PERFORMANCE EVALUATION OF LEAF CORIANDER (*Coriandrum sativum* L.) TYPES IN THE PLAINS OF KERALA

by

SURYA RAJ

(2015-12-021)

THESIS

Submitted in partial fulfillment of the requirements

for the degree of

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANTATION CROPS AND SPICES

COLLEGE OF HORTICULTURE,

KERALA AGRICULTURAL UNIVERSITY

VELLANIKKARA, THRISSUR- 680 656

KERALA, INDIA

2017

DECLARATION

I, hereby declare that the thesis entitled "**PERFORMANCE EVALUATION OF LEAF CORIANDER (*Coriandrum sativum* L.) TYPES IN THE PLAINS OF KERALA**" is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

Surya Raj

Date: 19/10/2017

(2015-12-021)

CERTIFICATE

Certified that this thesis entitled **"PERFORMANCE EVALUATION OF LEAF CORIANDER (*Coriandrum sativum* L.) TYPES IN THE PLAINS OF KERALA"** is a record of research work done independently by **Ms. Surya Raj (2015-12-021)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara

Date: 19/10/2017

Dr. P. Anitha.

(Major Advisor, Advisory Committee)

Associate Professor (AICVIP)

College of Horticulture

Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Surya Raj (2015-12-021)**, a candidate for the degree of **Master of Science in Horticulture** with major field in Plantation crops and Spices, agree that the thesis entitled **"PERFORMANCE EVALUATION OF LEAF CORIANDER (*Coriandrum sativum* L.) TYPES IN THE PLAINS OF KERALA"** may be submitted by Ms. Surya Raj in partial fulfillment of the requirement for the degree.

Dr. P. Anitha 19/10/17
Associate Professor
AICVIP,
College of Horticulture, Vellanikkara

Dr. P.V. Nalini 19/10/17
Professor and Head
Department of Plantation Crops & Spices
College of Horticulture, Vellanikkara

Dr. T. Girija 19/10/17
Professor and Head
Department of Plant Physiology
College of Horticulture, Vellanikkara

Dr. K. Krishnakumary 19/10/17
Professor
Department of Plantation Crops & Spices
College of Horticulture, Vellanikkara

19/10/17
EXTERNAL EXAMINER

ACKNOWLEDGEMENT

*Before I say a word of acknowledgement, I owe to bow my head before the **Almighty God**, whose unbound rays of blessings always enshrined in my thoughts, deeds and so also bestowed with good health, strength , confidence and enthusiasm.*

*It is with great respect and devotion, I place on record my deep sense of gratitude and indebtedness to my chairperson **Dr. P. Anitha,** Associate Professor , AICVIP, College of Horticulture, Vellanikkara for her sustained and valuable guidance, unflinching support, constructive professional criticism, motherly approach and whole hearted cooperation rendered throughout the conduct of my research work and preparation of thesis. I gratefully remember her knowledge and wisdom which nurtured this research project in right direction without which fulfillment of this endeavour would have not been possible.*

*Words fall short in expressing my profound sense of gratitude and sincere thanks to **Dr. P. V. Nalini,** Professor and Head, Department of Plantation crops and Spices and member of my advisory committee for her expert advice, constant inspiration and meticulous help throughout the course of study.*

*I am deeply obliged to **Dr. K. Krishnakumary,** Professor, Department of Plantation crops and Spices, a member of my advisory committee for her kind help, valuable suggestions, motherly approach and cooperation throughout the research program and critical scrutiny of the manuscript.*

*I render my sincere thanks to **Dr. T. Girija,** Professor and Head, Department of Plant Physiology, a member of my advisory committee, for her support, ever willing help, logical thinking, scholarly suggestions and cooperation throughout my study period and for open mindedness in allowing me to utilize the lab facilities at necessary times.*

*I consider it as my privilege to express my deep felt gratitude to **Dr. S. Krishnan,** Professor and Head, Department of Agricultural Statistics for his support, critical comments and valuable advice during the statistical analysis of data and preparation of manuscript.*

*I express my heartiest gratitude to **Dr. S. Nirmaladevi** , Professor, Department of Olericulture for her sincere support and guidance in several ways which helped me during the final days of thesis submission.*

I am indebted to all my beloved teachers in the Department of Plantation Crops and Spices viz. ***Dr. V.S. Sujatha ,Dr. N. Miniraj, Dr. B. Suma and Dr. Jalaja S. Menon****. for their kind concern, moral support and love.*

Words fail to express my heartful gratitude to ***Mr. Vasudev Rathod,*** *Assistant Professor, College of Horticulture, Hirur for his helping hands, constant encouragement and valuable guidance throughout the past six years.*

I gratefully thank ***Indian Council of Agricultural Research*** *for providing me financial support through Junior Research Fellowship Award for the entire PG programme.*

The financial and technical support provided by ***Kerala Agricultural University*** *is also highly acknowledged.*

My profound gratitude to the ***Department of Spices and Plantation crops, TamilNadu agricultural University*** *and* ***Indian Institute of Horticultural Sciences,Bangaluru*** *for providing me the seed materials needed for the research work.*

I duly acknowledge ***Sunil Kumar,*** *Farm officer, Department of Plantation crops and spices for providing all the labourers at the needful times, valuable technical advice and moral support throughout my field study.*

