EVALUATION OF MEDICINAL COLEUS [*Plectranthus forskohlii* (Willd) Briq.] GENOTYPES FOR GROWTH, TUBEROUS ROOT YIELD AND SUITABILITY FOR PICKLING

TAMMANNA M. WAGH

DEPARTMENT OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS
KITTUR RANI CHANNAMMA COLLEGE OF HORTICULTURE, ARABHAVI – 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES, BAGALKOT- 587 102

JULY, 2013

EVALUATION OF MEDICINAL COLEUS [*Plectranthus forskohlii* (Willd) Briq.] GENOTYPES FOR GROWTH, TUBEROUS ROOT YIELD AND SUITABILITY FOR PICKLING

Thesis submitted to the
University of Horticultural Sciences, Bagalkot
in partial fulfillment of the requirements for the
Degree of

MASTER OF SCIENCE (HORTICULTURE)

In

PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

By

TAMMANNA M. WAGH

DEPARTMENT OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS
KITTUR RANI CHANNAMMA COLLEGE OF HORTICULTURE, ARABHAVI – 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES, BAGALKOT- 587 102

JULY, 2013

DEPARTMENT OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS
Kittur Rani Channamma College of Horticulture, Arabhavi - 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES, BAGALKOT- 587 102

C E R T I F I C A T E

This is to certify that the thesis entitled "EVALUATION OF MEDICINAL COLEUS [*Plectranthus forskohlii* (Willd) Briq.] GENOTYPES FOR GROWTH, TUBEROUS ROOT YIELD AND SUITABILITY FOR PICKLING" submitted by TAMMANNA M. WAGH for the degree of MASTER OF SCIENCE (HORTICULTURE) in PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS, of the University of Horticultural Sciences, Bagalkot, is a record of research work carried out by him during the period of his study in this university, under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

Place: Arabhavi
Date: July, 2013

(SHANKARGOUDA PATIL)
Chairman
Professor
Dept. of Plantation, Spices,
Medicinal and Aromatic Crops
KRCCH, Arabhavi

Approved by Chairman: ______________________________
(SHANKARGOUDA PATIL)

Members: 1. ______________________________
(P. M. GANGADHARAPPA)

2. ______________________________
(PRABHULING. G.)

3. ______________________________
(A. M. SHIROL)

4. ______________________________
(R. B. NAIK)

5. ______________________________
(G. H. KRISHNAMURTHY)

ACKNOWLEDGEMENT

Any success requires the effort of many people and this work is not different. I would like to acknowledge the cooperation and assistances of every individual during my study period, who have assisted me, bring out my thesis.

First of all my sincere gratitude with great reverence to Dr. SHANKARGOUDA PATIL, Professor, Department of Spices Plantation Medicinal and Aromatic crops, Kittur Rani Channamma College of Horticulture, Arabhavi and the Chairman of my advisory committee for his untiring knowledgeable guidance and constant encouragement, and also for his support from all aspects in materialising my master degree into a reality.

It is my privilege to work under Dr. N. K. HEGDE, Professor and head, Department of Spices Plantation Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi for his constant encouragement, statutory advices and continuous support during my study period. I express my sincere gratitude and respect towards him.

I extend my gratitude to Dr. P. M. GANGADHARAPPA, Professor, Department of Spices Plantation Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi and member of my advisory committee for his guidance and help in the preparation of the thesis.

I am highly thankful to Dr. PRABHULING. G., Associate Professor, Department of Crop Improvement and Biotechnology, Kittur Rani Channamma College of Horticulture, Arabhavi and member of my advisory committee for his guidance and help in the preparation of the thesis.

I am highly thankful to Mr. A. M. SHIROL, Associate Professor and head of All India Co-ordinated Research Project (TF), Kittur Rani Channamma College of Horticulture, Arabhavi and member of my advisory committee for his guidance and help in the preparation of the thesis.

I am highly thankful to Mr .R. B. NAIK, Associate Professor, Department of Statistics, Kittur Rani Channamma College of Horticulture, Arabhavi and member of my advisory committee for his guidance and help in the preparation of the thesis.

I am highly thankful to Mr. G. H. KRISHNAMURTHY, Associate Professor, Department of Agricultural Engineering, Kittur Rani Channamma College of Horticulture, Arabhavi and member of my advisory committee for his guidance and help in the preparation of the thesis.

I avail myself of this opportunity to express my sincere thanks to Dr. M. S. Kulkarni, Dean, KRCCH, Arabhavi, Dr. S. I. Hanamashetti, Former Dean, KRCCH, Arabhavi, Dr. M. Vasundhara, Professor, Department of Horticulture, GKVK, UAS, Bangalore, Mr. J. S. Hiremath Assistant Professor, Dept. of PMA and Dr. Laxminarayan Hegde, Professor, Department of Plantation, Spices, Medicinal and Aromatic plants, COH, Sirsi, for their continues suggestions and cooperation throughout my studies.

I feel the inadequacy of my diction to find a more suitable word for a whole hearted thanks to my parents Sri. Maruti, Wagh and Smt. Akkavva, M. Wagh, brothers Anil and Manoj and all my relatives for their boundless love, unflagging interest and constant encouragement put confidence in me to reach this level.

I express my deep sense of gratitude to my friends 14th batch of Hortico's of Collage of Horticulture, Arabhavi for their help, inspiration and encouragement during the course of study, without them I would not have been possible to complete this work.

Words fall short for expressing my feelings to the affectionate friends Manjunath Hakkaldawar, Chandan, K. A, Ravi, J. P, Rahul, P, Shivanad. M. R, Rashmi, R, Chandrashekar, C. M (chita),Sreedhar, K. S, Mahesh, Giriraj, Paramappa, Siddappa, Anil, Nagaraj(uppi), Ramdas, Abhishek, Vijith, H, Nagaraj, K. S, Shivakumar, G, Prashanth, Praveen, Shabarish, Ajit, Anand, Ravi, Satish, Vinod, Mahboob, Nagesh, Basavaraj, Parashuram, Umesh, Shivanand, R, Hanamanth, Gururaj, Sangamesh, Samiyuddin, Lakkappa, Shivanand, K, Sachin, Santhosh, Chandrakanth, Abhijith, Sreekanth, *Kiranshankar, Tyagaraj, Vijaykumar, Honnappa, Chandrashekar, Ganesh, Amrut, Akshay, Chandrashekar, M, Shreedhara, K, and all my junior and senior friends who were the main spirit behind my success and in completion of my degree programme.*

I am thankful to Shantinat, B, Diwakar, for giving coleus cuttings during research work.

I am thankful to Mr. Doddamani, Field Assistant, and Department of Plantation, Spices, Medicinal and Aromatic plants, for his encouragement during the studies. I am extremely thankful to Hanamanth Jalli, Shivappa, Gudasab, Ramesh and Basavaraj, Smt. Kashamma, Smt. Sharamma and Smt. Chinnamma and other field workers for their constant support and help during the course of my investigation.

End is inevitable for any kind of work. Though acknowledging is an endless task, I end by saying infinite thanks to all those whom I am able to recall here and also to those whom I might have left unknowingly.

ARABHAVI

JULY, 2013 (Tammanna M. Wagh)

Affectionately dedicated to

My Parents, Brothers,

Teachers, Friends and Tiger

CONTENTS

Sl. No.	Chapter Particulars	
	CERTIFICATE ACKNOWLEDGEMENT LIST OF TABLES LIST OF FIGURES LIST OF PLATES LIST OF APPENDIX	
1	INTRODUCTION	
2	REVIEW OF LITERATURE	
	2.1	Evaluation of medicinal coleus genotypes for growth and yield
	2.2	Evaluation of other medicinal plants for growth and yield
	2.3	Evaluation of medicinal coleus genotypes for pickling
3	MATERIAL AND METHODS	
	3.1	Geographical location of the experimental site
	3.2	Climate
	3.3	Experimental details
	3.4	Statistical analysis and interpretation
4	EXPERIMENTAL RESULTS	
	4.1	Evaluation of medicinal coleus genotypes for growth and yield
	4.1.1	Growth parameter
	4.1.2	Yield parameter
	4.2	Evaluation of medicinal coleus genotypes for pickling
	4.2.1	Sensory evaluation of pickles of medicinal coleus genotypes
5	DISCUSSION	
	5.1	Evaluation of medicinal coleus genotypes for growth and yield
	5.2	Evaluation of medicinal coleus genotypes for pickling
6	SUMMARY AND CONCLUSIONS	
	6.1	Evaluation of medicinal coleus genotypes for growth and yield
	6.2	Evaluation of medicinal coleus genotypes for pickling
	6.3	Conclusion
	6.4	Future line of work
	REFERENCES	
	APPENDIX	

LIST OF TABLES

Table No.	Title
1.	Collection of coleus genotypes from different places
2.	Plant height in medicinal coleus genotypes at different stages of crop growth
3.	Plant spread (cm^2) in medicinal coleus genotypes at different stages of crop growth
4.	Stem diameter in medicinal coleus genotypes at different stages of crop growth
5.	Total number of branches per plant in medicinal coleus genotypes at different stages of crop growth.
6.	Number of leaves per plant in medicinal coleus genotypes at different stages of crop growth.
7.	Leaf length in medicinal coleus genotypes at different stages of crop growth
8.	Leaf breadth in medicinal coleus genotypes at different stages of crop growth
9.	Petiole length in medicinal coleus genotypes at different stages of crop growth
10.	Internodal length in medicinal coleus genotypes at different stages of crop growth
11.	Number of inflorescence per plant in medicinal coleus genotypes at different stages of crop growth
12.	Inflorescence length in medicinal coleus genotypes at different stages of crop growth
13.	Tuber characters, fresh weight, dry weight and per cent dry matter content of herbage in medicinal coleus genotypes at harvest (150 DAP)
14.	Fresh weight, dry weight, and per cent dry matter content of tubers and yield of medicinal coleus genotypes at harvest (150 DAP)
15.	Sensory evaluation of medicinal coleus genotypes for pickles

LIST OF FIGURES

Figure No.	Title
1	Plan and layout of experiment
2	Tuber characters of medicinal coleus genotypes
3	Total dry matter accumulation of medicinal coleus genotypes
4	Sensory evaluation of medicinal coleus genotypes for pickles
5	Fresh and dry weight of tubers of medicinal coleus genotypes
6	Tuber yield of medicinal coleus genotypes

LIST OF PLATES

Plate No.	Title
1	General view of experimental plot
2	Vegetative growth characteristics of different medicinal coleus genotypes
3	Tuber characteristics of medicinal coleus genotypes
4	Tuber characteristics of medicinal coleus genotypes
5	Superior genotypes of medicinal coleus

LIST OF APPENDIX

Sl. No.	Chapter Particulars
I.	Meteorological data recorded during the experimental period (May 2012 to November 2012) at Agricultural Research Station, Arabhavi

1. INTRODUCTION

Medicinal plants traditionally occupied an important position in rural and tribal lives of India and are considered as one of the most important sources of medicines since the dawn of human civilization. One such important medicinal plant is medicinal coleus [*Plectranthus forskohlii* (Willd) Briq.]. It is an ancient root drug recorded in Ayurvedic Materia Medica under the sanskrit name '*Makandi*' and '*Mayani*'. *Plectranthus forskohlii* [(Willd) Briq.] (*Coleus forskohlii* Briq.), belonging to the family Lamiaceae is an important medicinal plant indigenous to India. It is a perennial herb, popularly known as '*mainmool*' or '*makandiberu*' or '*mangani beru*' in the state of Karnataka and '*garmar*' in Maharashtra. Though medicinal coleus is distributed in tropical East Africa, Arabia, Brazil, Egypt and Ethiopia, Indian sub continent is believed to be the place of origin (Valdes *et al*., 1987). It is distributed in subtropical Himalayas from Garwal to Nepal upto an altitude of 2500 m. It is also grown in Rajasthan, Gujarat and South India and cultivated to a limited extent in Maharashtra, Gujarat and Karnataka mainly its tuberous roots which are pickled and eaten. Its roots occasionally used in Indian ayurvedic system of medicine have been subjected to detailed chemical investigation over the last four decades.

The tuberous roots of medicinal coleus yield forskohlin, a diterpenoid, which is used for glaucoma, asthma, congestive cardiomyopathy and certain cancers (De Souza *et al*., 1986). Roots are eaten for curing cough in Kumaon Himalayas and one to three tea spoonful of root decoction is recommended for treatment of asthma in Maharashtra. The leaves of the plant are given for the treatment of urinary and vaginal diseases. The essential oil obtained from the leaves is reported to possess antimicrobial activities. Tubers are used as antihelmintic for relief from constipation in infants, used to allay the burning sensation by the application of paste of fresh tubers. Paste prepared from the roots is mixed with mustard oil and is used for the treatment of skin infections by the natives of Kumaon Himalayas. Isolation and pharmacological evaluation of its active constituent, the forskolin resulted in the large scale indiscriminate collection of this plant from wild sources. The area under its cultivation is meager, the statistics on its exact area and production are lacking and it is cultivated in parts of Rajasthan, Maharashtra, Karnataka and Tamil Nadu in an area of about 2500 ha (Sharma, 2004).

Coleus is a perennial plant that grows to about 45 - 60 cm tall. It has four angled stems that are branched and nodes are often hairy, leaves are 7.5 to 12.5 cm in length and 3 to 5 cm in width, usually pubescent, narrowed into petioles. The root is typically golden brown, thick, fibrous and radially spreading. Roots are tuberous, fasciculated, 20 cm long and 0.5 to 2.5 cm in diameter, conical fusiform, straight, orange-red within and strongly aromatic. Inflorescence is raceme, 15 – 30 cm in length and flowers are stout, 2 to 2.5 cm in size, usually perfect and calyx hairy inside. Upper lip of calyx is broadly ovate and blue or lilac corolla is bilabiate. Lower lobes are elongated and concave so that they enclose the essential organs and ovary is four parted and stigma is two lobed. The flower is cross-pollinated and pollinating agents are wind or insects. It is propagated by terminal cuttings, because of the asexual method of perpetuation of this crop it is crop improvement through selection and mutation breeding.

It is the only known natural source of forskohlin. Due to its multifaceted pharmacological effects, forskolin is used for treatment of eczema (atopic dermatitis), psoriasis, cardiovascular disorders and hypertension, where decreased intracellular cyclic AMP level is believed to be a major factor in the development of disease process. The novel feature of forskolin is its unique mechanism of generating cyclic Adenosine Mono phosphate (cAMP) in the cells through the direct activation of the catalytic unit of the adenylate cyclase enzyme. It has been traditionally used to treat high blood pressure and other benefits including, to reduce weight, to improve digestion and nutrient absorption, to fight against cancer and boosting the immune system. The drug is also claimed to improve appetite, facilitate digestion, increase vitality and is useful against anaemia, inflammation, flatulence, dropsy, glaucoma, insomnia and convulsions. It grows wild as an indigenous medicinal plant and the knowledge of its variability is an essential prerequisite for direct exploitation as a cultivar and indirectly as a base material for breeding programmes. Vegetative method of propagation adopted in this species for commercial cultivation heightens the prospects of utilizing the superior genotypes indentified in the present study. In this species, occurrence of wide genetic diversity in nature for tuber yield has been reported by earlier workers (Hegde, 1992 and Vishwakarma *et al*., 1988). Though there have been several earlier studies on evaluation of medicinal coleus not much progress has been achieved for its exploitation as a condiment. The present study is undertaken to assemble the variability in coleus for its utility as a condiment.

Alternatively, the tubers of medicinal coleus are exploited for use as a condiment in pickle making in Karnataka and Tamil Nadu. Compared to the extensive studies on its screening for use as medicinal plant, the studies on its utility as a condiment are few. Patil *et al*. (2001) and Kavitha *et al.* (2009) evaluated medicinal coleus genotypes for use as condiment in pickling. Hence, the present investigation is taken under Ghataprabha Left Bank Canal (GLBC) command area with following objectives.

1. To study the performance of coleus genotypes for growth and tuberous root yield.

2. To evaluate the genotypes for their suitability for pickling.

2. REVIEW OF LITERATURE

Medicinal coleus [*Plectranthus forskohlii* (Willd) Briq.] is a perennial herb and it grows wild throughout India. Isolation and evaluation of forskolin lead to large scale indiscriminate collection of this plant from wild sources. Alternatively the tubers of medicinal coleus are used as condiment in pickle making (Kavitha *et al*., 2009). To meet its ever increasing demand, to bring the plant under cultivation and supply raw materials for small scale industries, identification of superior plant types is a pre-requisite. Hence, the present study was taken up to identify variability among the genotypes for root yield and forskohlin content and suitable types for use as condiment. So, the literature is reviewed on the variability in medicinal coleus and its use as condiment and presented in this chapter under the following subheadings – 2.1, 2.2 and 2.3.

2.1 Evaluation of medicinal coleus genotypes for growth, tuber yield and quality parameters

Vishwakarma *et al*. (1988) screened large number of genotypes (38) collected from diverse sources for forskohlin content and root yield. The forskohlin content showed a wide range of variation from 0.01 to 0.44 per cent. The highest content of forskohlin was recorded in IH-1 genotype. The dry root yield ranged from 16.6 to 203.3 g per plant. The forskohlin yield per plant varied from 0.004 to 0.803 g. Collection KM-2, recorded high root yield of 200.7 g per plant with forskohlin content of 0.4 per cent and proved superior by virtue of forskohlin yield of 0.803 g per plant.

Hegde (1992) studied the genetic variability present in coleus. Higher heritability was observed for total dry matter content, fresh weight of roots, harvest index and root diameter. Parameters such as total dry matter content, fresh weight of roots and harvest index recorded high phenotypic and genotypic variability.

Misra *et al*. (1994) reported the presence of wide variability in the essential oil contents of both diploids and tetraploids. The essential oil contents ranged from 0.03 to 0.19 per cent among different accessions.

Patil *et al*. (2001) reported significant differences among six diverse genotypes for plant height, plant spread, number of branches, number of leaves, lamina length, lamina breadth, fresh and dry weight of tubers and essential oil content.

