession of Kondagoan ranged between IKM-KG-2 (224g) to IKM-KG-5 (23.3 g), followed by accession of Raipur ranged between IKM-RPR-6 (148.5g) to IKM-RPR-1 (3.9 g),followed by accession of Durg ranged between IKM-DG-30 (125.7g) to IKM-DG-13 (21.1g), followed by accession of Ambikapur ranged between IKM-AM-1 (123.6g) to IKM-AM-3 (84.5g), followed by accession of Dhamtari ranged between IKM-Dh-118.2 (g) to 11.7 (g), followed by accession of Narayanpur ranged between IKM-NP-1 (88.3g) to IKM-NP-6 (29.1g), followed by accession of Raigarh ranged between IKM-RG-10 (73.3g) to IKM-RG-19 (12.9g), followed by accession of Baster ranged between IKM-BS-18 (66.7g) to IKM-BS- 6 (11.4g), followed by accession of Korea ranged between IKM-Kor-9

(64.7g) to IKM-Kor-2 (16.2 g), followed by accession of Dantewada ranged between IKM-DW-2 (63.8g) to IKM-DW -2 (55.1g) and the lowest yield was recorded in accession of accession of Kanker ranged between 53.3 (g) to 27.1 (g), followed by accession of Jagdalpur ranged between IKM-Jag-4 (49.7g) to IKM-2 (32.2g), followed by accession of Jashpur ranged between IKM-JS-18 (21.4 g) to IKM-JS-2 (10g).

Cluster analysis of Set-II, the maximum intra cluster distances was observed in cluster IX. Hence, genotype belonging to this cluster *viz.*, IKM-KK-13, IKM-Kor-85, IKM-BS-100,IKM-BS-101, IKM-BS-102, IKM-BS-104, IKM-BS-113, IKM-JS-120 and IKM-JS-124 may be utilized as parent in future breeding program with the genotype belonging to cluster II IKM-MO-93, IKM-MO-94 as the maximum inter cluster distance was noted between cluster II and VI followed by cluster II and VII. This suggested that the hybridization program involving parents from these cluster is expected to give higher frequency to better segregates or desirable combination for development of useful genetic stock or varieties. The highest variability in trait of collected genotype from different collection was found in number of tertiary branches (130 branches to 20 branches).

Suggestion for future work:

1. Based on results of genetic variability, heritability, genetic advance, correlation and path analysis, it is suggested that the genotype with high no. of tertiary branches plant^{-1}, Plant Height (cm), Chlorophyll Content, No of Sec. Branch, Leaf Length (cm), No. of seed pod^{-1}, Internode length(cm), Leaf width(cm), Collar girth(cm), Pod Length(cm), Petiole Length(cm), may be utilized to improve the fresh herbage yield plant^{-1} of kalmegh genotype through hybridization and selection.

2. Genetic variability created and evaluated under this study should fully be utilized to bring out genetic improvement of kalmegh.
3. From the study of cluster analysis those diverse parents belonging to different clusters depending upon per performance should be involved in the hybridization program.
4. There are large numbers of local genotypes available in C.G. which may have valuable genes for different characters should be collected or evaluated for different quantitative and qualitative traits.
5. On the basis of selection the best accession should be evaluated in next year for conformation.
6. Number of crosses should be attempted on appropriate bud stage and emphasis should be given to find out the cause for less success in hybridization.
7. Quantification should be done through HPLC of all the germplasm accessions for screening of high andrographolide content accessions.

Abstract

"Study of variability parameter in Kalmegh (*Andrographis paniculata* Wall.)"

By

Disha Nagvanshi

ABSTRACT

The present investigation entitled **"Study of variability parameter in Kalmegh(*Andrographis paniculata* Wall.)"** was carried out at Research cum Instructional Farm, Department of Crop Physiology, Agricultural Biochemistry and Herbal Science, College of Agriculture, Raipur (C.G.) during *Kharif* season 2013-14. The experiment was conducted in a Randomized Block Design with two set *viz;* in Set I, 22 germplasm accession collected from different district of the Chhattisgarh along with 2 check in Anand Kalmegh-1 (Directorate of Medicinal and Aromatic Plant Board) and Simmegha (Central Institute of medicinal and aromatic plants) and in Set II, 257 germplasm accessions was evaluated for estimation of genetic variability, coefficient of correlation, path analysis and cluster analysis.