With deep reverence, I express my whole hearted gratitude and never ending indebtedness to ***Bindu chechi, Devootty chechi, Chandrika chechi, Devu chechi, Veshu chechi, Lissi chechi, Rajan chettan, Vijayan chettan*** *and* ***Jinesh chettan*** *for their unbonded love, unwavering encouragement and care without which fulfillment of this endeavour would not have been possible.*

I am grateful to all the non-teaching staff of the Department of Plantation crops and Spices especially ***Sumi chechi, Deepa chechi, Sajitha chechi, Krishna chechi, Sindhu chechi and Manisha chechi*** *for the help rendered by them during the course of my study.*

With immense pleasure, I express my sincere thanks to my intimate friends ***Geethumuth, Manumon, Sru*** *and* ***Nimishechi (Dudes)*** *for their promt help, support, jovial companionship, care and encouragement throughout the PG programme.*

I owe a lot to all my dear friends ***Malu, Sree, GG, Aswathy, Deepa, Shilpa, Suvarna, Priya*** *and* ***Deepali****, for their whole hearted cooperation, companionship and personal support.*

I am also indebted to my Seniors and Juniors viz. ***Prinks, Akku chechi, Suju, Varsha, Nabeela, Ajmal, Vijaykumar, Surendra, Anila, Dharini, Shibana and Sreelekshmi*** *for their timely help when I needed the same.*

It's my fortune to gratefully aknowledge the infinite affection, warm concern, constant encouragement and moral support of my dearest and best friends ***Dr. Aswaghosh, Bose, Anju, Rahul, Aani, Isa, Kavya and Hannus.***

I am in dearth of words to express the deep sense of gratitude to my dear husband, ***Subin*** *and family for being always besides me during the happy and hard moments to push and motivate me.*

No expression of thanks will be sufficient to recognise the patronage bestowed upon me by my sister and best friend ***Suja Raj****, my brother-in –law* ***Shibulal*** *and my nephew* ***Sidhumon.***

Above all, I am forever beholden to my parents ***Mr. Rajendran and Mrs. Sujatha*** *for their unfathomable love, selfless sacrifice, constant prayers, boundless affection and incessant inspiration, which supported me to stay at tough tracks and helped me for the successful completion of all my endeavours.*

A word of apology to those I have not mentioned in person and a note of thanks to one and all who worked for the successful completion of this endeavour.

SURYA RAJ

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

APPENDICES

Appendix	Title
I	Monthly mean weather data during the period from April 2016 to March 2017

Introduction

1. INTRODUCTION

The culinary world would be lifeless without spices. Historically, herbs and spices have enjoyed a rich tradition of use for their flavor-enhancement characteristics and medicinal properties. Spices offer a host of powerful phytonutrients that can enhance human health and well-being. It constitutes an important group of agricultural commodities, since antiquity and have been considered virtually indispensable in culinary art. India has been the leading spice producing and exporting country of the world since the recorded history and still considered as the "Home of Spices". The usage of spices by consumers is increasing worldwide because they are completely natural, rather than artificial additives for seasoning and flavoring of foods.

Seed spices are annual herbs, whose dried seed or fruits are used as spices. They are nature's gift to humankind and add flavour to our food in addition to having preservative and medicinal value. There are about 20 seed spices grown in India. The most prominent among them are coriander, cumin, fennel, fenugreek, etc.

Coriander (*Coriandrum sativum* L.), belongs to the family Apiaceae, is an important annual spice herb, mainly cultivated for its fruits as well as for its tender green leaves (Kumar *et. al.,*1997). The crop, indigenous to Southern Europe and the Mediterranean region, is the most important seed spice grown in India. Its name has been derived from Greek word "Koris", meaning bed-bug, because of unpleasant, foetid bug like odour of the green unripened fruits. It is one of the finest aromatic and culinary herbs and is considered as a delighters' choice.

India is the largest producer, consumer and exporter of coriander seeds in the world accounting approximately 80 per cent of total world production. In India, it is mainly grown in Rajasthan, Madhya Pradesh, Assam, Gujarat, Andhra Pradesh, Tamil Nadu and Karnataka. According to National Horticulture Board (2015), coriander is grown for its grains in 44,700 hectares in India, and as a herb it is grown in nearly 20,000 to 25,000 ha. During the year 2014, 37.5 lakh metric tonnes of coriander leaves was traded through various agricultural markets indicating the commercial importance of the herb (Giridhar *et al.*, 2015).

Recent understanding of the neutraceutical and medicinal properties of the leaves elevated the status of this crop. All occidental cuisines are repleted with the herb dressings, garnishing or inclusion. The leaves and stem tips are rich in numerous anti-oxidant polyphenolic flavonoids such as quercetin, kaempferol, rhamnetin and epigenin. It is one of the richest herbal sources for vitamins especially Vitamin A, C and K. Leaves are also rich in β-carotene, water, dietary fiber, fats, protein and minerals like calcium, phosphorus, manganese, zinc, iron and magnesium, which accounts for its potential health benefits. The different plant parts possess antioxidant, diuretic, anti-diabetic, sedative, anti-microbial, anti-convulsant, hypnotic, anthelminthic and anti-mutagenic properties (Mandal and Mandal, 2015).

Generally, coriander can be grown throughout the year except during the periods of high rainfall and hot summers for leaf purpose, but for higher grain yield, it has to be grown in specific seasons. In Kerala, there is a high demand for coriander leaves throughout the year. Eventhough, scattered cultivation of coriander as herbal spice has been started in Wayanad and Idukki districts, domestic demand for coriander leaves is met from neighboring states of Karnataka and Tamil Nadu. The availability of the herb is unlimited during *rabi*, whereas limited during *kharif* and summer periods. In order to meet the growing needs of the consumers and to enhance the supply window, year round production of coriander leaves should be ensured.