Himabindu *et al*. (2005) evaluated fifty nine accessions of coleus for genetic variability and association between growth and tuber traits. Significant variability was observed among the accessions for all the traits studied. Root/shoot ratio, harvest index, root fresh weight, root dry weight recorded high genotypic coefficient of variation, heritability and genetic advance as per cent mean. Root diameter was positively correlated with collar diameter and root dry weight. Root yield has shown a strong positive association with root diameter, total dry weight and harvest index. They concluded that selection for traits like root diameter and harvest index may increase the root yield in coleus.

Hegde *et al*. (2005) evaluated thirteen accessions of coleus, a forskohlin yielding aromatic herb with fasciculate tuberous roots. Significant differences were recorded for all the characters except dry mass of roots. Maximum tuber number per plant (12.0) was in IIHR-59. Accession IIHR-59 also produced highest fresh and dry weight of tubers (870 g and 88.75 g, respectively) per plant. The harvest index was maximum (45.1%) in IIHR-80. The forskohlin content was estimated using HPLC and was found to vary from 0.025 per cent (IIHR-1) to 0.798 per cent (IIHR-12). Forskohlin yield per plant was highest in IIHR-7 (85.00 mg). The accession IIHR-80 with medium tuber yield and higher forskohlin content (0.715%) can be promoted for commercial cultivation as the crop can be propagated through vegetative means.

Swamy *et al*. (2006) evaluated twenty genotypes of coleus for estimation of genetic variability, heritability and genetic advance as per cent of mean. The genotypes varied significantly from one another for all the traits studied. The maximum fresh tuberous root yield was recorded in genotype SL-2. Whereas, the dry tuberous root yield was maximum in the genotype 17-1 and the forskolin content was found to be maximum in the genotype K-8/6. Phenotypic variance was higher than genotypic variance for all the eleven characters studied. Heritability was higher for all the traits except for leaf area and genetic advance as per cent of mean was also higher for all the eleven characters studied.

Kavitha *et al*. (2007a) studied the eleven qualitative and fourteen quantitative traits of coleus to assess the morphological variations available among thirty seven genotypes. For qualitative traits, a large number of genotypes out of thirty seven clustered together at 74 per cent similarity in four different groups. The dendrogram based on fourteen quantitative traits for the same set of genotypes did not reveal a clear pattern in grouping and the genotypes were grouped into ten different clusters. Cluster analysis of various sets of data revealed different groups of genotypes for each of the data set. A poor congruence observed among data sets of qualitative and quantitative traits in the comparison indicated that the morphological traits are not suitable for precise discrimination of closely related genotypes in coleus.

Kavitha *et al*. (2007b) evaluated thirty seven genotypes of coleus for studying variability in morphological traits. Eleven morphological traits of coleus were evaluated to estimate the mean, range, genetic variability, heritability and genetic advance. They reported high heritability and high genetic advance was observed for the characters *viz.*, plant height, number of leaves , number of roots per tubers, root per tuber length, root per tuber girth and foliage weight. They concluded that high heritability linked with high genetic advance of these traits indicates that improvement could be made possible through selection based on these characters.

Revadigar *et al*. (2008) studied the influence of genetic and environmental factors on the production of secondary metabolites in coleus. Fresh plant material and dry tuber roots were collected in the same season from seven different geographical regions of India. HPLC analysis has indicated the presence of optimum amount of forskohlin and 1, 9-dideoxyforskolin in the samples from Arkot (0.85% and 0.38%, respectively), Bangalore (0.66% and 0.24%, respectively) and Salem (0.56% and 0.27%, respectively). But 1, 9-dideoxyforskolin was absent and variation in the content of forskohlin was observed in Dharwad (0.69%), Hyderabad (0.5%), Baroda (0.33%) and Arabhavi (0.32%) samples. HPTLC fingerprint showed variation in the number of bands for each accession. Excluding the Dharwad accession, RAPD analysis of the other six accessions demonstrated a prominent genetic relationship among themselves. The agro climatic conditions of Arkot (21°0^1 E 77°0^1 N), Bangalore (13°5^1 E 77°35^1 N) and Salem (11°36^1 E 78°36^{1}N) were found to be suitable for commercial cultivation of this medicinal plant.

Velmurugan *et al*. (2009) reported that the plant height, number of branches per plant, number of leaves per plant, number of tubers per plant, tuber length and tuber girth were found to have positive and highly significant correlation with root yield. However, forskolin and essential oil content showed negative correlation with yield. Path analysis of component characters on yield of coleus in V_2M_1 (second vegetative generation with mutagenic treatment) generation exerted positive direct effect through the characters plant height, number of leaves per plant, and number of tubers per plant. Similarly, direct effect was observed to be negative through number of branches per plant (-0.930), total alkaloids (-0.066) and forskohlin content (-0.026). They concluded that residual effect 0.158 indicating the accuracy and appropriate selection component character for crop improvement programme.

Kavitha *et al*. (2010) reported that tuber/root yield contributed maximum towards total divergence. Leaf area index, harvest index and total dry matter production were the other important contributors for total divergence.

Bandeira *et al*. (2010) reported that higher genetic similarity was observed between the *Plectranthus neochilus* and *Plectranthus amboinicus* species (80%), followed by *Plectranthus grandis* and *Plectranthus barbatus* (77%). *Plectranthus barbatus* genotypes from Passo Fundo and Porto Alegre showed a genetic similarity which was close to 100 per cent, while the genetic similarity for *P. barbatus* genotypes from other locations was higher than 96 per cent. Although a low variability among genotypes of this species was found in this study, RAPD markers allowed a clear differentiation among the analyzed genotypes, showing a 53 per cent mean genetic similarity, with a high correlation value (r = 0.99), which proves a high agreement between the genetic similarity and clustering data.

Velmurugan *et al*. (2011) reported highest positive and significant genotypic correlation on yield with number of tubers per plant and it is followed by plant height. Other traits exhibited by positive and significant genotypic correlations with yield are number of laterals per plant, number of leaves per plant and tuber length, while the characters like forskolin content showed negative correlation with yield. The path analysis of component traits on yield exhibited positive direct effects through the characters, *viz.,* plant height, number of leaves per plant, number of tubers per plant, tuber length, tuber girth and essential oil content which resulted with a residual effect of 0.119. They concluded that direct selection of these characters will be effective. The direct effect was observed to be negative through number of laterals per plant, total alkaloid and forskohlin content.

2.2 Evaluation of other medicinal plants for growth and yield

1. Ashwagandha (*Withania somnifera* Dunal.)

Hegde and Shiragur (2003) reported that among 30 collections, accession KRC- 23 recorded significantly higher values for plant height (82.5 cm), North-South plant spread (46.25 cm), number of branches per plant (16.0), leaf length (13.37 mm), leaf breadth (8.54 cm), collar diameter (23.76 mm) and root diameter (7.82 mm).

Kumar *et al*. (2011) studied the morphological variants (morpho types) and the parental populations for root morphometric, quality and yield traits to study genetic association among them. Root morphometric traits (root length, root diameter and number of secondary roots/ plant) and crude fiber content exhibited strong association among them and showed significant positive genotypic correlation with yield. Starch-fiber ratio (SFR), determinant of brittle root texture showed strong negative association with root yield. The total alkaloid content had positive genotypic correlation with root yield. So genetic up gradation should aim at optimum balance between two divergent groups of traits *i.e.* root yield traits (root morphometric traits and crude fiber content) and root textural quality traits (starch content and SFR) to develop superior genotypes with better yield and quality.

Sangwan *et al*. (2013) evaluated twenty six diverse genotypes of ashwagandha for fourteen quantitative traits under rainfed conditions. Both phenotypic and genotypic coefficients of variation were higher for important traits like number of berries per plant, fresh weight of berries per plant, biomass yield at maturity and ratio of fresh above ground biomass: fresh root biomass. High heritability in conjunction with high genetic advance were observed for number of berries per plant, fresh weight of berries per plant, seed yield per plant, fresh root yield per plant, biomass yield at maturity and ratio of fresh above ground biomass : fresh root biomass which indicated predominant role of additive gene action for the expression of these characters. Fresh root yield per plant was found to be positively and significantly correlated with number of berries per plant, fresh weight of berries per plant, seed yield per plant and root diameter. Path analysis revealed that total alkaloid content showed the highest positive direct effect on fresh root yield per plant followed by biomass yield at maturity, seed yield per plant, root diameter and number of berries per plant, which suggested that selection for these traits would be quite effective to improve fresh root yield in ashwagandha.

2. Safed musli (*Chlorophytum borivillianum* Santapau and Fernades.)

Kothari and Singh (2001) observed the large variability for morphological and tuber yield attributing characters among different cultures tested. The culture CB/MS- 6 registered the highest number of leaves, leaf length, width, tubers, tuber thickness, fresh and dry weight of tubers per plant.

3. Glory lily (*Gloriosa superba* L.)

Chaitra and Rajamani (2009a) evaluated eighteen genotypes of Glory lily under tropical humid condition of Tamil Nadu. The genotype GS -15 exhibited superior performance for most of the characters, followed by GS -06. However, genotype GS -05 took maximum days to flowering, whereas maximum duration for fifty per cent flowering was recorded with GS -18. The genotype GS -7 exhibited the lowest PDI value and this genotype was considered as tolerant to leaf blight. Genotype GS -17 exerted poorest performance on various growth, flowering and yield attributes.

Chaitra and Rajamani (2009b) evaluated physiological and biochemical performance and correlation for yield and its quality characters of eighteen genotypes of glory lily. Genotypes GS -15, GS -06, GS -18, GS -03 and GS -02 were comparatively high yielding. The maximum leaf area, mean leaf area per plant, total chlorophyll, starch content and soluble protein content were observed in GS -15 while GS -12, recorded the highest total sugar content. Seed yield per plant exhibited highly positive significant correlation both at phenotypic and genotypic levels for eight traits. The remaining traits *viz.*, total sugar, mean leaf area, leaf area index and relative water content had negatively and non-significantly correlated with dry seed yield per plant both at phenotypic and genotypic levels.

Chaitra and Rajamani (2010a) reported that the maximum peroxidase, catalase and minimum polyphenol oxidase activities were observed in GS -15, while GS -12 recorded the highest total sugar content. The accession GS -15 excelled in the accumulation of starch, soluble protein and total phenol in tubers and thus can be utilized for extraction of colchicines and colochicoside.

Chaitra and Rajamani (2010b) evaluated eighteen glory lily genotypes to estimate character association and generate a path analysis for thirteen morpho-economic traits. Plant height, number of leaves per plant, number of branches per plant, days to 50 per cent flowering, number of flowers per plant, number of pods per plant, number of seeds per plant, fresh seed weight per plant, fresh seed yield per plant and fresh seed recovery were found to have positive association with dry seed yield per plant. Fresh seed yield per plant had highest positive effect on seed yield followed by number of pods per plant and fresh seed weight per pod. These associated yield components suggested that it may be good selection criteria to improve seed yield of Glory lily crop.

Chaitra and Rajamani (2010c) reported that the positive phenotypic and genotypic correlations of dry seed yield were found with number of flowers per plant, number of pods per plant, pod length, fresh pod yield per plant and fresh seed yield per plant in the first and second seasons and also for pooled analysis. These correlated yield components suggested that it may be good selection criteria to improve seed yield of glory lily crop.

Chaitra *et al*. (2013) reported that all genotypes of glory lily expressed significant variations for per cent disease index for leaf blight and varied from 21.73 to 64.48 per cent. The genotype GS -07 and genotype GS -05 exhibited the lowest disease index (21.73%) and highest disease index (64.48%), respectively. The per cent disease index exhibited highly positive significant correlation both at phenotypic and genotypic levels for phenol poly oxidase. But it had negative significant association with peroxidase, total phenol content and catalase activity. The genotype GS -07 exhibited the lowest PDI value and this genotype can be considered as tolerant to leaf blight.

4. Kalmegh (*Andrographis paniculata* Nees.)

Singh *et al*. (2001) observed wider genetic variation with regard to growth behavior, maturity period, dry biomass, leaf yield, per cent andrographolide content and its yield in three wild kalmegh populations, of which the Bangalore population significantly out yielded the Lucknow and Coimbatore populations in dry biomass, leaf yield and androgrgrapholide content.

Misra *et al*. (2003) noticed significant differences in mean performance value among thirty kalmegh accessions for characters like plant height, number of stem branches, leaf length, leaf width, fresh and dry biomass yield.

Raina *et al*. (2013) evaluated the wild growing populations of kalmegh collected from diverse locations to identify a suitable genotype with high andrographolide content. Andrographolide content ranged from 1.30 to 2.51 per cent among twenty two collections with mean andrographolide of 1.82 per cent. Promising collections identified were IC-342139 (2.51%), IC-471916 (2.16%), IC-111291 (2.20%) and IC-210635 (2.13%). Considering its value as a raw drug material, emphasis should be given for its commercial cultivation to get authentic raw material of known quality.

5. Periwinkle (*Catharanthus roseus* L. (G) Don.)

Singh *et al*. (1992) evaluated twenty seven germplasm lines of periwinkle, which exhibited wide range of variation for leaf yield and total leaf alkaloid content which ranged from 0.65 to 1.25 per cent.

Hegde and Gangadharappa (2002) observed significant variation for leaf length and breadth, dry leaf yield and root yield in seven improved genotypes (both pink and white flowered) of periwinkle.

Dwivedi *et al*. (1999) reported that the twenty six test genotypes varied significantly from one another for plant height, number of primary and secondary branches, leaf area index, total herbage yield, total fresh and dry leaf yield and per cent of total alkaloids.

6. Opium poppy (*Papaver somniferum* L.)

Singh *et al*. (2000) reported that the significant variations among thirty five genotypes of opium poppy for plant height, number of branches and number of leaves per plant.

7. Cowhage (*Mucuna pruriens* L.)

Vadivel and Janardhanan (2000) evaluated six accessions of cowhage among them Salem accessions registered the highest values for plant height, leaf area, number of branches and also early flowering.

2.3 Evaluation of genotypes of medicinal coleus for pickling

Traditionally the roots of medicinal coleus are used as condiments in the form of pickles. The quality parameters that contribute to the pickles of medicinal coleus are the sugars, starch and crude protein content. Research studies on the assessment of suitability of varieties for pickling in medicinal coleus are few. So the work done on the suitability of other crops for their processed products like suitability of varieties for cooking quality in sweet potatoes, frying quality in potatoes, for making chuharas in ber, for canning in mangoes *etc.*, were reviewed.

Patil *et al.* (2001) studied the acceptability of the pickles prepared from different accessions of coleus and revealed that pickles prepared from accession C-2 were highly acceptable.

Kavitha *et al.* (2007c) evaluated variation in starch accumulation in the leaves and tuberous roots in thirty seven genotypes of coleus. Wide variations for starch accumulation has been noticed among the genotypes and the tuberous genotypes accumulated less starch in the leaves than non tuberous genotypes which was confirmed by the microtome sections. However the starch accumulation was greater in the tuber in the tuberous genotypes than in non tuberous genotypes.

Kavitha *et al.* (2009) evaluated thirty seven coleus genotypes collected from various places of the important coleus growing states *viz.*, Tamil Nadu and Karnataka and were evaluated for total sugars, starch and crude protein contents to assess its suitability for edible purpose as condiment. The genotypes exhibited remarkable variations for all the characters studied. The total sugar, starch and crude protein content in the fresh tubers varied from 5.90 to 10.03 g, 6.97 to 20.94 g and 6.14 to 9.05 g per 100 g, respectively. The genotype CF-37 excelled in the accumulation of total sugars, starch and crude protein in tubers and thus can be utilized for both medicinal as well as edible purposes as condiment.

Pant and Kulashrestha (1994) evaluated the frying quality of six potato varieties. Of which the varieties evaluated for biochemical composition, Kufri Chandramukhi was having the lowest reducing sugar (0.94%) and total phenols (30.3 mg/ 100 g) and Kufri Badshah was having the highest starch content (12-15%) and were rated as superior for making chips. Whereas, JH -222 having the highest total phenols and JI -4486 having the highest reducing sugars and hence, were rated as inferior for making chips. The varieties Kufri Bahar and Kufri Jyothi were rated intermediate in suitability for the purpose of making chips.

Poonam *et al.* (1997) evaluated four varieties of ber, Sanaur-2, Sanaur-3, Sanaur-4 and Nalagarh for making ber chuharas. Ber cultivars were harvested at early ripe stage and dried in a mechanical drier at 65±2°C. After thirty one hour of dehydration, Sanur-3 and Nalagarh were found to have maximum dry weight (26%), followed by Sanaur-2 (25%), and Sanur-4 (23%), respectively. Organoleptically all the varieties were acceptable at 6 months storage as ber chuharas.

Doreyappagowda and Ramanjaneya (1995) evaluated eleven mango varieties for their suitability for canned mango juice. Alphonso was found to be the best for canned juice preparation due to its very good color, consistency and flavour. Bangenapalli, Kesar, and Langra gave canned juice comparable to Totapuri, which is commonly used by the canning industry.

Pasare *et al.* (1996) evaluated the cooking quality of selected sweet potato cultivars *i.e.* Belgaum local, Vikram, Srivardhan, I-57, CI-85413 for all components except for ash which ranged between 4.42 to 4.55, starch (71.66 to 84.66), total sugars (5.35 to 16.99) and reducing sugar (0.53 to 1.62) were differed among varieties on dry weight basis. The ascorbic acid content was ranged between 16.13 to 23.42 mg per 100 g. Acceptability of sweet potato variety upon boiling showed that the samples, Belgaum local scored highest and was *on par* with vikram. However there were no significant difference for texture, taste and flavor among the varieties. All the varieties were found to be acceptable.

Archana (1998) studied the suitability of nine potato cultivars for processing based on their biochemical composition and colour of fresh fried chips. They rated Kufri Kuber and Kufri Jawahar as acceptable for chips making, while Kufri Badashah, Kufri Sutlej, Kufri Lalima, Kufri Ashoka and Kufri Bahar were rated inferior.