Analysis of variance revealed significant differences among the kalmegh genotype for the Character *viz.,* days to 50% flowering plant^{-1}, number of secondary branches plant^{-1}, number of tertiary branches plant $^{-1}$, pod length pod^{-1} leaf width plant^{-1} (cm), petiol length plant^{-1} (cm), collar girth plant^{-1}(cm), fresh herbage yield of leaf plant^{-1}(g), dry herbage yield of leaf plant^{-1} (g). Whereas, characters internode length plant^{-1} (cm), pod length plant^{-1} (cm), number of seed pod^{-1}, leaf length plant^{-1} (cm), chlorophyll content plant^{-1}, canopy temperature plant^{-1}. Internode length exhibited maximum coefficient of variation at both level *i.e.* genotypic coefficient variation (GCV) and phenotypic coefficient variation (PCV).

High heritability coupled with high genetic advance as percentage of mean was found in the character number of tertiary branches/ plant followed by dry herbage yield /plant and fresh herbage yield plant height /plant.

Correlation study indicated that dry herbage yield plant^{-1} had positive and significant association with fresh herbage yield plant $^{-1}$ followed by internode length plant^{-1}, seed number pod $^{-1}$, plant height plant^{-1}.

Path coefficient analysis showed that collar girth plant^{-1} had the highest positive direct effect with fresh herbage yield plant^{-1} followed by number of secondary branch plant^{-1} followed by dry herbage yield, plant height, chlorophyll content, days to 50% flowering, leaf width, number of seed pod^{-1}.

The fruit set was high in 0.9 cm bud size with 0.8 cm style length if manually outcross is done between 8.00 am to 11.00 am. Out of 300 crosses only in seven cross the fruit was set. The result was quite poor.

In all the three method of drying sun drying method was the best and color and quality of the leaf sample was desirable to fetch good price.

Set-II consist of 257 accession from 14 locations of the Chhattisgarh state and was found that maximum variability was found for the traits herbage yield followed by tertiary branches followed by plant height followed by chlorophyll content followed by secondary branches. The highest range of yield was recorded in accession of MAPs the ranged between IKM-MO-11 (259.5g) to IKM-MO-37 (52.9 g), followed by accession of Kondagoan ranged between IKM-KG-2(224g) to IKM-KG-5(23.3 g), followed by accession of Raipur ranged between IKM-RPR-6 (148.5g) to IKM-RPR-1 (3.9 g), followed by accession of Durg ranged between IKM-DG-30

(125.7g) to IKM-DG-13 (21.1g), followed by accession of Ambikapur ranged between IKM-AM-1 (123.6g) to IKM-AM-3 (84.5g), followed by accession of Dhamtari ranged between IKM-Dh-118.2 (g) to 11.7 (g).

Cluster analysis result showed existence of considerable diversity in kalmegh germplasm accession. In set-1 the highest intra cluster distance was observed in cluster II followed by cluster-I and the highest inter cluster distance was observed in cluster III and cluster-IV followed by cluster-II and cluster –I whereas, in set-II the highest intra cluster distance was observed in cluster IX followed by cluster V and the highest inter cluster distance was observed in cluster-II and cluster-XVI followed by cluster-II and cluster VIII.

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References

REFERENCES

Chopra, R.N., Nayar, S.L. and Chopra, I.C. 1956. *Glossary of Indian Medicinal Plant. 1st ed.* Publication and information, new Delhi.

Nadkarni, A.K., 1954. *Nadkarni's Indian Materia Medica*. **1**. *1st ed*. Popular Book Depot. Bombay.

Lal, J. Tripathi, H.C and Tondan, S.K. 1986. Antidiabetic activity of andrographolide. *Indian J. Pharmacol*., **18**: 58-61.

Galen, C. and Plowright, R. C. 1987. Testing the accuracy of using peroxidise activity to indicate stigma receptivity. *Canadian Journal of Botany*. **65**(1): 107–111.

Najib, Nik a., Rahman, N., Furuta, T., Kojima, S., Takane, K., and mohd, M. Ali. 1999. Antimalarial acyivity of extract of Malaysian Medicinal Plant. *J. Ethnopharmacol.* **64**(3): 249-54.