The available information on growth, herbage yield and quality in coriander is scanty and so also the effect of different growing conditions on growth, herbage yield and quality, as no such studies were conducted in Kerala.

It was in this background the present study entitled “Performance of leaf coriander (*Coriandrum sativum* L.) types in the plains of Kerala” was taken up with the objectives of evaluating the growth and performance of leaf coriander types in rain shelter in different time of sowing (seasons) and to evaluate the performance of the crop in open field and in rain shelter during *rabi* season.

Review of literature

2. REVIEW OF LITERATURE

Coriander (*Coriandrum sativum* L.) is an annual herb, mainly cultivated for its fruits as well as for the tender green leaves. In India, it is grown in Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan and Madhya Pradesh. Major portion is though consumed locally; a small quantity is being exported now. In Kerala, there is high demand for coriander leaves throughout the year. Even though, scattered cultivation of coriander as herbal spice has been started in Wayanad and Idukki districts, domestic demand for coriander leaves is met from neighboring states of Karnataka and Tamil Nadu.

Growth, herbage yield and quality in coriander are influenced by time of sowing (seasons). Coriander is a tropical crop and can be grown throughout the year (except very hot season) for leaf purpose, but for higher grain yield, it has to be grown in specific season. Therefore, the present investigation entitled "Performance evaluation of leaf coriander (*Coriandrum sativum* L.) types in the plains of Kerala," was undertaken to study the growth and performance of coriander as leaf spice in different sowing times (seasons) and to evaluate the performance under different growing conditions viz., open and rain shelter during *rabi* season at the Department of Plantation Crops and Spices, College of Horticulture, Vellanikkara.

The available information on growth and performance on leaf coriander is very limited and so far, no such studies were conducted in Kerala, on the effect of different time of sowing (seasons) and growing conditions (rain shelter and open field). Therefore, literature available on above aspects on coriander and closely related crops like fenugreek, dill, and cumin are reviewed hereunder.

2.1.0. EFFECT OF TIME OF SOWING (SEASONS) AND GENOTYPES ON GROWTH AND YIELD PARAMETERS

Rajan *et al.,* (1990) screened 16 promising lines of coriander for field resistance to mould diseases during 3 seasons. The results over the 3 seasons were similar, with mean incidence ranging from 5.8 to 12.8 per cent. In addition, the lines, 695 and CS7, had the lowest disease incidence of 5.8 and 6.3 per cent respectively.

Salvarajan *et al.*, (2002) evaluated nine genotypes for three consecutive years and recorded the highest mean values for plant height (55.47 cm) in accession CS-12 followed by the accession CS-102 (49.67 cm) and lowest in the variety CO-3 (40.71 cm).

Kalra *et al.,* (2006) found a significantly higher aphid incidence in the first week of February and increased with the advance of the season in different growing years. The peak incidence of the pest was recorded during the end of February and 1st week of March (average of 31.5 aphids/umbel).

Meena and Malhotra (2006) reported a significantly higher green leaf yield per plant (13.09g) in coriander sown on 15^{th} October over the crop sown on 15 November (11.55g).

Velayudham *et al.,* (2006) studied 11 coriander genotypes for yield during *kharif* and *rabi* season in the year 2003-2004. Among them, var. CO-3 recorded the highest seed yield (0.70 t/ha and 0.78 t/ha), which was on par with CO-4 (0.74 t/ha and 0.56 t/ha) in both the seasons respectively under irrigated conditions. During *Kharif* season, CO-1 and RCr-41 recorded highest number of primary (6.66/plant) and secondary (14.26/plant) branches, but lowest primary branches (5.30/plant) in Guntur Local and secondary branches in Gadag Local (11.06/plant). In addition, they recorded maximum number of leaves in RCr-41 (52.83 and 68.20) and the minimum (21.40 and 31.53) in DWD-3 in *kharif* and *rabi* respectively at harvesting stage of the crop.

Verma and Sen (2008), suggested that GA_3 application with 50 ppm pre-plant soaking and spraying 20 days after sowing significantly improved the vegetative growth of coriander herb while NAA at 50 ppm improved the quality of the coriander herb during two consecutive years during the months of November-April.

Chaulagain *et al.,* (2011) conducted a field experiment to study the green leaf production potential of ten coriander cultivars. They concluded that there is good scope of coriander cultivation for green leaf production, but it is more suitable to sow the seeds in usual time of sowing for the better performance of all the cultivars.

Rajaraman *et al.,* (2011) found that the application of 125 per cent recommended dose of fertilizers through fertigation in variety CO (Cr)-4 recorded the highest plant height (33.93 and 34.22 cm) during first and second season, respectively at 45 DAS. In addition, the plant height showed an increasing trend of growth during different stages of observation.

Sarada *et al.,* (2011) opined that among various weather factors studied, soil temperature significantly influenced the germination, crop growth and yield of coriander. They also suggested that soil temperature had significantly negative effect with number of leaves, leaf length, green biomass, shoot weight and yield.

An experiment was conducted by Palanikumar *et al*., (2012a) to study the fresh yield, dry biomass yield and quality traits of coriander during three seasons viz., season I (June-August 2008), season II (October-December 2008) and season III (June-August 2009). They reported that the biomass yield showed positive significant association with plant height, number of branches, number of leaves, weight of leaves, weight of stem and weight of root during all the three seasons. They concluded that biomass yield in coriander is closely associated with all these characters.