3. MATERIAL AND METHODS

An investigation was carried out to evaluate the medicinal coleus genotypes for growth, tuber yield and suitability for pickling at the Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkot during May, 2012 to November, 2012. The details of the materials used and methods followed during the course of investigation are presented in this chapter.

3.1 Geographical location of the experimental site

Arabhavi is situated in Northern Dry Zone of Karnataka state at 16°15' North latitude and 94°45' East longitude. It is located at an altitude of 612 m above mean sea level. Arabhavi lies in Zone-3, Region-2 of agro-climatic zone of Karnataka. The region is commonly known as Ghataprabha Left Bank Canal (GLBC) command area as the area is under the coverage of the canal water from Hidkal Dam.

3.2 Climate

The average total rainfall of this area is about 650.2 mm per year, which is distributed over a period of seven to eight months from May to November with peaks during September. The meteorological data for the period of experimentation recorded at the meteorological observatory at Agricultural Research Station, Arabhavi, is presented in Appendix I.

3.3 Experimental details

Two experiments were conducted during the course of the study *i.e.*

I. Evaluation of medicinal coleus genotypes for growth and tuber yield.

II. Evaluation of genotypes of medicinal coleus for pickling.

3.3.1 Experiment-I: Evaluation of medicinal coleus genotypes for growth and tuber yield

3.3.1.1 Experimental material

Ten genotypes of coleus were used in the experiment. The geographical origin of genotypes used in the study is presented in Table 1.

3.3.1.2 Nursery operations

The unrooted cuttings from the terminal portion of each genotype were planted in polythene bags filled with 1:1 (v/v) mixture of well decomposed Farmyard manure (FYM) and red soil. The cuttings were watered daily till 30 days in the nursery.

Table 1: Collection of coleus genotypes from different places

Sl. No	Place of collection	Local Name of genotype	Code Number/Variety
1	Hiriyur	Hiriyur local	KRCCH-1
2	Bastwad	Bastwad local	KRCCH-2
3	UAS, Bangalore	Released variety	Aisiri
4	Belgaum	Belgaum local	KRCCH-3
5	Alarwad	Alarwad local	KRCCH-4
6	Chikkodi	Chikkodi local	KRCCH-5
7	Arabhavi	Arabhavi local	KRCCH-6
8	Arabhavi	Released variety	K-8
9	Madapur	Madapur local	KRCCH-7
10	Magihundi	Magihundi local	KRCCH-8

3.3.1.3 Preparation of the experimental plot

The experimental area was ploughed and harrowed by tractor drawn cultivator and leveled. The clods were crushed; weeds were removed and brought to fine tilth. Well decomposed FYM was applied a fortnight before transplanting, at the rate of 10 tons per hectare and mixed thoroughly in the soil. The ridges and furrows were opened at spacing of 60 cm. The net plot size was 4.32 sq. m and provision was made for irrigation channels.

3.3.1.4 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and ten genotypes during the year 2011-2012. The layout plan of the experiment is shown in Fig. 1.

3.3.1.5 Transplanting

After 30 days in the nursery, the rooted cuttings of each genotype were transplanted in the main field at a spacing of 60 x 45 cm. The polythene bags were removed without disturbing the root system and planted with minimum damage to the system.

The plants were applied with recommended dose of fertilizers at 40 : 60 : 50 kg N:P:K per ha in the form of urea, super phosphate and muriate of potash. Nitrogen was applied in split doses, 50 per cent nitrogen was applied as basal dose at the time of planting along with super phosphate and muriate of potash and remaining 50 per cent of nitrogen was top dressed at 30 days after transplanting.

3.3.1.6 Weeding and irrigation

The plots were kept weed free by hand weeding at 30, 60, 90 and 120 days after transplanting. The plots were irrigated once in three days in the initial stages of establishment and the irrigation frequency was reduced to once in seven to ten days at the later stages.

3.3.1.7 Plant protection

After 30 days of transplanting, the plants were applied with carbofuron (3G) @ 10 g per plant for the control of nematode. Also monocrotophos @ 1 ml per litre of water was sprayed twice for the control of damage by leaf eating caterpillars and sucking pests.

3.3.1.8 Harvesting

The crop was harvested at 150 days after transplanting. While harvesting, the crop was cut at 2-3 cm above the ground level with the help of a sharp sickle and tuberous roots were harvested by digging with the help of axe pick. Later tuberous roots were washed in running water.

R-I	R-II	R-III
KRCCH-1	Aisiri	KRCCH-2
Aisiri	KRCCH-4	KRCCH-3
KRCCH-4	KRCCH-5	KRCCH-8
KRCCH-6	KRCCH-7	K-8
KRCCH-7	KRCCH-8	KRCCH-1
KRCCH-3	KRCCH-2	KRCCH-4
KRCCH-5	KRCCH-6	Aisiri
K-8	KRCCH-1	KRCCH-5
KRCCH-2	KRCCH-3	KRCCH-6
KRCCH-8	K-8	KRCCH-7

Fig. 1. Plan and layout of experiment

3.3.1.9 Collection of experimental data

Five plants in each plot were selected at random avoiding the border row plants and they were tagged for recording observations on various growth and yield parameters.

3.3.1.9.1 Growth parameters

1. Plant height: Plant height was measured from ground level to the tip of the tallest branch and expressed in centimeter.

2. Plant spread: Plant spread calculated by multiplying in spread along north-south and east-west directions and was expressed in centimeter square.

3. Number of branches per plant: The number of primary and secondary branches per plant were counted and recorded.

4. Number of leaves per plant: This was estimated by counting the actual number of leaves present in one fourth of the canopy and multiplied by four (Hegde, 1992 and Naniah, 1993).

5. Leaf length: Lamina length of the fourth leaf from the top was measured and expressed in centimeter.

6. Leaf breadth: Lamina breadth of the fourth leaf from the top was measured and expressed in centimeter.

7. Petiole length: Petiole length of the fourth leaf from the top was measured and expressed in centimeter.

8. Internodal length: The length of the internode between the fourth and fifth pair of leaves was measured and expressed in centimeter.

9. Stem diameter: This was measured at the ground level using vernier calipers and expressed in centimeter.

10. Number of inflorescences per plant: The number of inflorescence spikes were counted and recorded as number of inflorescences per plant in genotypes.

11. Length of inflorescences per plant: The length of flowering spike was measured and recorded in centimeter.

3.3.1.9.1 Yield parameters

1. Number of tubers per plant: Total number of tubers was counted from each of the five selected plants and average was worked out.

2. Length of tubers: Length of the tuberous portion was measured in centimeter. Six tubers were drawn from each genotype at random and their mean length was calculated.

3. Diameter of tubers: The diameter of the tubers at the thickest portion was measured in centimeter using vernier calipers. The mean diameter of six randomly selected tubers per plant was calculated.

4. Density of tubers: Density of tubers was calculated by dividing fresh weight of tubers by the volume of tubers and expressed as gram per cubic centimeter.

5. Fresh weight of tubers (g/plant): Fresh weight of the tubers per plant was recorded after washing with water, using an electronic balance.

6. Dry weight of tubers (g/plant): After recording the fresh weight of tubers of five labeled plants they were dried in oven at 50°C till constant weight is achieved. When they attained constant weight, the dry weight was taken. The mean dry weight was calculated and expressed in gram.

7. Dry matter of tuber: Dry matter of tuber was worked out by the following formula and expressed in percentage.

$$\text{Tuber dry matter (\%)} = \frac{\text{Dry weight of tubers}}{\text{Fresh weight of tubers}} \times 100$$

8. Fresh weight of herbage (g/plant): Fresh weight of the herbage per plant was recorded by using electronic balance.

9. Dry weight of herbage (g/plant): After recording the fresh weight herbage yield of five labeled plants they were dried in oven at 50°C till constant weights achieved. When they attained constant weight the dry weight was taken. The mean dry weight was calculated and expressed in terms of gram.

10. Dry matter of herbage (%): Dry matter of herbage was worked out by the following formula and expressed in percentage.

$$\text{Herbage dry matter (\%)} = \frac{\text{Dry weight of herbage}}{\text{Fresh weight of herbage}} \times 100$$

11. Total dry matter accumulation (g/plant): Total dry matter accumulation was worked out by the following formula.

Total dry matter accumulation = Dry wt. of tuber + Dry wt. herbage

12. Yield of tuber (kg/plot): The fresh tuber yield per plot was recorded at the time of harvest. The fresh tuber yield per plot was expressed in terms of kilogram.

13. Yield of tuber (t/ha): The yield of tubers per hectare was estimated by taking into account fresh weight of tubers per plot in each genotype and expressed as tons per hectare.

3.3.2 Experiment-II: Evaluation of medicinal coleus genotypes for pickling

3.3.2.1 Experimental material

Among ten genotypes of medicinal coleus, nine were used in the experiment because one genotype is non-tuberous type.

3.3.2.2 Experimental design

The experimental design followed for the evaluation of pickles was Completely Randomized Design (CRD).

Plate 1: General view of the experimental plot

3.3.2.3 Methodology

For pickling, tubers were harvested at 120 days after transplanting. The freshly harvested tubers of each genotype of coleus were washed and outer layer was peeled and cut into small pieces of 1.0 to 1.25 cm size and were pickled as per the procedure suggested for pickling of raw Mango (Anon, 1996). The ingredients used for pickling were common for all the genotypes.

The pickles so prepared were evaluated for organoleptic characters like taste and aroma, flavor and overall acceptability at 30 days after pickling. Panel of sixteen judges consisting staff members of Kittur Rani Channamma College of Horticulture, Arabhavi were selected for the evaluation of organoleptic characters on a five point hedonic scale (Ranganna, 1986).

3.4 Statistical analysis and interpretation

The data on various biometric observations collected during the study were subjected to statistical analysis by using the Fischer's analysis technique (Panse and Sukhatme, 1978). The results were compared at 5 per cent level of significance. The interpretation of the data was done using the critical difference values calculated at P = 0.05.

4. EXPERIMENTAL RESULTS

The results of the experiment on “Evaluation of medicinal coleus [*Plectranthus forskohlii* (Willd) Briq.] genotypes for growth, tuber yield and suitability for pickling” are presented in this chapter.

4.1 Evaluation of medicinal coleus genotypes for growth and tuberous root yield

4.1.1 Growth parameters

4.1.1.1 Plant height (cm)

The data pertaining to plant height (cm) in different coleus genotypes were recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) and is presented in Table 2. Significant difference for plant height was observed among the genotypes at all the crop growth stages.

At 30 days: The maximum plant height (39.83 cm) was observed in genotype KRCCH-4 which was statistically *on par* with KRCCH-2 (39.13 cm), KRCCH-1 (37.40 cm), KRCCH-6 (37.37 cm), and KRCCH-3 (36.47 cm). The least plant height (27.77 cm) was noted in genotype KRCCH-5.

At 60 days: The genotype KRCCH-1 was recorded highest plant height (51.40 cm) and was *on par* with KRCCH-3 (50.27 cm), KRCCH-2 (49.00 cm), KRCCH-8 (48.73 cm) and KRCCH-4 (48.60 cm). The least plant height (30.93 cm) was observed in genotype KRCCH-5.

At 90 days: The maximum plant height (61.67 cm) was observed in genotype KRCCH-3 which was *on par* with KRCCH-1 (57.87 cm) and KRCCH-7 (56.27 cm). The least plant height (27.20 cm) was observed in genotype KRCCH-5.

At 120 days: The highest plant height (67.87 cm) was recorded in genotype KRCCH-7 and was *on par* with KRCCH-1 (65.07 cm) and K-8 (64.53 cm). The least plant height (32.27 cm) was observed in genotype KRCCH-5.

At 150 days: The maximum plant height (69.40 cm) was observed in genotype KRCCH-7 which was statistically *on par* with KRCCH-1 (68.20 cm) and K-8 (66.67 cm). The least plant height (33.73 cm) was recorded in genotype KRCCH-5.

4.1.1.2 Plant spread (cm^2)

The data pertaining to plant spread (cm^2) in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 3. Significant difference in plant spread was observed among the genotypes at all the crop growth stages.

At 30 days: The maximum plant spread (1641.47 cm^2) was noted in genotype KRCCH-6 and was *on par* with KRCCH-1 (1604.21 cm^2), KRCCH-3 (1589.89 cm^2), KRCCH-8 (1526.13 cm^2), KRCCH-4 (1430.17 cm^2), KRCCH-7 (1398.15 cm^2) and KRCCH-2 (1391.41 cm^2). Whereas, least plant spread (1023.39 cm^2) was observed in genotype K-8.

Table 2: Plant height in medicinal coleus genotypes at different stages of crop growth

Genotypes	Plant height (cm)				
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**	**150 DAP**
KRCCH-1	37.40	51.40	57.87	65.07	68.20
KRCCH-2	39.13	49.00	54.67	59.80	63.40
Aisiri	30.80	43.87	50.87	61.80	63.47
KRCCH-3	36.47	50.27	61.67	62.53	64.73
KRCCH-4	39.83	48.60	55.73	50.13	52.40
KRCCH-5	27.77	30.93	27.20	32.27	33.73
KRCCH-6	37.37	39.67	43.27	59.73	61.27
K-8	29.50	44.87	46.53	64.53	66.67
KRCCH-7	34.73	46.80	56.27	67.87	69.40
KRCCH-8	35.40	48.73	55.27	60.53	62.93
Mean	**34.84**	**45.41**	**50.93**	**58.43**	**60.62**
SEm±	1.41	1.28	1.93	1.23	1.30
CD @ 5%	4.20	3.81	5.73	3.66	3.86

*DAP – Days after planting

At 60 days: The highest plant spread (5483.77 cm^2) was recorded in genotype KRCCH-6 and it differed significantly with all other genotypes. The least plant spread (3005.52 cm^2) was observed in genotype K-8.

At 90 days: The highest plant spread (8680.43 cm^2) was observed in genotype KRCCH-6 and it differed significantly with other genotypes. The least plant spread (3374.15 cm^2) was recorded in genotype K-8.

At 120 days: The highest plant spread (10645.09 cm^2) was registered in genotype KRCCH-6 and it differed significantly with all other genotypes. The least plant spread (4418.87 cm^2) was observed in genotype KRCCH-2.

At 150 days: The genotype KRCCH-6 was recorded highest plant spread (11,859.47 cm^2) and it differed significantly with all other genotypes. The least plant spread (5075.33 cm^2) was observed in genotype KRCCH-5.

4.1.1.3. Stem diameter (cm)

The data pertaining to stem diameter (cm) observed in different coleus genotypes at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 4. Significant difference in stem diameter was observed among the genotypes at all the crop growth stages.

At 30 days: The highest stem diameter (1.35 cm) was observed in genotype KRCCH-2 and was *on par* with KRCCH-4 (1.32 cm) and KRCCH-7 (1.29 cm). The least stem diameter (0.96 cm) was recorded in genotype K-8.

At 60 days: The highest stem diameter (2.23 cm) was observed in genotype KRCCH-4 and was *on par* with KRCCH-1 (2.16 cm), KRCCH-2 (2.15 cm), KRCCH-7 (2.13 cm), KRCCH-3 (2.12 cm), KRCCH-8 (2.09 cm) and KRCCH-5 (2.06 cm). The least stem diameter (1.69 cm) was observed in genotype KRCCH-6.

At 90 days: The highest stem diameter (2.52 cm) was observed in genotype KRCCH-4 and was *on par* with KRCCH-1 (2.44 cm), KRCCH-2 (2.42 cm), KRCCH-7 (2.37 cm), KRCCH-8 (2.36 cm), KRCCH-3 (2.33 cm) and K-8 (2.30 cm). The least stem diameter (1.86 cm) was observed in genotype KRCCH-6.

At 120 days: The highest stem diameter (2.68 cm) was observed in genotype KRCCH-4 and was *on par* with KRCCH-7 (2.61 cm), KRCCH-3 (2.59 cm), KRCCH-8 (2.57 cm), KRCCH-1, KRCCH-2 and KRCCH-5 (2.52 cm). The least stem diameter (2.12 cm) was observed in genotype KRCCH-6.

At 150 days: The maximum stem diameter (2.90 cm) was observed in genotype KRCCH-4 and was *on par* with KRCCH-8 (2.86 cm) and KRCCH-3 (2.83 cm). The least stem diameter (2.30 cm) was observed in genotype KRCCH-6.

Table 3: Plant spread (cm^2) in medicinal coleus genotypes at different stages of crop growth

Genotypes	Plant spread (cm^2)				
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**	**150 DAP**
KRCCH-1	1604.21	3684.92	5023.76	5330.51	5727.19
KRCCH-2	1391.41	3592.56	4042.48	4418.87	5202.05
Aisiri	1302.40	3368.57	4096.81	4501.23	5162.87
KRCCH-3	1589.89	3829.39	4436.64	4693.05	5362.40
KRCCH-4	1430.17	3647.99	4242.03	4634.57	5319.41
KRCCH-5	1159.44	3401.47	4154.36	4505.88	5075.33
KRCCH-6	1641.47	5483.77	8680.43	10645.09	11859.47
K-8	1023.39	3005.52	3374.15	4870.09	5527.51
KRCCH-7	1398.15	3652.56	3978.61	4464.35	5194.00
KRCCH-8	1526.13	3736.03	4525.81	4731.05	5407.73
Mean	**1406.67**	**3740.28**	**4655.51**	**5279.47**	**5983.80**
SEm±	88.48	225.24	329.54	305.79	338.95
CD @ 5%	262.89	669.20	979.10	908.55	1007.06

*DAP – Days after planting

Table 4: Stem diameter in medicinal coleus genotypes at different stages of crop growth

Genotypes	Stem diameter (cm)				
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**	**150 DAP**
KRCCH-1	1.21	2.16	2.44	2.52	2.72
KRCCH-2	1.35	2.15	2.42	2.52	2.73
Aisiri	1.08	1.88	2.24	2.42	2.69
KRCCH-3	1.24	2.12	2.33	2.59	2.83
KRCCH-4	1.32	2.23	2.52	2.68	2.90
KRCCH-5	1.20	2.06	2.24	2.52	2.78
KRCCH-6	1.08	1.69	1.86	2.12	2.30
K-8	0.96	1.79	2.30	2.22	2.47
KRCCH-7	1.29	2.13	2.37	2.61	2.73
KRCCH-8	1.18	2.09	2.36	2.57	2.86
Mean	**1.19**	**2.03**	**2.31**	**2.48**	**2.70**
SEm±	0.03	0.07	0.08	0.06	0.05
CD @ 5%	0.09	0.20	0.25	0.18	0.16

*DAP – Days after planting

4.1.1.4 Total number of branches per plant

The data pertaining to total number of branches per plant in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 5. Significant difference in total number of branches per plant was observed among the genotypes at all the crop growth stages except at 30 DAP.