Akbarsha, M.A., Manivannam, B., Hamid, K.S. and Vijayan, B. 1990. Antifertility effect of andrographis paniculata (Nees) in male albino rat. *Indian J. Experimental Biol*. **28**(5): 421-426.

Handa, S.S. and Sharma, A. 1990. Hepatoprotective activity ofandrographolide against galactosamine and paracetamol intoxication in rats. *Indian J. Med. Res.,* **92**: 276-283.

Misra, P., Pal, M.L., Guru, P.Y., Katiyar, J.C., Srivastva, V. and Tandon, J.S. 1992. Antimalarial activity of *Andrographis paniculata* (Kalmegh), againt *Plasmodium berghei* NK 65 in *Mastomys natatensis*. *Int. J. Pharmacogenomi*. **30**: 263-274.

Kapil, A., Koul, I.B. Banjare, S.K. and Gupta, B.D. 1993. Antihepatotixic effect of major diterpenoid constituents of *Andrograhis paniculata*. *Bioche Pharmacol*., **46**(1): 182-85.

Puri, A., Saxena, R., Saxena, R.P., Saxena, K.C., Shrivastava, V. and Tondan, J.S. 1996. Immunostimulant agents from *Andrographis paniculata*. *J. Natural Product*. **56**(7): 995-999.

Techadamrongsin, Y., Dechatiwongse, N. A. T. and Punyarajun, S. 1999 .Studied at Harvesting, post- harvesting handling and storage of crude druge.Bulletin of department of Medicinal science, Nonthaburi, Thailand. (Thai Language).**39**(1):11-21.

Hossain, M.D., Rabbani, M.G., and Mollah, M.L.R. 2000. Genetic variability, correlation and path analysis of yield contributing charater in sweet potato. *Pakistan Journal of Scientific and Industrial Research*. **43**(5): 314-318.

Calabrese, C., Berman, SH., Babish, J.G., Ma X, Shinto., L, Dorm., M, Wells., Wenner, CA., Standish, LJ. 2000. A phase I trial of andrographolide in HIV positive patients and normal volunteers. *Phytother. Res.***14**: 333-338.

Misra, H.O., Sharma, J.R., Lal, R.K. and Shukla, N. 2001. Pattern of genetic variability for different traits in a collection of *Andrographis paniculata* (Kalmegh) genotype. *Journal of Medicinal and Aromatic Plant Sciences*. **22**(4): 348-351.

Sabu, K.K., Padmesh, P. and Seeni, S. 2001. Intraspecific variation in active principal content and isozymes of Andrographis paniculata a traditional hepatoprotactive mmedicinal herb India. *J. Med. Arom. Pl. Sci*., **23**: 637-647.

Trivedi, N.P. and Rawal, U.M. 2001. Hepatoprotective and antioxodent property of *Andrographis paniculata* (Nees) in BHC induced liver damage in mice. *Indian J. Exp. Biol*., **39**(1): 41-46.

Burke, J.M., Hamrick, J.L., 2002. Genetic variation and evidence of hybridization in the genus Rhus (Anacardiaceae). *J. Hered.*, **93**(1): 37–41.

Sabu, K.K. 2002. *Intraspecific variations in Andrographis paniculata Nees*, Ph.D. thesis, Kerala University, India.

Bhatnagar, P. and Sing, V.B. 2003. Processing and driage of *Andrographis paniculata* (Kalmegh). *Vaniki Sandesh* . State Forest Resarch Institute, Jabalpur (M.P).

Misra, H.O., Lal, R.K., Gupta, M.M., Bansal, R.P. and Khanuja, S.P. S.2003. Genetic variability in Kalmegh (*Andrographis paniculata*). *Journal of medicinal and Aromatic Plant Science.* **25**(3): 752-756.

Singha, P. K., Roy, S. and Dey, S. 2003. Antimicrobial activity of *Andrographis paniculata*, Fitoterapia. **74**(7-8): 692–694

Edlund, F., Swanson, R. and Preuss, D. 2004. "Pollen and stigma structure and function: the role of diversity in pollination," *Plant Cell*, **16**: S84–S97.

Kumar, R.A., Sridevi, K., Vijaya Kumar, N., Nanduri, S. and Rajagopal, S. 2004. Anticancer and immunostimulatory compounds from *Andrographis paniculata*. *Journal of Ethnopharmacology*. **92**(2-3): 291–295.