Meena *et al.,* (2013) conducted an experiment during *rabi* season to assess yield, quality and economics of coriander genotypes viz., RKD 25, RKD 29, RKD 13, RKD 36, RKD 18, RKD 27 and checks RCr-436 and CS-6 under irrigated condition. The results revealed that among the genotypes, RKD-13 took significantly minimum days (56) to produce 50% flowering and days to maturity (99) over best local check RCr-436.

Moniruzzaman *et al.*, (2013) observed that high temperature during hotter months significantly reduced seed germination and subsequently the performance of coriander genotypes.

Arif (2014) evaluated the performance and adaptability of promising genotypes of coriander in hilly areas of Karnataka during the months of January to March 2012.The result showed that highest plant height (18.98cm) was in DCC-37 and the lowest (8.9cm) in DCC-13. At 30 DAS, the highest numbers of leaves (22.19) were found in DCC-44 and the lowest (7.93) in DWD-3. The genotype DCC-8 took minimum (40.09) number of days to 50% flowering while DCC 2 recorded maximum number of days (52.15) to 50% flowering. He also recorded that the highest herbage yield (8.27 g/plant) in the genotype DCC-44 and lowest (2.95 g/plant) in Dharwad Local. He also recorded the number of primary and secondary branches of genotypes wherein CO-1, CO-2 and CO-4 possessed 4.37, 4.17 and 4.23 primary branches and 7.28, 6.61 and 8.33 secondary branches respectively.

Guha *et al.,* (2014) suggested that the time of sowing influenced significantly the days taken for seedling emergence and the production of the first, second and third leaf. From the study, they reported that the best time of sowing for early seed germination and for leaf production was November among all other sowing dates. In addition, both sowing date and harvest time had significant effect on flowering time, leaf serration, seed setting and physiological maturity of coriander. Significantly superior leaf yield was observed for October sown crop. April sown seeds germinated 12.56 days after sowing (DAS), May (12.22 DAS), June (12.44 DAS), August (13.56 DAS). However, July sown seeds were noticed to germinate at the earliest (11.78 DAS) compared to all other sowing dates. June and July sown seeds were found to emerge first leaf at 13.22 DAS and August sown seeds at 15.44 DAS. Similarly, June and August sown seeds took 14.56 DAS and 17 DAS respectively for the emergence second leaf. In addition, in the case of third leaf emergence, June and August sown seeds took 14.78 DAS and 19DAS.Two harvests may be recommended as a crucial agronomic practice for better green leaf yield. They concluded that protected cultivation was a possible strategy in the summer months for farmers in controlling external climate, which was a limiting factor for seed germination.

Sharangi and Roychowdary (2014) reported that early winter sowing preferably November 5thwas best for producing higher seed yield. They also suggested that the performance of coriander was greatly influenced by a change in sowing time due to change in weather microclimate.

Sinta *et al.,* (2015) found that maximum number of umbels (33.7) were observed during *rabi* season, but in *kharif* significantly less number of umbels (13.7) were seen in coriander.

Devi (2016) evaluated 12 genotypes of coriander during two consecutive years in *rabi* season and found that Assam collection took significantly lowest (42.33) days and NRCSS A.Cr-1 took maximum (77.00) days for flowering and significantly highest number of primary (10.67) and secondary branches (17.00) were seen in NRCSS A.Cr-1.

Katar *et al.,* (2016) suggested that locations with different climatic and geographic characters had significant effects in coriander genotypes for yield, yield components and essential oil content. In addition, while conducting research in two successive *rabi* seasons of 2013 and 2014, they found that with increasing rainfall, an increase in seed yield and decrease in essential oil content occurred.

Lal and Singh (2016) conducted an experiment for the evaluation of coriander varieties ACr-1 and RCr-41 during *rabi* season. They recorded significantly higher growth and yield parameters in ACr-1 with maximum number of primary branches (7.87/plant), secondary branches (21.55/plant), number of umbels (29.20/plant), number of umbellates (5.81/plant) and number of seeds (8.40/umbellate) with earliest flowering (66.05) DAS and highest seed yield (1296.31 kg/ha) than RCr-41.

Similar works in related crops are reviewed here under. Mirshekari *et al.*, (2011) suggested that delayed sowing of cumin seeds resulted in insufficient vegetative growth, wherein the plants immediately responded to photoperiod so that the number of umbels per plant and plant height were reduced significantly.

Agarwal *et al.*, (2013) studied on three varieties of fenugreek during *rabi* season. They found that plant height, fresh weight, dry weight, number of primary branches, leaf area, number of leaves, increased significantly with the advancement of age. The highest plant height (45.30cm), fresh weight (16.2g), dry weight (3.33g) were recorded in variety Rmt-1 at 60 DAS and lowest (6.67cm, 0.46g and 0.07g respectively) in Pusa Kasuri at 30 DAS.

Lataye *et al.*, (2016) evaluated different varieties of fenugreek during *rabi* 2014-15. Among the varieties tested, the number of days for germination was significantly different in which the minimum (3.93) days for germination was observed in Hisar Suvarna. With respect to the plant height (17.95 cm), number of branches (5.08), fresh weight (7.97 g) and green leaf yield, the variety Hisar Sonali was superior.