At 30 days: No significant differences were observed among different genotypes with reference to the total number of branches per plant.

At 60 days: The maximum total number of branches per plant (67.87) was observed in genotype KRCCH-6 and it differed significantly with all other genotypes. The minimum total number of branches per plant (33.07) was observed in genotype K-8.

At 90 days: The highest total number of branches per plant (71.07) was registered in genotype KRCCH-6 and it differed significantly with all other genotypes. The least total number of branches per plant (35.07) was observed in genotype K-8.

At 120 days: The highest total number of branches per plant (72.53) was observed in genotype KRCCH-6 and it differed significantly with all other genotypes. The least total number of branches per plant (42.27) was observed in genotype K-8.

At 150 days: The highest total number of branches per plant (75.74) was observed in genotype KRCCH-6 and it differed significantly with all other genotypes. The least total number of branches per plant (44.93) was observed in genotype K-8.

4.1.1.5 Number of leaves per plant

The data pertaining to number of leaves per plant in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 6. Significant difference in number of leaves per plant was observed among the genotypes at all the crop growth stages.

At 30 days: The highest number of leaves per plant (149.73) was observed in genotype KRCCH-6 and it differed significantly with all other genotypes. The least number of leaves per plant (86.40) was recorded in genotype KRCCH-2.

At 60 days: The highest number of leaves per plant (203.47) was observed in genotype KRCCH-6 and it differed significantly with other genotypes. The least number of leaves per plant (104.67) was observed in genotype KRCCH-2.

At 90 days: The highest number of leaves per plant (219.47) was observed in genotype KRCCH-6 and it differed significantly with other genotypes. The least number of leaves per plant (109.33) was observed in genotype KRCCH-4.

At 120 days: The highest number of leaves per plant (214.07) was observed in genotype KRCCH-6 and it differed significantly with other genotypes. The least number of leaves per plant (110.20) was observed in genotype Aisiri.

At 150 days: The highest number of leaves per plant (237.33) was observed in genotype KRCCH-6 and it differed significantly with other genotypes. The least number of leaves per plant (115.00) was observed in genotype Aisiri.

Table 5: Total number of branches per plant in medicinal coleus genotypes at different stages of crop growth

Genotypes	Total number of branches per plant				
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**	**150 DAP**
KRCCH-1	17.20	39.93	43.87	47.87	50.60
KRCCH-2	18.93	38.53	41.33	45.27	47.33
Aisiri	15.13	37.47	38.47	47.47	50.00
KRCCH-3	17.47	36.13	38.00	47.27	50.47
KRCCH-4	18.00	34.00	38.05	46.00	48.00
KRCCH-5	15.27	33.87	37.53	52.07	50.53
KRCCH-6	21.53	67.87	71.07	72.53	75.74
K-8	15.20	33.07	35.07	42.27	44.93
KRCCH-7	17.67	41.13	43.07	52.53	55.07
KRCCH-8	19.13	43.33	46.81	45.00	47.07
Mean	**17.55**	**40.53**	**43.33**	**49.83**	**51.97**
SEm±	1.58	2.70	2.67	1.44	1.25
CD @ 5%	NS	8.00	7.93	4.28	3.71

*DAP – Days after planting * Non Significant

Table 6: Number of leaves per plant in medicinal coleus genotypes at different stages of crop growth

Genotypes	Number of leaves per plant				
	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP
KRCCH-1	102.40	114.82	128.00	124.67	131.33
KRCCH-2	86.40	104.67	117.67	129.00	133.67
Aisiri	90.40	104.93	123.53	110.20	115.00
KRCCH-3	108.27	126.60	145.67	130.67	137.67
KRCCH-4	86.67	107.33	109.33	119.53	125.67
KRCCH-5	102.00	113.87	126.07	122.73	131.40
KRCCH-6	149.73	203.47	219.47	214.07	237.33
K-8	101.07	114.07	141.67	134.67	139.67
KRCCH-7	114.13	127.33	149.00	140.00	143.00
KRCCH-8	113.87	122.67	135.33	133.00	138.00
Mean	**105.49**	**123.98**	**139.57**	**135.85**	**143.27**
SEm±	9.55	3.64	4.09	3.01	3.59
CD @ 5%	28.38	10.83	12.15	8.94	10.67

*DAP – Days after planting

4.1.1.6 Leaf length (cm)

The data pertaining to leaf length in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 7. Different genotypes showed significant differences in leaf length at all crop growth stages.

At 30 days: The maximum leaf length (9.02 cm) was observed in genotype KRCCH-5 and it differed significantly with other genotypes. Whereas, it was least (6.78 cm) in genotype KRCCH-6.

At 60 days: The highest leaf length (9.36 cm) was observed in genotype KRCCH-5 and it differed significantly with other genotypes. The least leaf length (7.13 cm) was observed in genotype KRCCH-6.

At 90 days: The significantly highest leaf length (9.74 cm) was noted in genotype KRCCH-5. The least leaf length (7.70 cm) was observed in genotype KRCCH-6.

At 120 days: The highest leaf length (9.80 cm) was observed in genotype KRCCH-5 and was *on par* with KRCCH-4 (9.31 cm). The least leaf length (7.85 cm) was observed in genotype KRCCH-6.

At 150 days: The highest leaf length (11.48 cm) was observed in genotype KRCCH-3 and was *on par* with KRCCH-4 (11.39 cm), KRCCH-2 (11.23 cm) KRCCH-1 (11.21 cm), K-8 (11.03 cm), KRCCH-7 (11.01 cm), Aisiri (10.68 cm) and KRCCH-8 (10.65 cm). The least leaf length (8.29 cm) was recorded in genotype KRCCH-6.

4.1.1.7 Leaf breadth (cm)

The data pertaining to leaf breadth in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 8. Significant difference in leaf breadth was observed among the genotypes at all the crop growth stages.

At 30 days: The highest leaf breadth (3.63 cm) was observed in genotype KRCCH-5 and was *on par* with KRCCH-6 (3.55 cm) and KRCCH-2 (3.36 cm). The least leaf breadth (3.03 cm) was observed in genotype K-8.

At 60 days: The highest leaf breadth (3.81 cm) was observed in genotype KRCCH-5 and was *on par* with KRCCH-6 (3.79 cm), KRCCH-3 (3.67 cm), KRCCH-7 (3.60 cm) , Aisiri (3.55 cm), KRCCH-8 (3.53) and KRCCH-2 (3.52). The least leaf breadth (3.35 cm) was observed in genotype K-8.

At 90 days: The highest leaf breadth (4.01 cm) was observed in genotype KRCCH-5 and was *on par* with KRCCH-6 (3.99 cm), KRCCH-3 (3.89 cm), KRCCH-7 (3.83 cm) and Aisiri (3.79 cm). The least leaf breadth (3. 49 cm) was observed in genotype KRCCH-1.

At 120 days: The highest leaf breadth (4.47 cm) was observed in genotype KRCCH-6 and it differed significantly with all other genotypes. The least leaf breadth (3.67 cm) was observed in genotype KRCCH-2.

At 150 days: The highest leaf breadth (4.87 cm) was observed in genotype KRCCH-4 and was *on par* with KRCCH-3 and KRCCH-7 (4.57 cm) and KRCCH-8 (4.51 cm). The least leaf breadth (3.98 cm) was observed in genotype KRCCH-5.

Table 7: Leaf length in medicinal coleus genotypes at different stages of crop growth

Genotypes	Leaf length (cm)				
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**	**150 DAP**
KRCCH-1	7.23	7.57	7.85	8.92	11.21
KRCCH-2	7.65	7.89	8.09	8.97	11.23
Aisiri	7.47	7.81	8.09	9.18	10.68
KRCCH-3	7.85	8.38	8.55	9.16	11.48
KRCCH-4	7.48	7.79	8.05	9.31	11.39
KRCCH-5	9.02	9.36	9.74	9.80	9.97
KRCCH-6	6.78	7.13	7.70	7.85	8.29
K-8	7.83	8.21	8.48	9.06	11.03
KRCCH-7	8.01	8.42	8.71	9.07	11.01
KRCCH-8	7.53	7.90	8.36	8.96	10.65
Mean	**7.68**	**8.05**	**8.36**	**9.03**	**10.69**
SEm±	0.33	0.28	0.33	0.17	0.29
CD @ 5%	0.98	0.82	0.97	0.50	0.86

*DAP – Days after planting

Table 8: Leaf breadth in medicinal coleus genotypes at different stages of crop growth

Genotypes	Leaf breadth (cm)				
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**	**150 DAP**
KRCCH-1	3.17	3.37	3.49	3.77	4.48
KRCCH-2	3.36	3.52	3.69	3.67	4.48
Aisiri	3.16	3.55	3.79	3.73	4.32
KRCCH-3	3.08	3.67	3.89	3.82	4.57
KRCCH-4	3.25	3.51	3.69	4.05	4.87
KRCCH-5	3.63	3.81	4.01	3.82	3.98
KRCCH-6	3.55	3.79	3.99	4.47	4.04
K-8	3.03	3.35	3.53	3.81	4.43
KRCCH-7	3.19	3.60	3.83	3.81	4.57
KRCCH-8	3.25	3.53	3.73	3.79	4.51
Mean	**3.27**	**3.57**	**3.76**	**3.87**	**4.42**
SEm±	0.12	0.10	0.09	0.09	0.12
CD @ 5%	0.36	0.29	0.27	0.28	0.37

*DAP – Days after planting

4.1.1.8 Petiole length (cm)

The data pertaining to petiole length in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 9. Significant difference in petiole length was observed among the genotypes at all the crop growth stage.

At 30 days: The highest petiole length (2.08 cm) was observed in genotype KRCCH-5 and it differed significantly with all other genotypes. The least petiole length (0.78 cm) was observed in genotype KRCCH-6.

At 60 days: The highest petiole length (2.15 cm) was observed in genotype KRCCH-5 and it differed significantly with all other genotypes. The least petiole length (0.80 cm) was observed in genotype KRCCH-6.

At 90 days: The highest petiole length (2.22 cm) was observed in genotype KRCCH-5 and it differed significantly with all other genotypes. The least petiole length (0.86 cm) was observed in genotype KRCCH-6.

At 120 days: The highest petiole length (2.27 cm) was observed in genotype KRCCH-5 and it differed significantly with all other genotypes. The least petiole length (0.90 cm) was observed in genotype KRCCH-6.

At 150 days: The highest petiole length (2.31 cm) was observed in genotype KRCCH-5 and it differed significantly with all other genotypes. The least petiole length (0.92 cm) was observed in genotype KRCCH-6.

4.1.1.9 Internodal length (cm)

The data pertaining to internodal length in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 10. Significant difference in internodal length was observed among the genotypes at all the crop growth stages except at 30 DAP.

At 30 days: No significant differences were observed among different genotypes with reference to the internodal length.

At 60 days: The highest internodal length (5.10 cm) was recorded in genotype KRCCH-6 and it differed significantly with all other genotypes. The least internodal length (3.41 cm) was observed in genotype KRCCH-7.

At 90 days: The highest internodal length (5.47 cm) was noted in genotype KRCCH-6 and it differed significantly with all other genotypes. The least internodal length (3.66 cm) was observed in genotype KRCCH-7.

At 120 days: The highest internodal length (6.06 cm) was observed in genotype KRCCH-6 and it differed significantly with all other genotypes. The least internodal length (3.57 cm) was observed in genotype KRCCH-2.

At 150 days: The highest internodal length (7.30 cm) was observed in genotype KRCCH-6 and it differed significantly with all other genotypes. The least internodal length (3.98 cm) was observed in genotype KRCCH-5.

Table 9: Petiole length in medicinal coleus genotypes at different stages of crop growth

Genotypes	Petiole length (cm)				
	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP
KRCCH-1	1.19	1.27	1.32	1.36	1.40
KRCCH-2	1.25	1.30	1.35	1.37	1.39
Aisiri	1.26	1.32	1.35	1.39	1.42
KRCCH-3	1.34	1.39	1.41	1.45	1.46
KRCCH-4	1.20	1.27	1.30	1.33	1.36
KRCCH-5	2.08	2.15	2.22	2.27	2.31
KRCCH-6	0.78	0.80	0.86	0.90	0.92
K-8	1.31	1.35	1.37	1.39	1.41
KRCCH-7	1.18	1.23	1.26	1.28	1.34
KRCCH-8	1.20	1.24	1.29	1.31	1.37
Mean	**1.28**	**1.33**	**1.37**	**1.40**	**1.44**
SEm±	0.03	0.02	0.01	0.01	0.02
CD @ 5%	0.09	0.05	0.04	0.03	0.05

*DAP – Days after planting

4.1.1.10 Number of inflorescence per plant

The data pertaining to number of inflorescence per plant in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 11. Among the different genotypes, KRCCH-5 and KRCCH-6 were the only flowering genotypes and other genotypes were non-flowering type. At 30 days, flowering was not observed among KRCCH-5 and in KRCCH-6. The number of inflorescence per plant recorded in KRCCH-5 was 4.40 at 60 days, 19.67 at 90 days, 22.40 at 120 days and 25.27 at 150 days.

The number of inflorescence per plant recorded in KRCCH-6 was 1.13 at 60 days, 24.13 at 90 days, 25.67 at 120 days and 29.07 at 150 days.

4.1.1.11 Length of inflorescence per plant

The data pertaining to length of inflorescence per plant in different coleus genotypes recorded at different crop growth stages (30, 60, 90, 120 and 150 days after transplanting) is presented in Table 12. Among the different genotypes, KRCCH-5 and KRCCH-6 were the only flowering genotypes and all other genotypes were non-flowering type. The length of inflorescence per plant recorded in KRCCH-5 was 37.67 cm at 60 days, 46.73 cm at 90 days, 49.40 cm at 120 days and 52.33 cm at 150 days.

The length of inflorescence per plant recorded in KRCCH-6 was 27.33 cm at 60 days, 29.13 cm at 90 days, 31.67 cm at 120 days and 34.47 cm at 150 days.

4.1.2 Yield parameters

4.1.2.1 Number of tubers per plant

The data pertaining to number of tubers per plant recorded at 150 days (at harvest) is presented in Table 13. There were significant differences among the genotypes with reference to the number of tubers per plant. The highest number of tubers per plant (20.20) was observed in genotype KRCCH-7 and was *on par* with KRCCH-1 (18.80). The least number of tubers per plant (5.03) was recorded in genotype KRCCH-6.

4.1.2.2 Length of tubers (cm)

The data pertaining to length of tubers recorded at 150 days (at harvest) is presented in Table 13. There were significant differences among the genotypes with reference to the length of tubers. The highest tuber length (20.68 cm) was observed in genotype KRCCH-8 and it differed significantly with all other genotypes. The least tuber length (10.16 cm) was observed in genotype K-8.

4.1.2.3 Diameter of tubers (cm)

The data pertaining to tuber diameter recorded at 150 days (at harvest) is presented in Table 13. There were significant differences among the genotypes with reference to the tuber diameter. The highest tuber diameter (2.51 cm) was observed in genotype KRCCH-8 and was *on par* with KRCCH-1 (2.48 cm), KRCCH-4 (2.46 cm), KRCCH-7 (2.37 cm), KRCCH-2 (2.36 cm), K-8 (2.26 cm) and KRCCH-5 (2.24 cm). The least tuber diameter (0.56 cm) was observed in non tuberous genotype KRCCH-6.