Pio, L.A.S., Ramos, J.D.M., Pasqual, F.C., Santos and Junqueira, K. P. 2004. "Receptiveness of the stigma and in vitro germination of orange pollen, submitted to different temperatures." *Ciênciae Agrotecnologia*. **28**(5): 1087–1091.

Joseph, T. A., Gopal, J. and Sood. S. K. 2005. Genetic parameters and characters associations in potato under sub-tropical plains and temperate hill conditions. *Potato J.* **32(1-2)**:49-53.

Maison, Tathaporn, Volkaert, Hugo, Boonprakob, Unaroj, and Paisooksantivatana, Yingyong. 2005. Genetic diversity of *Andrographis paniculata* as revealed by morphological characters and molecular marker. *Kasetsart J.,* (*Nat. Sci.*) **39**: 388-399.

S. K. Lattoo, S. Khan, A. K. Dhar, D. K. Choudhary, K. K. Gupta, and P. R. Sharma.2006. "Genetics and mechanism of induced male sterility in *Andrographis paniculata* (Burm. f.) Nees and its significance," *Current Science*. **91**(4): 515–519.

Chandrakar, A. 2007. Genetic analysis of clonal hybrids (C1 progenies) for tuber yield and its components in potato (*Solanum tuberosum* L.) breeding . *M.Sc. (Ag.) Thesis,*Indira Gandhi Krishi Vishwavidyalay, Raipur (C.G.).

Pandey, A.K. and Mandal, A.K. 2008. Cultivation of *Andrographis paniculata*. *J. Tropical Medicinal Plant*. **9**(1): 705-709.

Shivanna, K. R. 2008. Pollination biology, breeding sysem and reproductive success in Adhatoda vasica, an important medicinal plant. *Current Science*. **96**(3): 408-412.

Yadav, A.K., Tiwari, N., Srivastava, P., Singh, S.C., Shanker, K., Verma, R.K., Gupta, M.M. Iridoid Glycoside-Based Quantitative Chromatographic Fingerprint Analysis: A Rational Approach for Quality Assessment of Indian Medicinal Plant Gambhari (*Gmelina arborea*) . *J. Pharm. Biomed. Anal.* **47**: 841 – 846.

Chia, S.H. 2009. Reproductive system and genetic diversity of Hempedu Bumi (*Andrographis paniculata*). M.Sc. (Ag.) Thesis. University Putra Malaysia.

Lin, F.L., Wu, S.J., Lee, S. C. and Ng, L.T. 2009. Antioxidant, antioedema and analgesic activities of *Andrographis paniculata* extracts and their active constituent andrographolide. *Phytotherapy Research*. **23**(7): 958–964.

Mishra, K., Dash, A.P., Swain, B.K. and Dey, N. 2009. Anti-malarial activities of *Andrographis paniculata* and Hedyotis corymbosa extracts and their combination with curcumin. *Malaria Journal*. **8**(1): 26.

Patel, B. Jigar, Lahiri, K. Suman and Shah, B. Mamta. 2009. Development of a new method for identification and estimation of *Withania somnifera* root, and a method for quantitative analysis of withaferin A in young and old roots. *J. of Planer Chromatography*. **22**: 283-286.

Pandey, A.K. and Mandal, A.K. 2010. Variation in morphological characteristics and Andrographolide content in *Andrographis paniculata* of central India. *Iranica Journal of Energy and Environment.* **1**(2): 165-169.

Minz, P.L. and Koche,Vijaya. 2012. Variation in morphological parameter and Andrographolide content in *Andrographis paniculata* collected from different provenances of Chhattisgarh. *Research Journal of Biotechnology*. **7**(4): 5714-5722.

Mir, B. A., Koul, S., Kuar, A., Sharma, S., Kaul, M. K. and Soodan, A. S. 2012. Reproductive behaviour and breeding system of wild and cultivated types of *Withania somnifera* L. (Dunal). *Journal of Medicinal Research*, **6(5)**:754-75.

Shankar, R., Deb, S. and Sharma, B. K. 2012. Antimalarial plants of northeast India: An overview. *J. Ayurveda Integr Med*., **3**(1): 10–16.

Sharma, M.M. and Singh, O.P. 2012. Heritability and genetic advance for different morphological and quality traits in germplasm of Kalmegh(*Andrographis paniculata*). *Advance in Plant Science*. **25**(2): 681-683.