2.1.1. EFFECT OF TIME OF SOWING (SEASONS) AND GENOTYPES ON QUALITY PARAMETERS

Maurya (1990) evaluated the effects of seasons on essential oil yield in coriander during three consecutive years. He found that after 120 days of sowing, the essential oil content of seed was highest (0.85-0.88%) in 16th October sown crop than other sowing dates.

Agrawal *et al.*, (1993) evaluated coriander varieties for essential oil purpose and reported that the yield of essential oil was highest in local variety and CS-287 (0.37% each). However, it was the lowest in DH-5 and UD-436 (0.18% each).

Hussein (1995) studied the influence of different sources of N (ammonium nitrate, calcium nitrate or urea) on the essential oil yield and composition of *Coriandrum sativum* and *Anethum graveolens* during two successive seasons. Among the treatments, the application of ammonium nitrate resulted in the highest oil concentration and yield in coriander while urea was best for dill oil.

Rajagopalan *et al.,* (1996) evaluated thirteen coriander cultivars for seed and essential oil yield. Although no significant differences in essential oil content or yield were observed between the cultivars/accessions, JC.81 produced the highest essential oil yield (3.95 kg/ha).

Kalra *et al.*, (1999) evaluated coriander varieties for essential oil and found that the content of essential oil of Indian genotypes ranged from 0.2 to 0.4 per cent and reported a good crop yield of nearly 6-8 kg per hectare of essential oil. Among the genotypes, C-1 gave the highest seed and oil yield.

Rao *et al.*, (2004) recorded that oil yields of leaves ranged from 0.04 to 0.08 % and 0.06 to 0.12 % per 100g of fresh weight at vegetative and flowering stage respectively. Oils from leaf had decanol as the major component followed by (E)-2-decen-1-ol, (E)-2-dodecenal and (E)-2-tetradecenal and decanal.

In a study on the quality attributes of fifteen genotypes of coriander, Singh *et al.,* (2002) found the highest oil content (0.40 %) in genotype S-33 followed by RCr-20 (0.10 %).

Prabhu and Balakrishnamurthy (2006) evaluated coriander genotypes for quality attributes. The study revealed that the accession UD-243 recorded the highest essential oil (0.34%), whereas the lowest oil content was noticed in local accession 812 (0.19%).

Meena *et al.*, (2006) suggested that foliar spray of 25 ppm NAA or 50 ppm GA_3 at 30 DAS significantly increased chlorophyll and carotenoids content in leaves and essential oil content in seeds of coriander. They also reported that early sown(15th October) coriander crop recorded significantly higher chlorophyll and carotenoids content in leaves and essential oil in seeds over 15th November sown crop during *rabi* season.

In a study on evaluation of coriander genotypes at northern Karnataka by Velayudham *et al.*, (2006) the varieties CO-3 and RCr-41 recorded the highest oil yield of 5.83 kg/ha and 5.84 kg per hectare, respectively.

Divya (2007) noticed the highest essential oil content in CIMPO-S-33 (0.73%) followed by Sindhu and CO-4 (0.43%) and the lowest in Ghataprabha Local (0.30%) seeds. Tehlan *et al.*, (2007) described Hisar Surabhi (DH-246) as a very promising variety of coriander which was high yielding having good oil content (0.425%).

Sunilkumar (2010) observed that the variety CIMPO-S-33 recorded highest essential oil content (0.74 %) followed by RCr-41 (0.61%), CO-4 (0.55%) and Swathi (0.49%) while the lowest was in Ghataprabha Local (0.23%). The essential oil yield per hectare was highest in CIMPO-S-33 (3.98 kg/ha) and the lowest was in Ghataprabha Local (1.21 kg/ha).

Ebrahimia *et al.*, (2010) reported that essential oil content of the dried seeds varied from 0.10 to 0.36 per cent. Thirty-four different compounds were identified in essential oils of all accessions studied. Among them, Linalool (40.9-79.9%), Neryl acetate (2.3%-14.2), γ-terpinene (0.1-13.6%) and α-pinene (1.2-7.1%) were identified as the main components in the oil of coriander accessions.

Padalia *et al.*, (2011) pointed out that the peculiar, foetid-like aroma of coriander leaves was mainly because of the aliphatic compound (90.20%) comprising of C8-C16 aldehydes and alcohol steam volatiles.

Rajaraman *et al.*, (2011) studied the effect of fertigation on leafy types of coriander in two growing seasons. They found that fertigation with 125 percent water soluble fertilizer showed significant influence on chlorophyll content of the leaves.

Application 125 percent recommended dose of fertilizer recorded the maximum chlorophyll 'a' of 2.20 and 2.54 mg g-1 at harvest stage in coriander variety CO(Cr-4).

Palanikumar and Rajamani (2012b) evaluated different coriander genotypes during three seasons viz., season I (June-August 2008), season II (October-December 2008) and season III (June -August 2009). The experiment revealed that the genotype CS 101 recorded highest chlorophyll 'a' (0.67, 0.36 and 0.42 mg) and ascorbic acid (195.14, 156.45 and 149.08 mg) in all the three seasons. However, the genotype CS-88 recorded significantly highest chlorophyll 'b' (0.86, 0.86 and 0.71 mg) compared to all others.

Varalakshmi *et al.,* (2012) found that during both *rabi* and *kharif* seasons the variety Arka Isha possessed vitamin C up to 167.05 mg/100g, total soluble solids (17.6%), and leaf moisture (82.4%). However, the leaf oil yield was very less (0.083%) with good aroma, but was significantly higher than the check variety Jaipur Local (0.043%).