Table 10: Internodal length in medicinal coleus genotypes at different stages of crop growth

Genotypes	Internodal length (cm)				
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**	**150 DAP**
KRCCH-1	3.42	3.61	3.90	4.09	4.72
KRCCH-2	3.43	3.66	4.12	3.57	4.40
Aisiri	3.18	3.61	3.87	4.00	4.78
KRCCH-3	3.23	3.63	3.90	4.37	4.23
KRCCH-4	3.12	3.45	3.93	4.00	4.64
KRCCH-5	3.38	3.65	3.85	3.92	3.98
KRCCH-6	4.79	5.10	5.47	6.06	7.30
K-8	3.23	3.65	3.96	4.02	5.24
KRCCH-7	3.26	3.41	3.66	4.07	5.09
KRCCH-8	3.53	3.79	4.09	4.25	4.87
Mean	**3.46**	**3.76**	**4.07**	**4.23**	**4.93**
SEm±	0.33	0.30	0.30	0.23	0.4
CD @ 5%	NS	0.89	0.89	0.68	1.00

*DAP – Days after planting * Non Significant

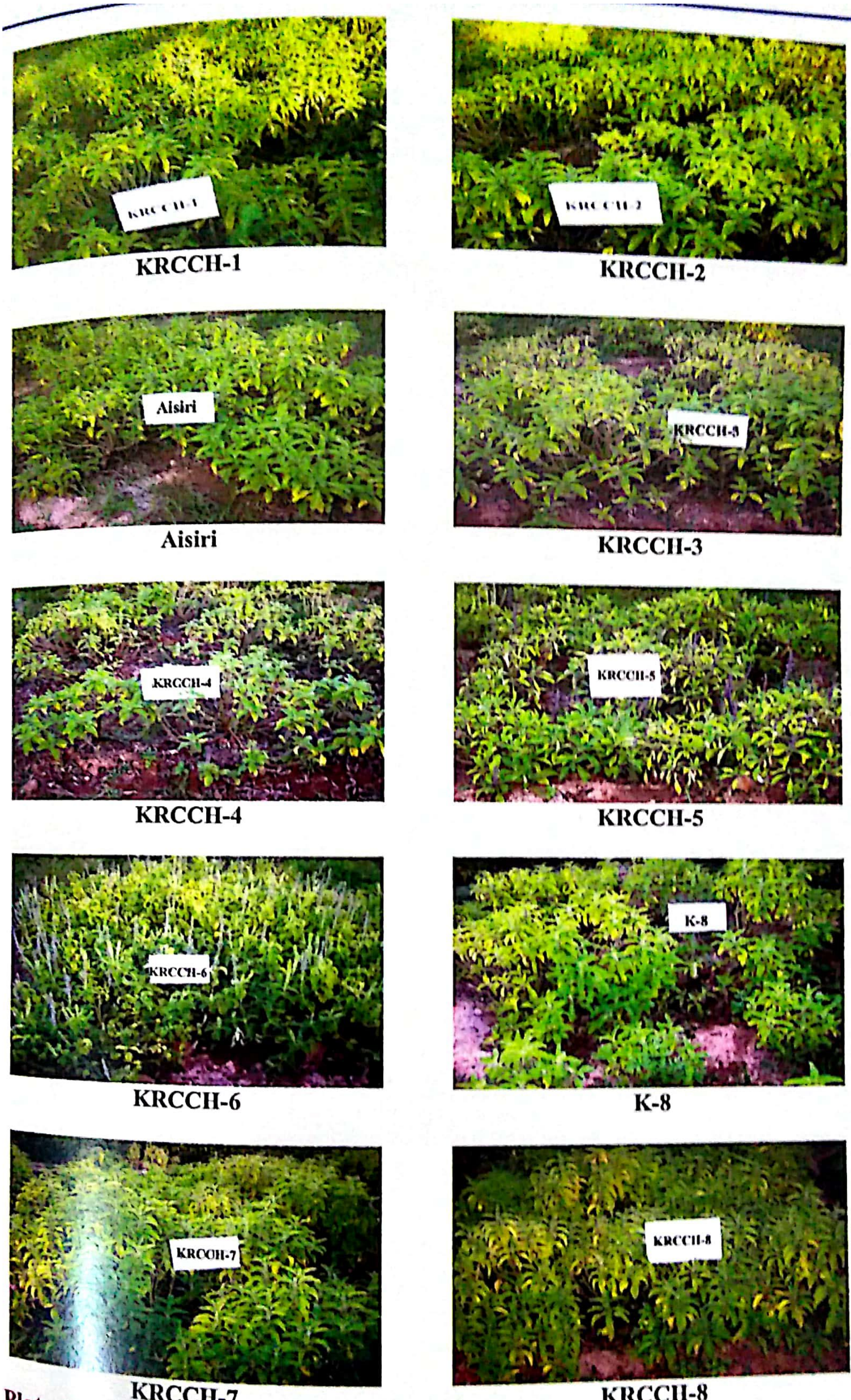


Plate 2: Vegetative growth characteristics of different medicinal coleus genotypes at harvest

4.1.2.4 Tuber density (cc)

The data pertaining to tuber density recorded at 150 days (at harvest) is presented in Table 13. There were significant differences among the genotypes with reference to tuber density. The highest tuber density (1.97 cc) was observed in genotype KRCCH-2 and was *on par* with all other genotypes except KRCCH-6. The least tuber density (0.36 cc) was observed in genotype KRCCH-6.

4.1.2.4 Fresh weight of herbage (g)

The data pertaining to fresh weight of herbage per plant recorded at 150 days (at harvest) is presented in Table 13. There were significant differences among the genotypes with reference to the fresh weight of herbage per plant. The highest fresh weight of herbage per plant (968.80 g) was observed in genotype KRCCH-8 and was *on par* with KRCCH-6 (931.73 g), KRCCH-2 (891.33 g) and KRCCH-1 (833.33 g). The least fresh weight of herbage per plant (452.07 g) was observed in genotype KRCCH-4.

4.1.2.5 Dry weight of herbage (g)

The data pertaining to dry weight of herbage per plant recorded at 150 days (at harvest) is presented in Table 13. There were significant differences among the genotypes with reference to the dry weight of herbage per plant. The highest dry weight of herbage per plant (152.01 g) was observed in genotype KRCCH-6 and was *on par* with KRCCH-2 (141.23 g) and KRCCH-8 (133.47 g).The least dry weight of herbage per plant (71.35 g) was observed in genotype KRCCH-4.

4.1.2.6 Per cent dry matter content of herbage

The data pertaining to per cent dry matter content of herbage recorded at 150 days (at harvest) is presented in Table 13. There were significant differences among the genotypes with reference to per cent dry matter content of herbage. The highest per cent dry matter content of herbage (16.23) was observed in genotype KRCCH-5 and was *on par* with KRCCH-6 (15.98), KRCCH-4 (15.75), KRCCH-2 (15.07), KRCCH-3 (15.05) and KRCCH-7 (14.77).The least per cent dry matter content of herbage (13.33) was observed in genotype KRCCH-8.

4.1.2.7 Fresh weight of tubers (g)

The data pertaining to fresh weight of tubers per plant recorded at 150 days (at harvest) is presented in Table 14. There were significant differences among the genotypes with reference to the fresh weigh of tubers per plant. The highest fresh weight of tubers per plant (417.67 g) was observed in genotype KRCCH-1 and was *on par* with KRCCH-3 (399.87 g) and KRCCH-5 (398.47 g). The least fresh weight of tubers per plant (21.07 g) was observed in non tuberous genotype KRCCH-6.

4.1.2.8 Dry weight of tubers (g)

The data pertaining to dry weight of tubers per plant recorded at 150 days (at harvest) is presented in Table 14. There were significant differences among the genotypes with reference to the dry weight of tubers per plant. The highest dry weight of tubers per plant (56.05 g) was observed in genotype KRCCH-3 and was *on par* with KRCCH-1 (53.75 g) and KRCCH-5 (51.27 g). The least dry weight of tubers per plant (3.13 g) was observed in non tuberous genotype KRCCH-6.

Table 11: Number of inflorescence per plant in medicinal coleus genotypes at different stages of crop growth

Genotypes	Number of inflorescence per plant				
	30DAP	60DAP	90DAP	120DAP	150DAP
KRCCH-1	0.00	0.00	0.00	0.00	0.00
KRCCH-2	0.00	0.00	0.00	0.00	0.00
Aisiri	0.00	0.00	0.00	0.00	0.00
KRCCH-3	0.00	0.00	0.00	0.00	0.00
KRCCH-4	0.00	0.00	0.00	0.00	0.00
KRCCH-5	0.00	4.40	19.67	22.40	25.27
KRCCH-6	0.00	1.13	24.13	25.67	29.07
K-8	0.00	0.00	0.00	0.00	0.00
KRCCH-7	0.00	0.00	0.00	0.00	0.00
KRCCH-8	0.00	0.00	0.00	0.00	0.00

*DAP – Days after planting

Table 12: Inflorescence length in medicinal coleus genotypes at different stages of crop growth

Genotypes	Inflorescence length (cm)				
	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP
KRCCH-1	0.00	0.00	0.00	0.00	0.00
KRCCH-2	0.00	0.00	0.00	0.00	0.00
Aisiri	0.00	0.00	0.00	0.00	0.00
KRCCH-3	0.00	0.00	0.00	0.00	0.00
KRCCH-4	0.00	0.00	0.00	0.00	0.00
KRCCH-5	0.00	37.67	46.73	49.40	52.33
KRCCH-6	0.00	27.33	29.13	31.67	34.47
K-8	0.00	0.00	0.00	0.00	0.00
KRCCH-7	0.00	0.00	0.00	0.00	0.00
KRCCH-8	0.00	0.00	0.00	0.00	0.00

*DAP – Days after planting

Table 13: Tuber characters, fresh weight, dry weight and per cent dry matter content of herbage in medicinal coleus genotypes at harvest (150DAP)

Genotypes	Number of tubers/ plant	Length of tubers (cm)	Tuber diameter (cm)	Tuber density (cc)	Fresh weight of herbage (g/plant)	Dry weight of herbage/plant (g/plant)	Per cent herbage dry matter content
KRCCH-1	18.80	12.59	2.48	1.83	833.33	108.02	13.60
KRCCH-2	14.80	13.62	2.36	1.97	891.33	141.23	15.07
Aisiri	14.53	12.34	2.16	1.58	786.67	115.10	13.73
KRCCH-3	16.67	13.11	2.22	1.54	689.07	98.94	15.05
KRCCH-4	15.53	13.81	2.46	1.78	452.07	71.35	15.75
KRCCH-5	14.80	13.29	2.24	1.57	498.93	81.41	16.23
KRCCH-6	5.03	12.24	0.56	0.36	931.73	152.01	15.98
K-8	9.27	10.16	2.26	1.54	530.27	72.75	14.52
KRCCH-7	20.20	12.15	2.37	1.64	678.93	100.47	14.77
KRCCH-8	10.20	20.68	2.51	1.69	968.80	133.47	13.33
Mean	**13.98**	**13.40**	**2.16**	**1.55**	**726.11**	**107.48**	**14.80**
SEm±	0.85	0.77	0.09	0.16	59.89	9.20	0.52
CD @ 5%	2.52	2.27	0.27	0.48	177.93	27.32	1.54

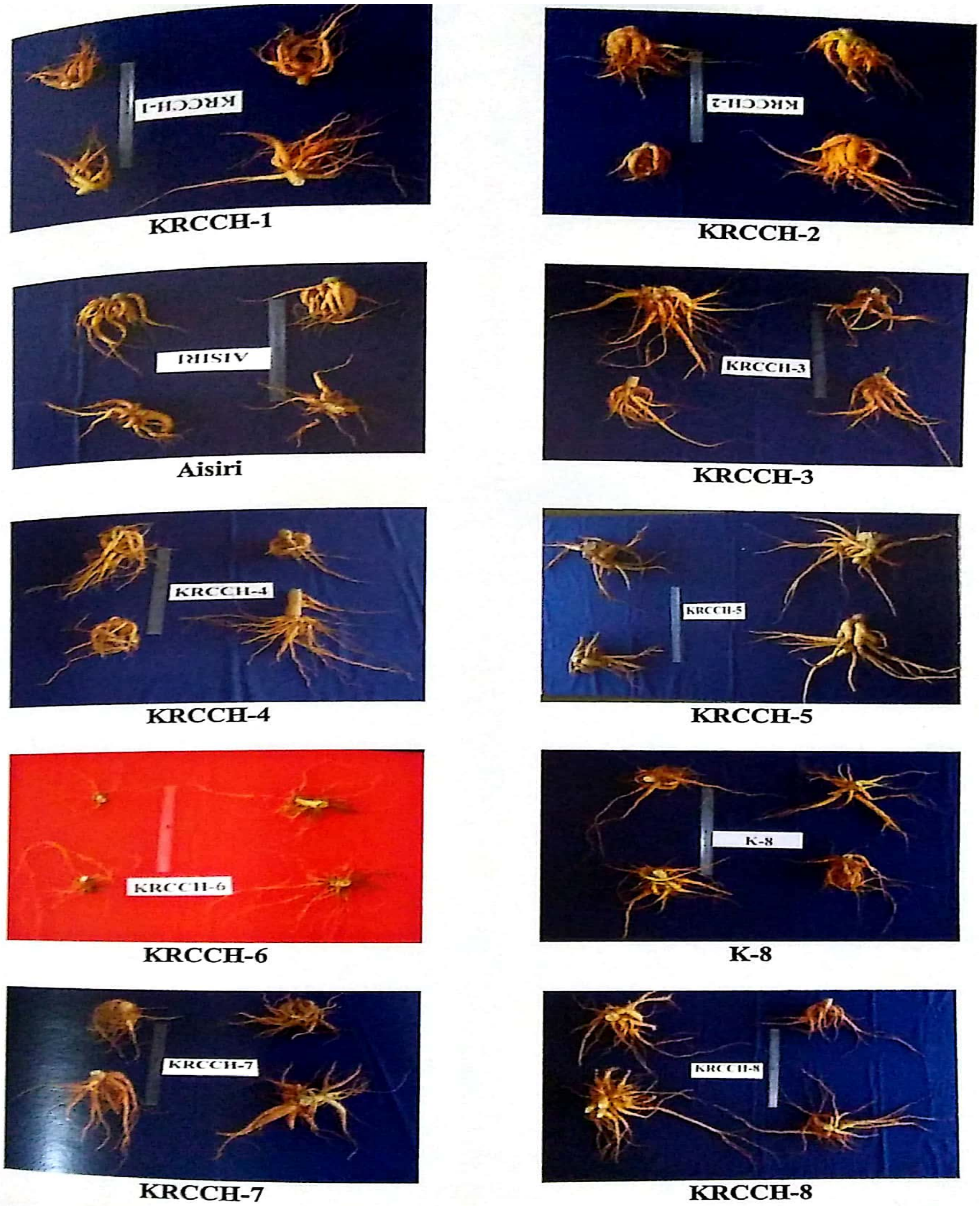


Plate 3: Tuber characteristics of medicinal coleus genotypes

Table 14: Fresh weight, dry weight, and per cent dry matter content of tubers and yield of medicinal coleus genotypes at harvest (150 DAP)

Genotypes	Fresh weight of tubers (g/plant)	Dry weight of tubers (g/plant)	Per cent dry matter content of tubers	Tuber yield (kg/plot)	Tuber yield (t/ha)	Total dry matter accumulation (g/plant)
KRCCH-1	417.67	53.75	12.73	6.53	15.18	172.11
KRCCH-2	315.60	44.01	13.19	4.70	11.59	205.20
Aisiri	224.53	30.70	14.06	3.90	9.10	144.15
KRCCH-3	399.87	56.05	12.91	6.23	14.48	151.28
KRCCH-4	330.80	45.25	13.59	4.70	10.98	117.11
KRCCH-5	398.47	51.27	12.44	6.30	15.31	130.02
KRCCH-6	21.07	3.13	17.53	0.33	0.76	148.36
K-8	124.53	16.88	13.39	1.73	4.09	89.63
KRCCH-7	322.18	45.38	13.32	5.30	12.34	147.18
KRCCH-8	321.47	36.10	12.65	5.40	12.65	185.37
Mean	**287.62**	**38.25**	**13.58**	**4.51**	**10.65**	**149.04**
SEm±	18.48	1.85	0.62	0.30	0.69	8.93
CD @ 5%	54.90	5.49	1.86	0.91	2.05	26.52