Valdiani, A., Kadir, A.M. and Sad, S. Mohd. 2012. Intra- specific hybridization: Generator of genetic diversification and hetrosis in *Andrographis paniculata*. *Gene*. **505** (1): 23-36.

Hudedamani, U.B. and Yadav, O.P. 2013. Floral biology of kalmegh *(Andrograhis paniculata). Environment and Ecology.* **31**(1): 76-79.

Raina, A.P., Kumar, A., Pareek, S.K. and Sharma, S.K. 2013. *Evaluation Studies on Kalmegh . Acta Horticulture*. **972**: 117-120.

Appendices

Appendix-I

Weekly meteorological data during the crop period: 2013-14

(June, 2013 to January, 2014) Station: Labhandi, Raipur

Wk no.	Max. Temp.(0C)	Min tem	Rainfall (mm)	Relative humidity(%)		Vapour pressure (mm of Hg)		wind velocity (Kmph)	Evaporation (mm)	Sun Shine (hours)
				I	II	I	II			
26	30.4	24.9	041.0	88	73	22.6	22.8	11.8	3.9	1.4
27	31.3	24.5	073.5	90	70	22.4	22.8	06.7	4.7	4.4
28	31.2	24.3	144.4	93	78	22.7	23.6	07.7	4.3	3.9
29	30.5	25.3	044.6	95	74	23.5	24.6	06.4	2.9	2.3
30	28.4	24.7	088.2	92	83	22.2	22.6	09.0	2.1	0.7
31	28.3	23.9	255.8	95	84	22.1	23.0	07.4	2.7	1.3
32	31.1	24.7	087.4	93	76	23.2	23.2	05.2	3.6	3.3
33	31.3	24.3	177.0	95	80	23.0	24.1	03.2	3.2	3.3
34	27.9	23.8	060.5	92	84	21.0	22.3	09.3	2.1	1.5
35	29.3	24.5	120.8	95	80	23.0	23.9	05.8	2.8	3.1
36	31.1	24.8	054.8	93	76	23.5	24.2	03.0	4.0	4.2
37	31.9	25.2	011.6	92	73	24.2	23.6	02.0	3.6	6.2
38	29.9	24.1	092.6	93	77	22.4	22.9	03.7	2.8	2.5
39	32.0	24.9	028.6	93	68	23.3	22.2	02.7	4.0	6.3
40	30.1	24.1	045.2	95	75	22.3	22.7	03.6	3.0	4.2
41	30.2	23.3	008.6	89	71	20.4	20.8	04.6	3.4	3.5
42	30.7	21.4	0	91	56	18.9	18.0	02.0	3.5	8.6
43	28.8	22.6	032.6	96	73	20.5	20.4	03.9	2.7	2.1
44	30.5	17.3	0	92	38	15.5	12.1	00.7	3.5	8.9
45	30.0	16.7	0	91	37	14.4	11.2	00.6	3.1	8.2
46	27.5	13.2	0	91	36	11.6	09.6	01.0	2.8	7.6
47	30.3	16.7	0	87	40	13.0	12.4	01.5	3.2	7.3
48	30.0	15.6	0	83	35	12.0	10.8	01.6	3.5	8.4
49	28.1	11.8	0	91	31	10.4	08.3	01.3	3.1	8.5
50	27.7	09.8	0	90	27	08.9	07.3	01.3	3.0	9.0
51	28.1	11.7	0	90	34	10.1	09.2	01.6	2.6	8.0
52	28.3	12.7	0	93	40	10.8	10.9	00.9	2.6	6.5
1	28.6	28.6	0	90	40	11.1	11.0	00.7	2.6	6.9
2	27.8	27.8	0	90	47	11.5	12.5	01.6	2.5	5.4
3	29.0	29.0	0	89	46	13.0	12.0	02.5	2.8	4.6
4	28.2	28.2	0	87	38	11.0	10.0	02.3	3.5	7.0
5	28.8	28.8	0	86	28	08.5	07.9	02.0	3.7	9.5