The variation in the synthesis of essential oil might be due to the promotive or inhibitive mechanism through physiological and biochemical reactions in the genotypes as reported by Palanikumar and Rajamani (2012a).

Ghobadi and Ghobadi (2012) conducted a study during the months of May and June to find the effect of planting time on the essential oil yield of coriander and suggested that a delay in planting date increased the oil content.

Malik and Tehlan (2013) studied on various growth parameters, seed yield and essential oil content. Even though, no significant differences were observed in essential oil content between the cultivars, DH-220 produced the highest essential oil content (0.39%).

Meena *et al.,*(2013) studied the mean data of *rabi* coriander in two consecutive years and observed the highest essential oil content (0.40%) in genotype RKD-18 which was significantly higher (20.6%) over the check variety RCr-436 (0.03%).

Bhatt *et al.,* (2014) suggested that coriander leaves contain high amount of vitamin A (β-carotene) and vitamin C.

Priyadarshi and Borse (2014) suggested that the essential oil content and composition in coriander was greatly influenced by the prevailing climatic conditions, agro technology and the stage of maturity at the time of harvest, geography of growing region, abiotic stress such as salinity and extraction techniques adopted.

Sinta *et al.,*(2015) recorded a difference in essential oil content during *rabi* (0.39%) and *kharif* (0.51%) seasons when the crop was applied with 0.5% $FeSO_4$.

Kumar *et al.,* (2015) conducted a study during *rabi* season on coriander and suggested that essential oil as well as moisture content in the seeds varied significantly with the application of various organic sources of nutrients either alone or in combination. Incorporation of FYM 25 % in combination with vermi-compost 75 % recorded the highest essential oil production and moisture contents of 0.66 % and 12.7% respectively.

Lataye (2015) found that during *rabi* season, the leaves of Hisar Sonali possessed the highest leaf chlorophyll content (43.73 mg/g), while iron content was highest (112.90 ppm) in Rajenda Kranti. In addition, the moisture content (84.69%) was maximum in Pant Ragini.

Similar works in related crops are reviewed here under. Malhotra and Vashishtha (2007) recorded 16th November sown Indian dill possessed significantly highest volatile oil (3.41%) compared to 15th October sown (3.26%) crop.

Agarwal *et al.,* (2013) studied different varieties of fenugreek during *rabi* season and recorded maximum chlorophyll a content (1.7mg/g) in Pusa Kasuri at 45 DAS and minimum in Rmt-1(0.25mg/g) at 60 DAS. Maximum chlorophyll b (0.4mg/g), total chlorophyll (2.1 mg/g) and carotenoid content (0.1mg/g) was recorded in Pusa Kasuri at 45 DAS.

Singh *et al.,* (2015) conducted field experiments during *rabi* season to study the response of bio-fertilizers and different fertility levels of nitrogen and phosphorus on *Kasuri methi.* The results suggested that combined application of 75 per cent recommended dose of fertilizers along with Rhizobium and phosphorus-solubilising bacteria can be recommended for better quality and yield of fenugreek leaves.

Tsamaidi *et al.,* (2017) evaluated the quality of fresh dill leaves during spring and autumn seasons. They found that during autumn with the increase in salinity, the chlorophyll and total phenolics content of leaves increased, whereas vitamin C and carotenoids were unaffected. However, during spring, increasing salinity caused fluctuations in the chlorophyll and vitamin C content of the leaves and a decrease in total phenolics. Overall, the season of cultivation was very crucial for both yield and quality in dill.

2.2.0. EFFECT OF GROWING CONDITIONS ON GROWTH AND YIELD PARAMETERS

The yield of coriander was largely affected by conditions like temperature, rainfall and weather conditions at different growth stages and declined with delayed dates of sowing as reported by Baswana *et al.,* (1989); Sharma and Israel (1991) and Venkateshwarlu *et al.*, (1993).

Dixit (2007) recorded significantly higher plant height (15.24cm) and number of leaves (6) in coriander grown under greenhouse than in the open (12.62cm and

5cm, respectively). In addition, he suggested that the protected condition gave superiority in yield and its related characters than in the open condition.

Tehlan *et al.,* (2007) described Hisar Surabhi as a very promising variety of coriander which is high seed yielding (1.8-2.0 t/ha) under open field condition.

A high seed yielding coriander cultivar, Sudha was reported by Sarada *et al.,* (2009) which performed better than existing cultivars with an additional yield advantage of 18-25%. This cultivar gave an average yield of 1.0 t/ha under rain fed conditions and more than 1.50t/ha under irrigated conditions.

Hiwale *et al.,* (2009) conducted an experiment in open field condition to study the performance of different varieties of coriander for growth and yield under Marathwada condition during 2007-08. The variety Japani exhibited maximum height of plant but variety Surbhi was superior in case of maximum number of primary and secondary branches. Highest yield per hectare was recorded in variety Surbhi followed by DWD-3, while lowest yield was found in variety Gawran.

The shade net houses during off-season reduced the temperature up to 5°C and increase the relative humidity, thus offering optimum environmental conditions for the growth of coriander (Shoba and Rajamani, (2009).

Kotadia *et al.,* (2012) studied the influence of different growing conditions on leaf yield of fenugreek and coriander during summer season. The results suggested that fenugreek and coriander grown in 75 per cent shade net got maximum growth attributes compared to open field situation during summer season.