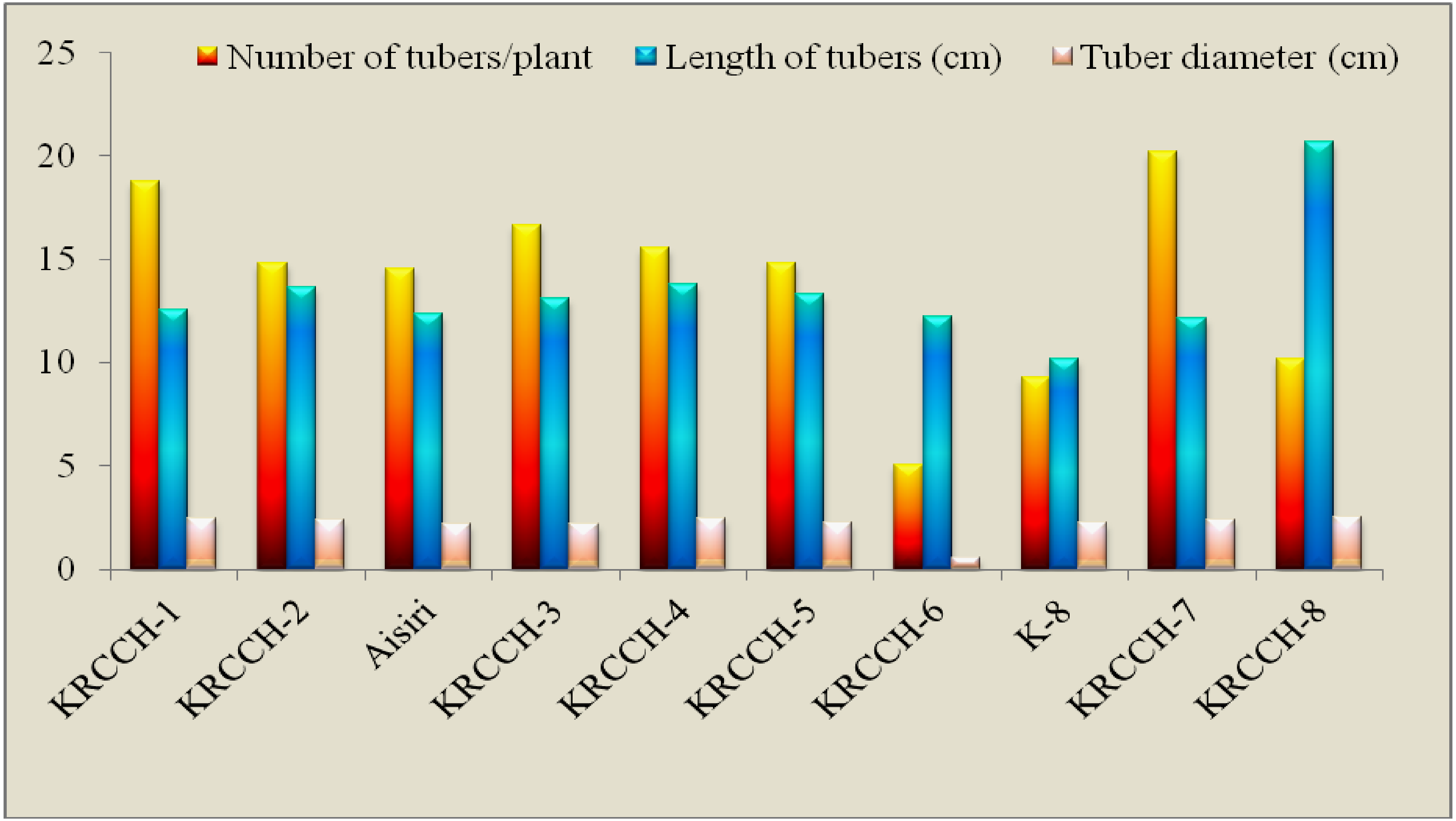


Fig. 2: Tuber characters of medicinal coleus genotypes

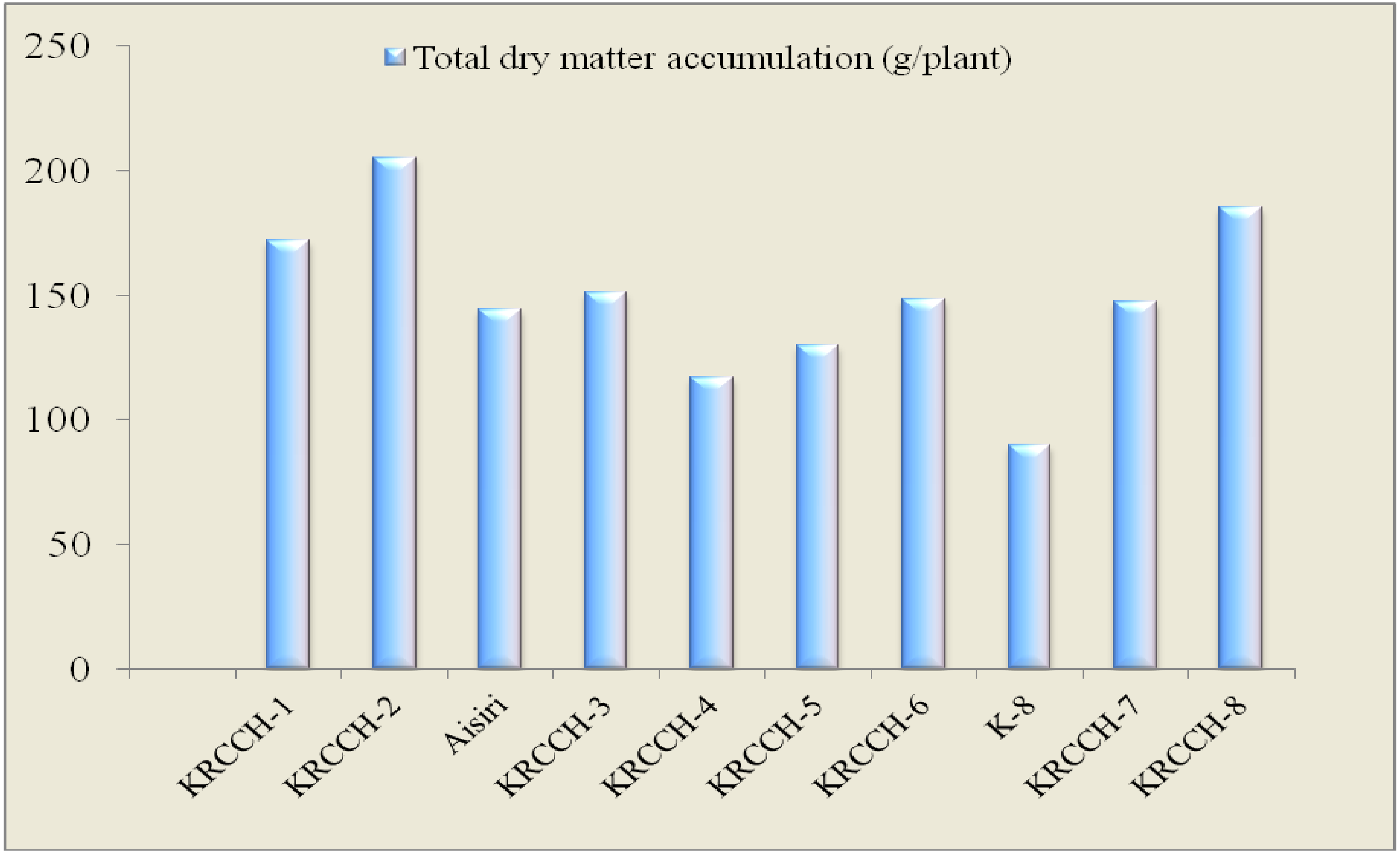
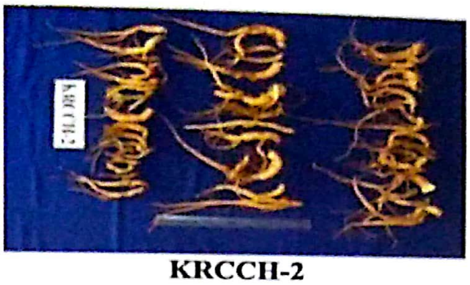


Fig. 3: Total dry matter accumulation of medicinal coleus genotypes

KRCCH-1

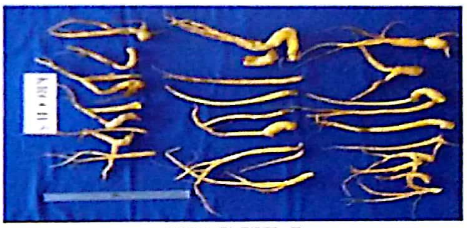


KRCCH-2

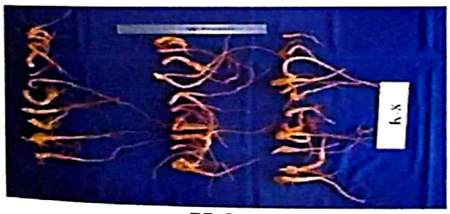
Aisiri

KRCCH-3

KRCCH-4

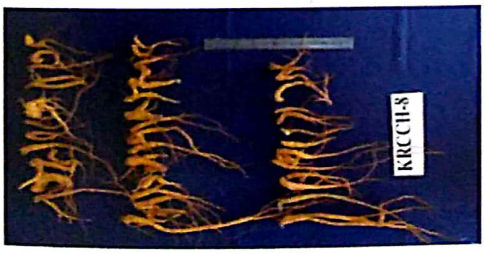


KRCCH-5



K-8

KRCCH-7



KRCCH-8

Plate 4: Tuber characteristics of medicinal coleus genotypes

Table 15: Sensory evaluation of medicinal coleus genotypes for pickles

Genotypes	Taste and aroma	Flavour	Overall acceptability
KRCCH-1	3.19	3.20	3.20
KRCCH-2	3.11	3.15	3.10
Aisiri	3.41	3.48	3.45
KRCCH-3	3.21	3.12	3.40
KRCCH-4	3.09	2.92	3.10
KRCCH-5	4.02	4.03	4.43
K-8	3.24	2.93	3.16
KRCCH-7	3.27	3.25	3.46
KRCCH-8	3.31	3.36	3.41
Mean	**3.32**	**3.27**	**3.41**
SEm±	0.10	0.08	0.06
CD @ 5%	0.30	0.23	0.19
CD @ 1%	0.40	0.30	0.25

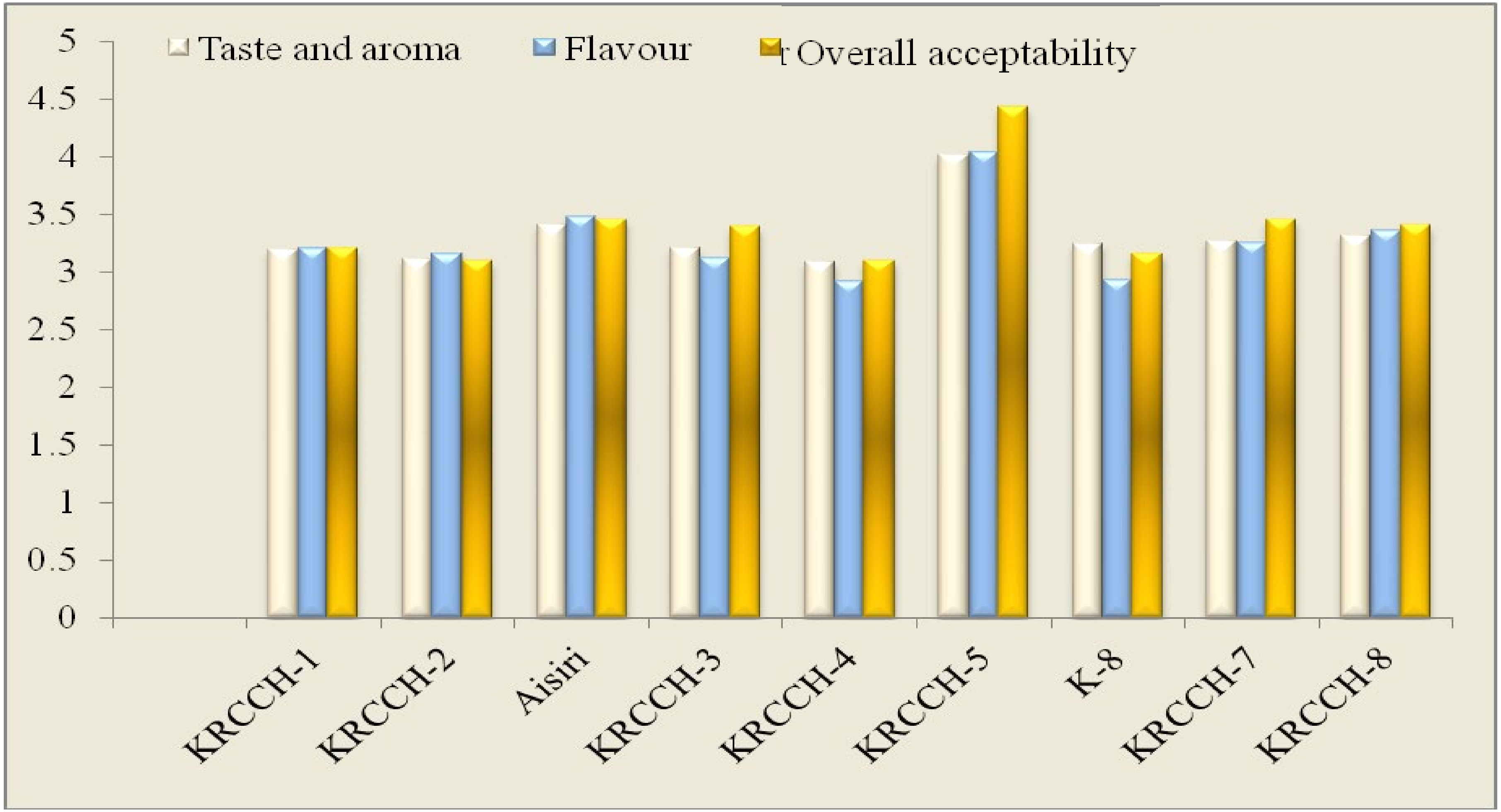


Fig. 4: Sensory evaluation of medicinal coleus genotypes for pickles

4.1.2.9 Per cent dry matter content of tubers

The data pertaining to per cent dry matter content of tubers recorded at 150 days (at harvest) is presented in Table 14. There were significant differences among the genotypes with reference per cent dry matter content of tubers. The highest per cent dry matter content of tubers (17.53) was observed in genotype KRCCH-6 and it differed significantly with all other genotypes. The least per cent dry matter content of tubers (12.44) was observed in genotype KRCCH-5.

4.1.2.10 Tuber yield per plot (kg)

The data pertaining to tuber yield per plot recorded at 150 days (at harvest) is presented in Table 14. There were significant differences among the genotypes with reference to tuber yield per plot. The highest tuber yield per plot (6.53 kg) was observed in genotype KRCCH-1 which was *on par* with KRCCH-5 (6.30 kg) and KRCCH-3 (6.23 kg). The least tuber yield per plot (0.33 kg) was observed in non tuberous genotype KRCCH-6.

4.1.2.11 Tuber yield per hectare (tons)

The data pertaining to tuber yield per hectare recorded at 150 days (at harvest) is presented in Table 14. There were significant differences among the genotypes with reference to tuber yield per hectare. The highest tuber yield per hectare (15.31 t) was observed in genotype KRCCH-5 and was *on par* with KRCCH-1 (15.18 t) and KRCCH-3 (14.48 t). The least tuber yield per hectare (0.76 t) was observed in non tuberous genotype KRCCH-6.

4.1.2.12 Total dry matter accumulation (g)

The data pertaining to total dry matter accumulation per plant recorded at 150 days (at harvest) is presented in Table 14. There were significant differences among the genotypes with reference to the total dry matter accumulation per plant. The highest total dry matter accumulation per plant (205.20 g) was observed in genotype KRCCH-2 and was *on par* with KRCCH-8 (185.37 g). The least total dry matter accumulation per plant (89.63 g) was observed in genotype K-8.

4.2 Evaluation of medicinal coleus genotypes for pickling

4.2.1 Sensory evaluation of pickles of medicinal coleus genotypes

4.2.1.1 Taste and aroma

The data pertaining to sensory evaluation of pickles prepared from different coleus genotypes is presented in Table 16. The evaluation of the pickles for taste and aroma prepared from different genotypes exhibited significant difference. The highest score for taste and aroma (4.02) was recorded in genotype KRCCH-5, which differed significantly with all other genotypes. The least score for taste and aroma (3.09) was recorded in genotype KRCCH-4.

4.2.1.2 Flavour

The evaluation of the pickles for flavour prepared from different genotypes exhibited significant differences among themselves. The highest score for flavour (4.03) was recorded in genotype KRCCH-5, which differed significantly with all other genotypes. The lowest score for flavour (2.92) was recorded in genotype KRCCH-4.

4.2.1.3 Overall acceptability

The evaluation of the pickles prepared for overall acceptability from different genotypes exhibited significant differences among themselves. The highest score for overall acceptability (4.43) was recorded in genotype KRCCH-5, which differed significantly with all other genotypes. The least score for overall acceptability (3.10) was recorded in KRCCH-4 and KRCCH-2 (3.10) genotypes.

5. DISCUSSION

Medicinal coleus is an important medicinal crop belonging to the family Lamiaceae, which gained importance due to forskolin, a diterpenoid present in tuberous roots. This crop is cultivated on large scale in Tamil Nadu, Karnataka, Gujarat and Maharashtra. Forskolin is an alkaloid extensively used in the preparation of drugs against heart diseases, glaucoma, asthma and certain cancers.

The exclusive presence of root alkaloids in medicinal coleus and the current recognition as a medicinal crop of high medicinal economic importance internationally, renders a high profile for this crop. A systematic study on the extent of the variation under uniform cultural conditions has so for been reported scantily. In this medicinal crop, knowledge of genetic variability encompassed within species will greatly aid direct exploitation of variability as cultivars and indirectly as base material for different breeding programmes. Vegetative method of propagation adopted in this species for commercial cultivation heightens the prospects of utilizing superior genotypes identified in the present study. The expressions of various morphological characters were mentioned through monthly observations. These observations provide a fair insight into exomorphic diversity present in the genotypes examined and also provide a physiological basis for differences in the yield potential. Traditionally coleus is grown for its tubers which are pickled and eaten (Anon, 1950).The medicinal value of the tubers is an added advantage in addition to its utility as a condiment.

Success of crop improvement programme depends on the extent of genetic variability existing in the germplasm. Magnitude of genetic variability can determine the pace and quantum of genetic improvement through selection. Therefore, in the present investigation, evaluation of medicinal coleus genotypes for growth, yield and suitability for pickling was carried out and results of the experiment are discussed in this chapter.

5.1 Evaluation of medicinal coleus genotypes

Selection of genotype for a particular region has its own significance and shows considerable variability in several characters when grown under uniform environmental conditions. The yield of genotype is determined by complex physiological processes taking place in different parts of plant, which are governed by the genetic constituent of genotypes and environmental conditions under which the crop is raised. Therefore, attempts are being made to select superior genotypes in different crops to suit different agro ecological systems. One such attempt was made in the present study to select high yielding coleus genotypes suitable as a condiment for the GLBC area of Karnataka.

5.1.1 Growth parameters

Ten coleus genotypes evaluated in the present study varied significantly with respect to plant height, total number of branches per plant, plant spread, stem diameter, number of leaves per plant, leaf length and breadth, internodal length, petiole length, number of inflorescence per plant and inflorescence length at all the stages of crop growth.

The plant height increased with the crop duration. Among ten genotypes evaluated, the highest plant height was observed in KRCCH-7 (69.40 cm) and the least plant height was observed in KRCCH-5 (33.73 cm) at 150 DAP, as it is a dwarf type. There are few reports in the medicinal coleus which reveal the significant variation in the plant height among the genotypes tried. Swamy *et al.* (2006) reported highest plant height was observed in TL-3 genotype (69.80 cm). The difference in plant height in different genotypes of the present studies is mainly due to the genetic makeup of these genotypes. The highest plant spread was observed in KRCCH-6 genotype (11,859.47 cm^2) at 150 DAP. Similarly, Swamy *et al.* (2006) reported highest plant spread in 43-6 accession (31,219.01 cm^2) at 150 DAP. The genotype KRCCH-6 has more plant spread compared to other genotypes as it is a non-tuberous type.