Appendix-II

Mean performance of different characters of 24 Kalmegh genotype

Genotype	Days to 50% flowering	Plant height (cm)	No. of secondary branches	No. of tertiary branches	Internode Length (cm)	Pod length (cm)	Seed no pod^{-1}	Leaf length (cm)	Leaf width (cm)	Chlorophyll content	Petiole length (cm)	Canopy Temperature	Collar girth (cm)	Fresh herbage yield(g)	Dry herbage yield(g)
IKM-1	152.50	61.20	31.50	159.50	4.15	2.05	10.50	7.40	2.40	36.85	0.90	30.65	2.30	30.50	13.60
IKM-2	145.50	71.95	27.50	103.00	4.25	2.20	10.50	8.40	2.25	39.80	1.15	30.25	2.20	21.20	10.95
IKM-3	149.00	60.80	22.50	52.00	3.45	2.45	11.00	8.75	2.20	38.00	0.80	30.65	1.70	16.30	5.55
IKM-4	149.50	57.15	23.50	40.50	3.25	2.45	10.50	9.10	2.35	38.65	0.90	29.85	1.45	6.95	2.80
IKM-5	144.50	72.50	24.00	46.50	3.65	2.55	11.00	7.70	2.20	38.05	1.10	30.60	1.95	17.75	7.25
IKM-6	149.00	57.10	30.00	54.50	2.60	2.50	11.50	7.10	2.05	39.30	0.70	30.15	1.35	16.20	7.80
IKM-7	155.50	57.55	27.00	63.00	3.55	2.35	11.50	7.90	2.30	36.40	0.80	31.60	1.40	30.50	12.85
IKM-8	157.50	55.95	24.00	74.50	3.10	2.40	11.50	8.80	2.50	36.75	0.90	30.50	1.60	11.25	4.20
IKM-9	148.50	72.30	32.50	124.50	3.06	2.40	10.00	8.40	2.65	40.60	1.00	30.65	1.60	10.85	3.60
IKM-10	146.00	43.95	21.00	43.00	3.20	2.30	10.50	7.90	1.90	38.30	0.70	30.60	1.35	8.15	3.05
IKM-11	152.00	43.15	20.00	37.50	3.35	2.30	10.50	7.15	1.85	36.45	0.95	29.95	1.45	12.25	4.80
IKM-12	154.00	49.10	26.00	41.50	4.00	2.20	10.50	7.65	1.75	36.75	1.10	29.95	1.35	12.55	4.95
IKM-13	122.00	46.20	24.50	50.50	3.40	2.20	10.50	7.65	2.70	37.70	1.15	31.55	1.60	17.80	4.80
IKM-14	157.50	59.20	31.50	103.50	3.20	2.15	11.50	8.55	3.20	38.00	0.90	31.55	1.75	14.50	6.00
IKM-15	161.00	46.20	29.50	87.50	2.80	2.35	10.50	7.90	3.00	32.30	0.90	32.25	1.55	14.75	6.40
IKM-16	167.50	45.50	22.00	31.00	3.30	2.25	11.50	7.80	3.10	34.30	0.80	32.00	1.55	14.00	5.00
IKM-17	156.50	45.20	30.00	82.50	3.30	2.25	10.50	8.00	1.90	37.80	0.90	30.90	1.85	14.60	5.80
IKM-18	160.50	51.25	24.00	51.00	3.80	2.20	11.50	8.70	1.75	33.95	1.10	31.75	1.70	14.25	4.95
IKM-19	160.50	42.70	22.50	31.00	3.35	2.25	11.00	7.90	2.25	33.25	0.90	30.55	1.60	11.75	3.80
IKM-20	160.00	58.15	23.00	34.50	3.25	2.25	11.50	9.00	2.30	32.75	0.80	30.50	1.35	25.90	8.90
IKM-21	159.50	59.85	31.00	55.00	3.30	2.55	11.00	9.15	2.30	38.80	1.05	29.00	1.55	21.60	9.80
IKM-22	154.00	70.95	25.00	73.50	3.85	2.20	11.00	8.35	2.15	41.90	0.80	30.60	1.60	19.15	7.10
IKM-23	153.50	66.50	28.50	49.00	3.25	2.25	11.00	7.70	2.05	43.45	0.80	29.95	1.50	20.80	9.50
IKM-24	160.50	60.75	25.00	51.50	3.80	2.27	10.00	8.70	2.30	40.95	0.80	29.80	1.95	22.75	12.00

Indian Journal of Plant Genetic Resources

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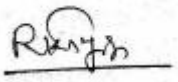

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