Rajasekhar *et al.,*(2013) studied the effect of different crops including coriander under shade net house (33% shade) and open field for year round production. They found that coriander had the highest leaf area under open field than in shade net during winter season. They also pointed out that the lower temperature in protected condition lead to an increase in plant height, number of branches, intermodal length, average fruit weight and yield per plant than in the open field.

Karetha *et al.,*(2014) conducted a research on coriander using different protected structures. The study gave significantly highest germination percentage(76.30%) and plant dry weight (2.11g/plant) in natural ventilated polyhouse, but the number of leaves per branch(3.98) was highest in net house and fresh weight of plant (6.61g) was highest in fan and pad polyhouse.

Lal *et al.,* (2015) studied the effect of different protected environments and irrigation methods on growth and yield of coriander during *rabi* season using four treatments of protected environments, viz. plastic covered walk in tunnel, insect proof net covered walk in tunnel, shade net covered walk in tunnel, plastic low tunnel and open conditions. Among the treatments, the plastic covered walk in tunnel protection with low-pressure drip method of irrigation resulted in highest plant height, maximum branches/plant at harvest, maximum number of umbels/plant, maximum number of seeds/umbel and highest seed yield.

Lal and Singh (2016) suggested that application of 60 kg nitrogen per hectare found most congenial for seed germination vigor, plant growth and green leaf yield of coriander variety AGCr-1 under off season cultivation using 50% green shade nets.

2.2.1. EFFECT OF GROWING CONDITIONS ON QUALITY PARAMETERS

Girenko (1982) reported that coriander leaves are rich source of Vitamin A upto 12mg/100g and C upto160mg/100g. Nadeem *et al.,* (2013) reported that coriander grown in the open field contains an essential oil (0.03%-2.6%) and the different parts of coriander contain monoterpenes, limonene, coriandrol etc.

Bhuiyan *et al.,* (2009) reported that odour and flavor of essential oil from fresh herb grown in open field was completely different from seed oil. The essential oil (%) on fresh weight basis was lesser than that of seed oil.

Wierdak (2013) suggested that coriander leaves grown in glasshouse condition contained less oil than the fruit and the concentration of volatile substances is determined by cultivation factors.

Guha *et al.,*(2016a) evaluated the effect of sowing date and cutting in coriander. The results showed that there was no significant difference in the essential oil content of leaf and seed of coriander sown during different dates. In the first year, October sown seeds 0.088% and 0.486% in leaf and seed respectively were found to yield more essential oil over the March sown seeds (0.085% and 0.466% in leaf and seed respectively.

Yeganehpoor *et al.,*(2016) stated that reduction of chlorophyll content under stress conditions was because of changes in nitrogen metabolism due to synthesis of compounds such as proline, which has a role in osmotic adjustment.

2.3.0. EFFECT OF CUTTING ON GROWTH AND YIELD PARAMETERS

Menon and Khader (1997) and Thapa (1999) suggested that leaf plucking of coriander seed crop at early stages could provide an additional income to the growers. Megeji and Korla (2002) observed wide range and high coefficient of variability for leaf yield per plot under single cutting and double cutting systems.

Nandal *et al.,* (2007) conducted an experiment to study the response of spacing, phosphorus levels and cutting of leaves on growth and yield of coriander cv. Hissar Anand. He found a significant higher green leaf yield in the treatment combination of highest levels of phosphorus i.e.,75 kg and spacing (20x20cm) and two cutting of green leaves treatment. Moreover, a minimum seed yield was recorded in 25 kg P_2O_5/ha and 20x20cm spacing with two cutting of green leaves treatment combination.

Tehlan *et al.*, (2008) studied the effect of leaf cutting on leaf as well as seed yield of coriander. There was significant reduction in plant height but no significant differences in number of branches per plant and umbellates per umbel at any stage of cutting. They clearly indicated that one leaf cutting at 45 DAS is desirable for getting higher seed yield along with additional income from leaf yield.

Sharangi *et al.,* (2011) showed that a foliar spray of Urea 2.5% was beneficial for coriander leaf production under multi-cut system and the crop was sensitive to rainfall, photo-temperature and morning humidity.

Varalakshmi *et al.,*(2012) conducted a research work at the Indian Institute of Horticultural Research and resulted in the development of a leafy coriander variety, Arka Isha, with a high yield potential and good aroma. It was a multi-cut variety where the plants are bushy, leaves were broad and leaf lobes were short, and were late flowering. It yielded 3.74t/ ha of herbage by pulling at 40 DAS.

Guha *et al*., (2013*)* suggested that different time of sowing of coriander seeds and different levels of cutting influenced significantly the time taken for initiation of serrated leaf and also time taken for flowering. Early serration was not desirable for farmers as its marketability was lost.

2.4.0. CORRELATION STUDIES

Association analysis of forage yield components in fenugreek by Sohoo and Bharadwraj (1986) revealed significant positive correlation of green yield with plant height and number of leaves per plant. Further, the number of leaves per plant and number of shoots per plant expressed negative association with leaf length suggesting that genotypes showing high yield of greens tend to be tall and leafy.

Varalakshmi and Reddy (1994) established a highly significant and positive correlation between yield and plant height, leaf breadth, stem girth, leaf weight per plant, stem weight per plant and leaf length both at phenotypic and genotypic levels, but it produced positive and non- significant correlation with number of leaves. On the other hand, yield showed negative association with leaf stem ratio indicating that high yields should always have a low leaf stem ratio.