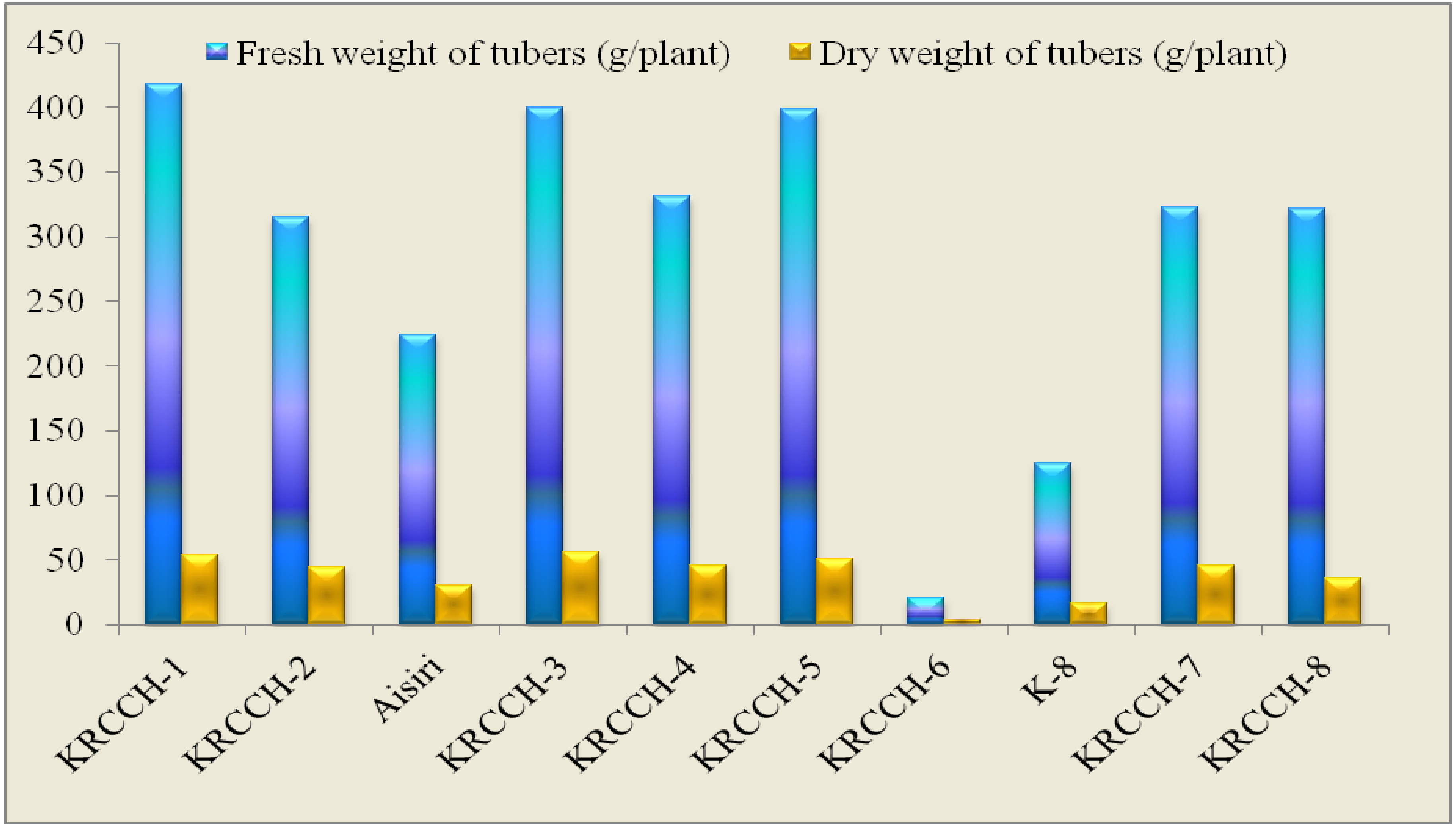


Fig. 5: Fresh and dry weight of tubers of medicinal coleus genotypes

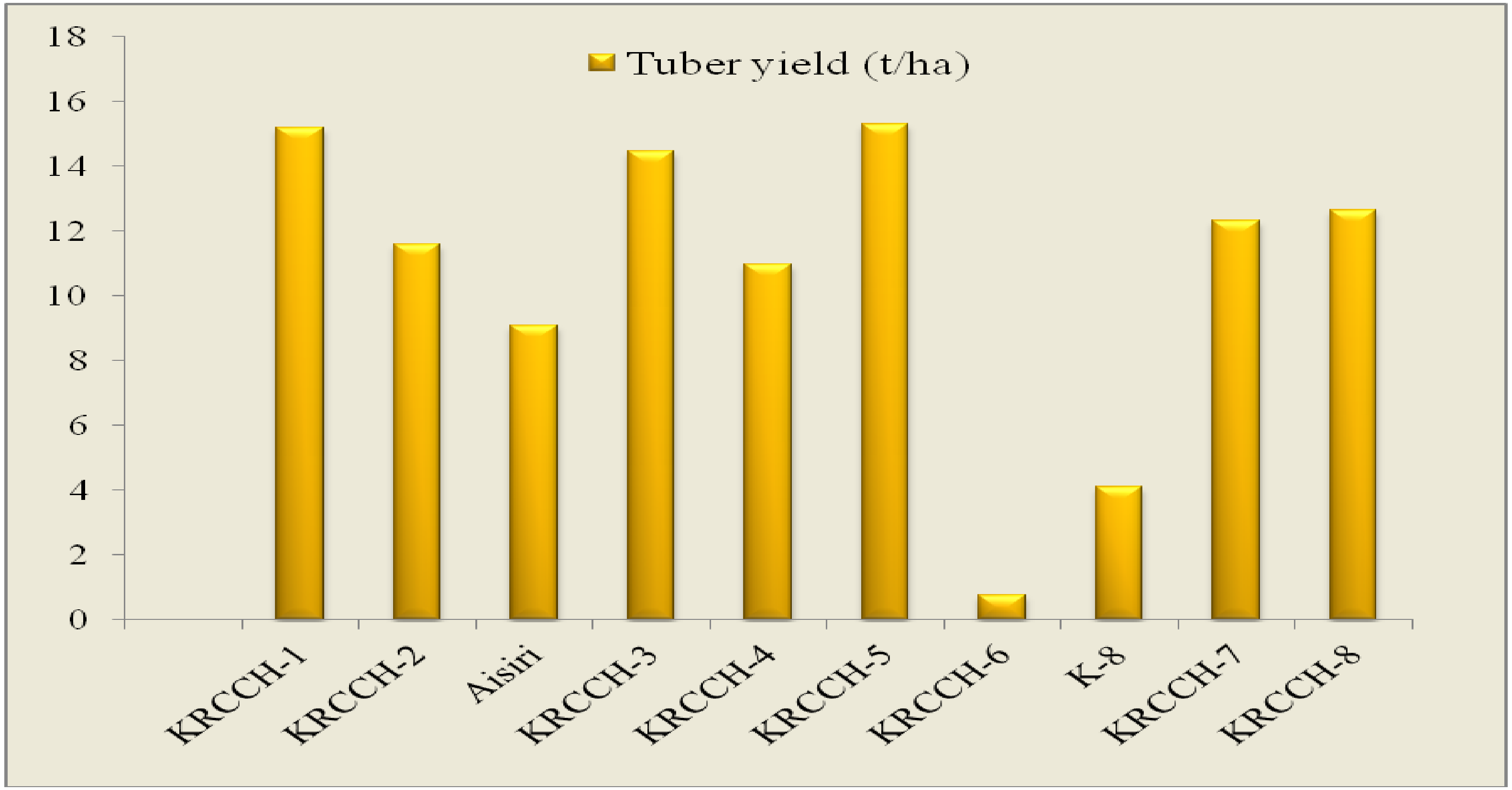


Fig. 6: Tuber yield of medicinal coleus genotypes

The highest stem diameter was observed in KRCCH-4 genotype (2.90 cm) at 150 DAP. The total number of branches were increased with the crop duration. Higher total number of branches was observed in the genotype KRCCH-6 (75.74) at 150 DAP, whereas, the K-8 genotype (44.93) recorded lower total number of branches. The crop is propagated by tip cuttings, which ensures faster multiplication rate. Thus, genotypes with large number of branches per plant can provide larger number of terminal shoot cuttings for their multiplication. Patil *et al.* (2001) observed that highest total number of branches (111.05) in C-2 accession. To the present study highest number of leaves was observed in KRCCH-6 genotype (237.33) at 150 DAP. Higher number of leaves can help in the better synthesis of photosynthates and its utilization for buildup of new cells. This might help in better absorption of nutrients and accumulation of starch materials in the roots. Patil *et al.* (2001) reported highest number of leaves (349.29) in BL accession. Similarly Chaitra and Rajamani (2009a) recorded highest number of leaves (620) in GS-15 genotype in glory lily.

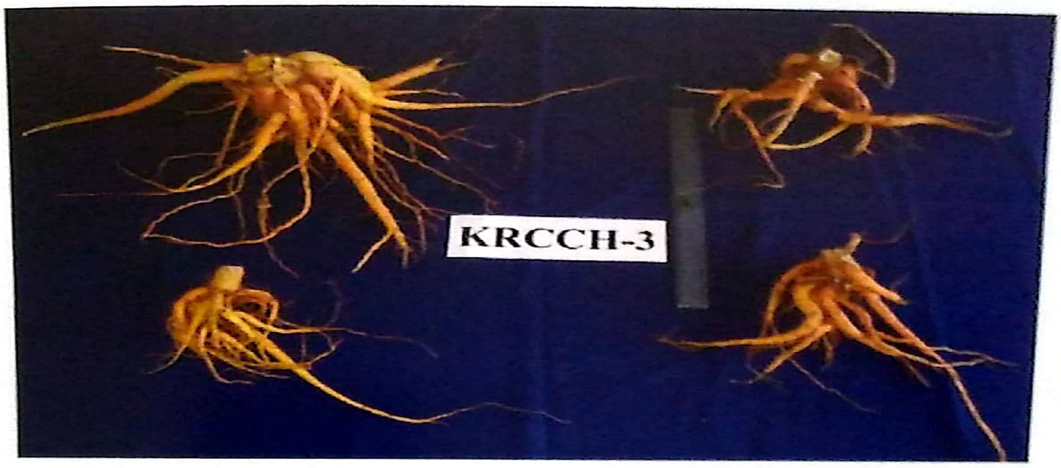
During the crop growth period the leaf length and leaf breadth increased as the duration of the crop increased. Highest leaf length (11.48 cm) was observed at 150 days in the genotype KRCCH-3. Highest leaf breadth (4.87 cm) was observed at 150 days in the genotype KRCCH-4. The genotype KRCCH-6 showed consistently shorter leaves at all the stages of crop growth, which might be due to the inherent feature of the genotype. Hegde and Shiragur (2003) reported that highest leaf length (13.37 cm) and leaf breadth (8.54 cm) in accession KRC-23 in Ashwagandha under Arabhavi conditions. Highest petiole length (2.31 cm) was observed at 150 days in the genotype KRCCH-5 and it showed consistently longer petiole length at all the stages of crop growth, which might be due to the inherent feature of the genotype. The genotype KRCCH-6 showed consistently shorter petiole length at all the stages of crop growth, which might be due to the inherent feature of the genotype. Patil *et al.* (2001) reported highest petiole length (0.92 cm) in C-2 accession. Highest internodal length (7.30 cm) was observed in KRCCH-6 genotype at 150 DAP. Among the different genotypes, KRCCH-5 and KRCCH-6 were the only flowering genotypes and all other genotypes were non-flowering types. In KRCCH-5 genotype, seed set is absent due to sterility of the flowers, whereas, seed set was observed in KRCCH-6 genotype due to presence of fertile flowers. Highest number of inflorescence (29.07) was observed in KRCCH-6 genotype at 150 days. The genotype KRCCH-5 recorded highest inflorescence length (52.33 cm) at 150 days. These findings are in line with the reports of Chaitra and Rajamani (2009a) highest number of flowers (56.33) in GS-15 genotype in glory lily.

5.1.2 Yield parameters

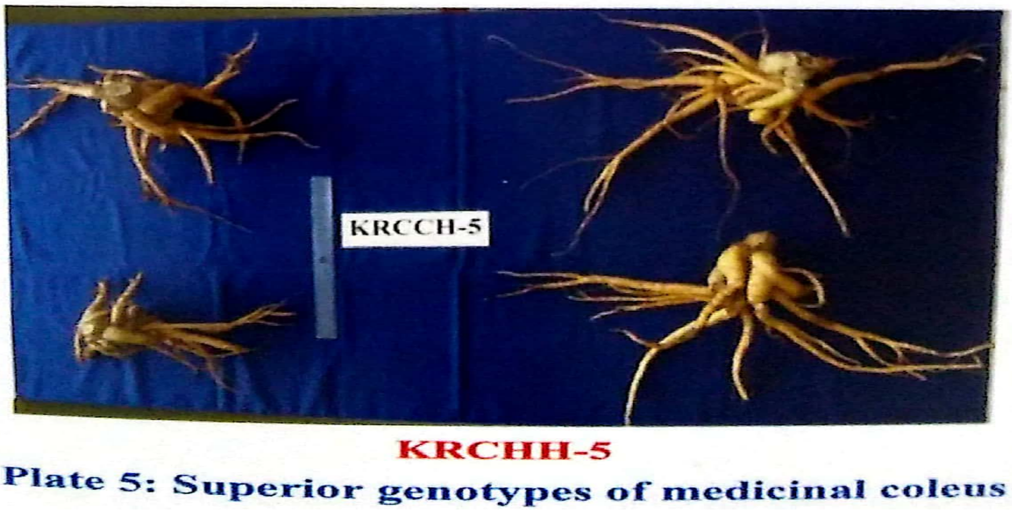
The present studies indicated that, yield components like number of tubers, tuber length, tuber diameter, fresh and dry weight of tubers varied significantly among the genotypes. Highest number of tubers per plant (20.20) was observed in KRCCH-7 genotype, whereas, tuber length (20.68 cm) and tuber diameter (2.51 cm) was in KRCCH-8 genotype and tuber density (1.97 cc) in KRCCH-2 genotype. These variations are mainly attributed to the genetic makeup of these genotypes. Swamy *et al.* (2006) reported that highest number of tubers per plant (16.80) in SL-2 accession, tuber length (39.00 cm) in accession of 60 and tuber diameter (1.89 cm) in TL-3 accession in coleus. Similar observations were also reported by Kavitha *et al.* (2007b) in coleus. Highest total fresh weight of herbage (968.80 g) was observed in KRCCH-8 genotype, total dry weight of herbage (152.01 g) in KRCCH-6 genotype and per cent herbage dry matter (16.23) in KRCCH-5 genotype.

Highest fresh weight of tubers (417.67 g) was observed in KRCCH-1 genotype which was *on par* with KRCCH-3 (399.87 g) and KRCCH-5 (398.47 g) genotype. This could be attributed to better vegetative growth parameters like plant height, plant spread, stem diameter, total number of branches and number of leaves. It is evident that, the yield of genotype is dependent on vigour of the plant. The genotype KRCCH-6 recorded highest plant spread, number of branches and number of leaves but tuber yield was very low, as it is a non tuberous type. Highest dry weight of tubers (56.05 g) was observed in KRCCH-3 genotype which was *on par* with KRCCH-1 (53.75 g) and KRCCH-5 (51.27 g) genotypes. The variations in fresh and dry weight of tubers per plant among the different genotypes was mainly due to genetic makeup of these genotypes. Hegde *et al.* (2005) reported that highest fresh and dry

KRCHH-1



KRCHH-3



KRCHH-5

Plate 5: Superior genotypes of medicinal coleus

weight of tubers (870 g and 88.75 g, respectively) per plant in IIHR-59 accession of coleus. Also Swamy *et al.* (2006) observed that highest fresh weight of tubers (330.20 g) in SL-2 accession and dry weight of tuber (54.20 g) in 17-1 accession of coleus. Similar results were also reported by Patil *et al.* (2001) and Himabindu *et al.* (2005) in coleus. Highest per cent tuber dry matter (17.53) was observed in KRCCH-6 genotype, tuber yield per plot (6.53 kg) in KRCCH-1 genotype, tuber yield per hectare (15.31 t) in KRCCH-5 genotype and total dry matter accumulation per plant (205.20 g) in KRCCH-2 genotype.

5.2 Evaluation of medicinal coleus genotypes for pickling

In India, medicinal coleus is cultivated in parts of Karnataka, Tamil Nadu, and Maharashtra and Gujarat states. Traditionally, tubers of medicinal coleus are pickled and used as condiment. There are few studies on the evaluation of the genotypes for their suitability as condiment. In the present study, the genotypes of medicinal coleus were pickled and evaluated for their suitability for pickling.

Organoleptic evaluation for the overall acceptability of pickles prepared from the nine genotypes revealed that pickles of genotype KRCCH-5 were highly acceptable. The factors that were found to influence the overall acceptability of the pickles seems to be its constituent factors like taste, aroma and flavour of the pickles. The genotype KRCCH-5 had significantly highest scores for taste, aroma and flavour. Similar results were also reported by Patil *et al.* (2001). Kavitha *et al.* (2009) evaluated medicinal coleus genotypes for total sugars, starch and crude protein content to assess their suitability for edible purpose as condiment. They observed that highest accumulation of total sugars, starch and crude protein in the tubers was found to influence the suitability for edible purpose as condiment. Hence from the present study the acceptability of KRCCH-5 genotype for use as condiment may be due to its quality parameters like sugars, starch and crude protein.

In the present study, the highest tuber yield was registered in KRCCH-1, KRRCCH-3 and KRCCH-5 genotypes under Ghataprabha Left Bank Canal (GLBC) command area of Karnataka. The genotype KRCCH-5 can be exploited by small scale cottage industries for pickling.

6. SUMMARY AND CONCLUSIONS

The investigation was carried out to evaluate the medicinal coleus genotypes for growth, tuber yield and suitability for pickling at the Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi, during May, 2012 to November, 2012. The experiment was conducted in a randomized complete block design having three replications with ten genotypes. The main objective of the study was to find out superior genotype for tuber yield and suitability for pickling. The salient features of the experimental findings are summarized below.

The medicinal coleus genotypes showed significant variation for growth and yield parameters.

6.1 Evaluation of medicinal coleus genotypes for growth and yield

1. The maximum plant height (69.40 cm) was observed in genotype KRCCH-7 and the minimum plant height (33.73 cm) was observed in KRCCH-5 at harvest.

2. The highest plant spread (11,859.47 cm^2) was recorded in genotype KRCCH-6 and the least plant spread (5075.33 cm^2) was observed in genotype KRCCH-5 at harvest.

3. The highest stem diameter (2.90 cm) was observed in genotype KRCCH-4 and the least stem diameter (2.30 cm) was observed in KRCCH-6 at harvest.

4. The highest total number of branches per plant (75.74) was recorded in genotype KRCCH-6 and the least total number of branches per plant (44.93) was observed in K-8 at harvest.

5. The highest number of leaves per plant (237.33) was observed in genotype KRCCH-6 and the least number of leaves per plant (115.00) was observed in Aisiri at harvest.

6. The highest leaf length (11.48 cm) was observed in genotype KRCCH-3 and the least leaf length (8.29 cm) was observed in KRCCH-6 at harvest.

7. The highest leaf breadth (4.87 cm) was observed in genotype KRCCH-4 and the least leaf breadth (3.98 cm) was observed in KRCCH-5 at harvest.

8. The highest petiole length (2.31 cm) was observed in genotype KRCCH-5 and the least petiole length (0.92 cm) was observed in KRCCH-6 at harvest.

9. The highest internodal length (7.30 cm) was observed in genotype KRCCH-6 and the least internodal length (3.98 cm) was observed in KRCCH-5 at harvest.

10. The highest number of inflorescence per plant (29.07) was recorded in genotype KRCCH-6 and highest length of inflorescence per plant (52.33 cm) was recorded in KRCCH-5 at harvest.

11. The highest number of tubers per plant (20.20) was observed in genotype KRCCH-7 and the least number of tubers per plant (5.03) was recorded in KRCCH-6.

12. The highest tuber length (20.68 cm) was observed in genotype KRCCH-8 and the least length of tuber (10.16 cm) was observed in K-8.

13. The highest tuber diameter (2.51 cm) was observed in genotype KRCCH-8 and the least tuber diameter (0.56 cm) was observed in non tuberous KRCCH-6.

14. The highest tuber density (1.97 cc) was observed in genotype KRCCH-2 and the least tuber density (0.36 cc) was observed KRCCH-6.

15. The highest fresh weight of herbage per plant (968.80 g) was observed in genotype KRCCH-8 and the least fresh weight of herbage per plant (452.07 g) was observed in KRCCH-4 genotype.

16. The highest dry weight of herbage per plant (152.01 g) was observed in genotype KRCCH-6 and the least dry weight of herbage per plant (71.35 g) was observed in KRCCH-4.

17. The highest per cent dry matter content of herbage (16.23) was observed in genotype KRCCH-5 and the least per cent dry matter content of herbage (13.33) was observed in KRCCH-8.

18. The highest fresh weight of tubers per plant (417.67 g) was observed in genotype KRCCH-1 and the least fresh weight of tubers per plant (21.07 g) was observed in KRCCH-6.

19. The highest dry weight of tubers per plant (56.05 g) was recorded in genotype KRCCH-3 and the least dry weight of tubers per plant (3.13 g) was observed in KRCCH-6.

20. The highest per cent dry matter content of tubers (17.53) was observed in genotype KRCCH-6 and the least per cent dry matter content of tubers (12.44) was observed in KRCCH-5.

21. The highest tuber yield per plot (6.53 kg) was observed in genotype KRCCH-1 and the least tuber yield per plot (0.33 kg) was observed in KRCCH-6.

22. The highest tuber yield per hectare (15.31 t) was observed in genotype KRCCH-5 and the least tuber yield per hectare (0.76 t) was observed in KRCCH-6.

23. The highest total dry matter accumulation per plant (205.20 g) was observed in genotype KRCCH-2 and the least total dry matter accumulation per plant (89.63 g) was observed in K-8.

6.2 Evaluation of medicinal coleus genotypes for pickling

1. The highest score for taste and aroma (4.02) was recorded in genotype KRCCH-5 and the least score for taste and aroma (3.09) was recorded in KRCCH-4.

2. The highest score for flavour (4.03) was recorded in genotype KRCCH-5 and the lowest score for flavour (2.92) was recorded in KRCCH-4.

3. The highest score for overall acceptability (4.43) was recorded in genotype KRCCH-5 and the least score for overall acceptability (3.10) was recorded in KRCCH-4 and KRCCH-2 (3.10).

6.3 Conclusion

In the present study, the highest tuber yield was registered in KRCCH-1, KRRCCH-3 and KRCCH-5 genotypes under Ghataprabha Left Bank Canal (GLBC) command area of Karnataka. These genotypes can be used for further selections in the crop improvement programmes. High overall acceptability was recorded in genotype KRCCH-5 for use as condiment. Therefore, KRCCH-5 can be exploited by small scale cottage industries for pickling.

6.4 Future line of work

1. Evaluation of best performing genotypes of KRCCH-1, KRCCH-3 and KRCCH-5 to be carried out on large scale trials to confirm the findings of the present study.

2. Further surveys to assemble the genetic resources of medicinal coleus from South Indian states.

3. Industrial tie-up with small scale industries to utilize the promising types for pickling.

REFERENCES

Anonymous, 1950, *Coleus forskohlii.* In : Wealth of India-Raw materials, Vol. II. Central Scientific and Industrial Research New Delhi. p. 308.

Anonymous, 1996, Home scale preservation and processing of fruits and vegetables. CFTRI, Mysore.

Archana, P., 1998, Evaluation of potato cultivars for processing. Indian food packer, **52**(1) : 22-25.

Banderia, J. M., Valmor, J. B., Silvia, R., Jose, A. P. and Eugenia, J. B. B., 2010, Genetic similarities among four species of the *Plectranthus* (L'Hér.) genus. Acta Scientiarum Biological Sciences, **32**(1) : 43-48.

Chaitra, R. and Rajamani, K., 2009a, Evaluation of different glory lily (*Gloriosa superba* L.) genotypes for vegetative, floral, and yield characters. Agric. Sci. Digest, **29**(3) : 190-193.

Chaitra, R. and Rajamani, K., 2009b, Per se performance and correlation for yield and its quality characters in glory lily (*Gloriosa superba* L.). Academic Journal of Plant Sciences, **2**(1) : 39-43.

Chaitra, R. and Rajamani, K., 2010a, Assessment of different glory lily (*Gloriosa superba* L.) accessions for biochemical traits. Research Journal of Medicinal Plant*,* **4**(1) : 21-25.

Chaitra, R. and Rajamani, K., 2010b, Character association and path analysis in glory lily (*Gloriosa superba* L.). International Journal Communications in Biometry and Crop Science, **5**(2) : 78–82.

Chaitra, R. and Rajamani, K., 2010c, Correlation studies on yield and its components in glory lily (*Gloriosa superba* L.). World J. Agric. Sci., **6**(1) : 110-114.

Chaitra, R., Muthulakshmi, P. and Rajamani, K., 2013, Performance of some promising genotypes of glory lily (*Gloriosa superba* L.) against leaf blight disease. J. of Horticulture and Forestry, **5**(1) : 13-16.

De Souza, N. J., Dohadwaha, A. N. and Rupp, R. M., 1986, Forskolin- Its chemical, biological and medicinal potential. Hoechst India Ltd., Bombay.

Doreyappagouda, I. N. and Ramanjaneya, 1995, Evaluation of some mango varieties for their suitability for canned mango juice. J. of Food Science and Technology, **32**(4) : 323-325.

Dwivedi, S., Maneesha, S., Singh, A. P., Sharma, S., Uniyal, G. C. and Sushil, K., 1999, Genetic variability, heritability and genetic advance for alkaloid yield attributing traits in 26 genotypes of periwinkle (*Catharanthus roseus* L.). J. of Medicinal and Aromatic Plant Sciences, **21**(2) : 320-324.

Hegde, L., 1992, Studies on germplasm evaluation, induced autotetraploidy and hybridization in *Coleus forskohlii* (Wild) Briq. Ph. D. Thesis, University of Agricultural Sciences, Bangalore

Hegde, L. and Gangadharappa, P. M., 2002, Performance of periwinkle (*Catharanthus roseus* L.) genotypes in Northern Karnataka. Karnataka J. Agric. Sci., **15**(4) : 675-678.

Hegde, L. and Shiragur, M., 2003, Genetic variability in Ashwagandha (*Withania somnifera* Dunal). National Seminar on New Prospectves in Spices, Medicinal and Aromatic Plants, 27-29 November, Goa.

Hegde, L., Kumar, T. V. and Himabindu, K., 2005, Evaluation of *Coleus forskohlii* accessions for tuber and forskolin yield. Acta Horticulturae, **675 :** 217-219.

Himabindu. K., Kumari, V. K. and Kumar, V. T., 2005, Genetic variability and association between growth and tuber traits in *Coleus forskohlii.* J. of Medicinal and Aromatic Plant Sciences, **27** : 233-237.

Kavitha, C., Vadivel, E., Rajamani, K. and Thangamani, C., 2007a, Analysis of variability for qualitative and quantitative traits in *Coleus forskohlii* Briq. J. Hort. Sci., **2**(1) : 44-46.

Kavitha, C., Vadivel, E., Thangamani, C. and Rajamani, K., 2007b, Variability studies for morphological traits in *Coleus forskohlii.* J. of Medicinal and Aromatic Plant Sciences, **29 :** 60-62.

Kavitha, C., Vadivel, K., Thagamani, C. and Rajamani, K., 2007c, Variations in starch accumulation among tuberous and non tuberous genotypes of *Coleus forskohlii* Briq. Plant Archives, **7** : 161-164.

Kavitha, C., Vadivel, K., Rajamani, K. and Thagamani, C., 2009, Evaluation of *Coleus forskohlii* genotypes for bio chemical characters. Research Journal of Medicinal Plant, **3**(2) : 75-79.

Kavitha, C., Vadivel, K., Rajamani, K. and Thagamani, C., 2010, Genetic divergence in *Coleus forskohlii* Briq. South Indian Hort., **58 :** 15-19.

Kothari, S. K. and Singh, K., 2001, Evaluation of safed musli (*Chlorophytum borivillianum* Santapau and Fernades.) germplasm. J. of Spices and Arom. Crops, **10**(2) : 147-149.

Kumar, R. R., Reddy, L. P. A., Subbaiah, J. C., Kumar, A, N., Nagendraprasad, H. N. and Bhukya, B., 2011, Genetic association among root morphology, root quality and root yield in ashwagandha (*Withania somnifera).* Genetika, **43(**3**)** : 617 -624.

Misra, H. O., Sharma, J. R., Lal, R. K. and Nidhi, S., 2003, Pattern of genetic variability of different traits in collection of kalmegh (*Andrographis paniculata*) genotypes. J. of Medicinal and Aromatic Plant Sciences, **22**(4A) : 348-351.

Misra, L. N., Tyagi, B. R., Ahmed, A. and Bahl, J. R., 1994, Variability in the chemical composition of the essential oil of *Coleus forskohlii* genotypes. J. of essential Oil Research, **6** : 243-247.

Naniah, K. M., 1993, Studies on hybridization, chromosomal doubling, grafting and leaf anatomy in *Coleus forskohlii*. Briq. Ph. D Thesis, University of Agricultural Sciences, Bangalore.

Panse, V. G. and Sukhatme, P. V., 1978, Statistical methods for agricultural workers, ICAR Publication, New Delhi.

Pant, S. and Kulshrestha, K., 1994, Frying quality of six varieties of potato. J. of Food Science and Technology, **31**(5) : 428-429.

Pasare, A. B., Meera, R., Srinivasan, C. N. and Pushpa, P., 1996, Composition and cooking quality of five sweet potato varieties. J. of Root Crops, **22**(2) : 101-104.

Patil, S., Hulamani, N. C. and Rokhade, A. K., 2001, Performance of genotypes of *Coleus forskohlii* Briq. for growth, yield and essential oil content. Indian Perf., **45**(1) : 17-21.

Poonam, A., Kaur, B. and Bal, J. S., 1997, Studies on dehydration of different ber cultivars for making ber chuharas. J. of Food Science and Technology, **34**(6) : 534-536.

Raina, A. P., Kumar, A., Pareek, S. K. and Sharma, S. K., 2013. Evaluation studies on kalmegh (*andrographis paniculata* Nees). Acta Horticulturae, **972** : 117-120.

Ranganna, S., 1986, Manual of analysis of fruits and vegetables products. Tata McGraw Hill publishing Co. Ltd., New Delhi.

Revadigar, V., Shashidhara, S., Pradeep, N. S., Murali, B., Rajasekharan, P. E. and Prakashkumar, R., 2008, Variability in the chemical constituents in the roots of *Coleus forskohlii* from different geographical regions of India. Acta Horticulturae, **675** : 245-253.

Sangwan, O., Avtar, R. and Singh, A., 2013, Genetic variability, character association and path analysis in ashwagandha [*Withania somnifera* (L.) Dunal] under rainfed conditions. Research in Plant Biology, **3**(2) : 32-36.

Singh, A. K., Singh, H. P., Aparbal, S. and Gupta, M. M., 2001, Domestication and evaluation of kalmegh (*Andrographis paniculata*) populations. Journal of Medicinal and Aromatic Plant Sciences, **23**(2) : 63-68.

Singh, B. M., Pareek, S. K., Mandal, S., Maheshwari, M. L. and Gupta, R., 1992, Variability in periwinkle (*Catharanthus roseus* L.). Indian J. Agric. Sci., **62**(1) : 47-50.

Singh, O. P., Singh, T. P., Yadav, A. L. and Yadav, P. N., 2000, Genetic variability, genotypic and phenotypic correlation germplasm of opium poppy (*Papever somniferum* L.). Adv. Plant Sci., **13**(1) : 69-73.

Swamy, M. T. S., Sreeramu, B, S. and Mallikarjuna, G. A. P., 2006, Genetic variability, heritability and genetic advance for yield and yield attributing traits in *Coleus barbatus* Benth. genotypes. Biomed, **1**(2) : 153-158.

Sharma, R., 2004, Agro-techniques of medicinal plants. Daya Publishing House. pp. 60-62.

Vadivel, V. and Janardhanan, K., 2000, Preliminary agro botanical traits and chemical evaluation of *Mucuna pririens.* A less known food medicinal legume. J. of Medicinal and Aromatic Plant Sciences, **22**(2&3) : 191-199.

Valdes, L. J., Mislanker, S. G. and Paul, A. G., 1987, *Coleus barbatus* (*Coleus forskohlii*) (Lamiaceae) and the potential new drug forskolin (Coleonol). Econ. Bot., **44** : 474-483.

Velmurugan, M., Rajamani, K., Paramaguru, P., Gnanam, R. and Kannanbapu, J. R., 2009, Studies on correlation and path analysis in mutants of Coleus (*Coleus forskohlii* Briq.) for yield and forskolin content in V_2M_1 generation. J. Hort. Sci., **4**(1) : 63-67.

Velmurugan, M., Rajamani, K., Paramaguru, P., Gnanam, R. and Kannanbapu, J. R., 2011, Studies on correlation and path analysis in callus derived *in vitro* mutants of Coleus (*Coleus forskohlii* Briq.) for yield and forskolin content in TC_1M_1 generation. J. of Medicinal and Aromatic Plant Sciences, **33**(1) : 31-35.

Vishwakarma, R. A., Tyagi, B. R., Ahmed, B. and Hussain, A., 1988, Variation in forskolin content in the roots of *Coleus forskohlii.* Planta Medica, **54**(5) : 471-472.

Appendix I: Meteorological data recorded during experimental period (2012-2013) at Agricultural Research Station, Arabhavi

Month	Temperature °C				RH (%)	Rainfall (mm)	No. of rainy day	Rainfall Normal (mm)	Evapor – ation (mm)
	Min.	Min Nor	Max.	Max. Nor.					
April	-	18.2	36.19	35.1	65.78	92.0	03	17.56	5.1
May	-do-	19.9	36.43	34.4	63.03	85.6	02	65.96	5.7
June	-do-	20.9	28.88	29.1	77.80	81.1	08	99.09	9.7
July	-do-	19.9	29.22	28.3	81.74	60.2	08	74.31	2.8
August	-do-	19.1	28.80	28.5	81.35	89.3	08	48.21	2.7
September	21.21	18.3	29.75	29.2	77.48	26.0	04	91.49	3.3
October	20.88	14.7	31.14	30.0	73.74	213.7	08	107.69	2.5
November	16.81	19.96	29.17	29.26	67.95	0.0	00	14.77	3.6

EVALUATION OF MEDICINAL COLEUS [*Plectranthus forskohlii* (Willd) Briq.] GENOTYPES FOR GROWTH TUBEROUS ROOT YIELD AND SUITABILITY FOR PICKLING

TAMMANNA M. WAGH 2013 Dr. SHANKARGOUDA PATIL
Major Advisor

ABSTRACT

Investigations were carried out to evaluate the medicinal coleus [*Plectranthus forskohlii* (Willd) Briq.] genotypes for growth, tuberous root yield and suitability for pickling at the Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi during 2012- 2013. The experiment was conducted in a Randomized Complete Block Design having three replications and ten medicinal coleus genotypes collected from different geographical locations. The main objectives of the study was to find out superior genotype for tuberous root yield and suitability as condiment. Among the genotypes evaluated for growth parameters maximum plant height (69.40 cm) was recorded in KRCCH-7, while highest plant spread (11,859.47 cm^2) was observed in genotype KRCCH6, highest stem diameter (2.90 cm) in KRCCH-4, highest total number of branches (75.74) and number of leaves per plant (237.33) in KRCCH-6 , highest petiole length (2.31 cm) in KRCCH-5 was observed at harvest.

Among the yield parameters, highest number of tubers per plant (20.20) was recorded in KRCCH-7, highest tuber length (20.68 cm) and tuber diameter (2.51 cm) in KRCCH-8. The highest fresh weight of tubers (417.67 g) was observed in KRCCH-1, highest dry weight of tubers (56.05 g) was observed in KRCCH-3. The highest tuber yield (15.31 t) in KRCCH-5, highest total dry matter accumulation per plant (205.20 g) was observed in KRCCH-2. Among the genotypes evaluated for use as condiment, KRCCH-5 was found to be highly suitable.