Hariharan (1996) observed that plant height influenced directly on yield of greens per plot followed by total dry matter production and number of leaves per plant in path coefficients analysis.

The direct influence of weight of leaves, weight of stem and plant height on yield of green per plant were recorded by Dhanasekar (1997). He also noticed negative direct effects of number of branches, number of leaves and leaf stem ratio on green yield.

Srivastava *et al.,* (2000) reported positive direct influence of plant height and number of branches per plant on yield in coriander while other traits exhibited negative direct effect.

Tripathi *et al.,* (2000) in their correlation analysis observed that plant height had a positive relationship with yield of greens in coriander.

Vijayalatha and Chezhiyan (2004) conducted correlation and path analysis studies using ninety genotypes of coriander for eight traits related to yield and quality. They found that the traits such as plant height, number of primary branches, number of umbels, and essential oil exhibited positive and significant association at phenotypic and genotypic levels with yield.

Materials and methods

3. MATERIALS AND METHODS

The present investigation entitled "Performance evaluation of leaf coriander (*Coriandrum sativum* L.) types in the plains of Kerala," was carried out at the Department of Plantation Crops and Spices, College of Horticulture, Kerala Agricultural University, Thrissur during 2016-17 in four different seasons and two growing conditions The experimental plot was laid out in central Kerala at 10° 31'N latitude and 76° 13' E longitude, with an altitude of 22.25m above mean sea level.

CLIMATIC CONDITION

The monthly meteorological data on rainfall, temperature, sunshine duration and relative humidity during the crop period is presented in Appendix I. During the crop period from April 2016 to March 2017, the total rainfall received was 2201.00 mm. The maximum temperature varied from 36.3 °C to 36.0 °C (monthly mean). While the minimum temperature varied from 25.2 C to 23.2 °C (monthly mean). The maximum and minimum relative humidity were 89% and 51% (monthly mean) respectively.

SOILS: Soil of the experimental site was loamy.

Details of the materials used and methods followed in the study are described in this chapter.

3.1 THE EXPERIMENTAL MATERIAL

Five genotypes of coriander namely CO-1, CO-2, CO-3, CO (Cr-4) and Arka Isha were used in the experiment. The seeds of CO-1, CO-2, CO-3 and CO(Cr-4) were collected from the Department of Spices and Plantation crops, Tamil Nadu Agricultural University, Coimbatore and seeds of Arka Isha were obtained from Indian Institute of Horticultural Research, Hessarghatta, Bengaluru during the period February and June 2016.

3.2. DESIGN AND LAYOUT OF THE EXPERIMENTS

The study consisted of two experiments viz. Experiment No.1: Evaluation of coriander types in the rain shelter condition and Experiment No.2: Performance evaluation of coriander types in different growing conditions.

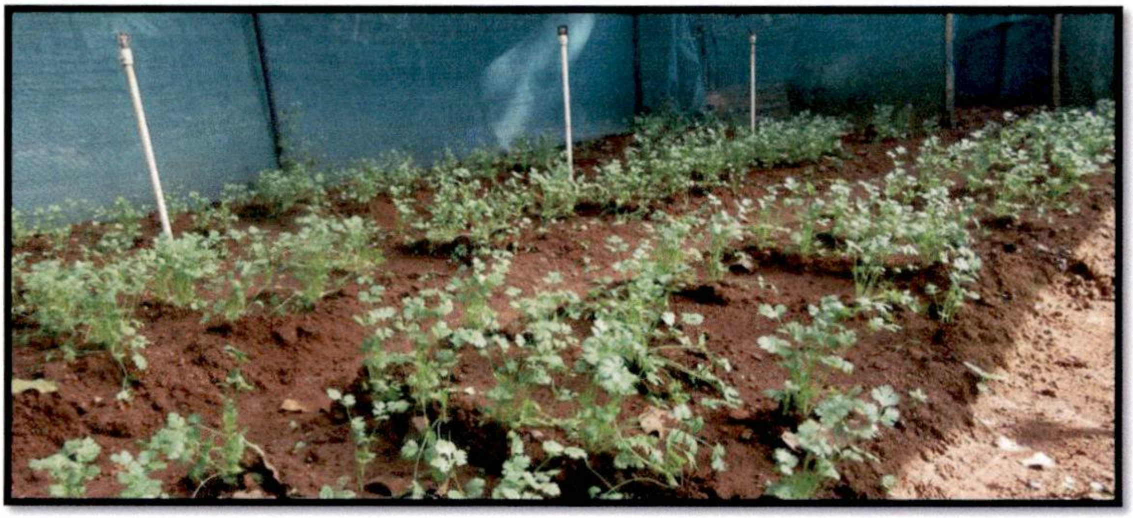
Experiment No.1: Evaluation of coriander types in the rain shelter condition. The experiment was laid out in 4 different time of sowing (seasons) viz. April-June 2016 (S1), July-September 2016 (S2), October-December (S3) and January-March 2017 (S4) by following Completely Randomized Design (CRD) with five varieties (Plate 1) and four replications in the rain shelter (Plate 2) to evaluate the performance of the varieties (treatments) in different time of sowing (seasons), as shown below:

Treatments	Genotypes/Varieties	Time of sowing(seasons)	Growing conditions
T1	CO-1	April-June (S1)	Rain shelter
T2	CO-2	July-September (S2)	Open field
T3	CO-3	October-December (S3)	
T4	CO (Cr-4)	January-March (S4)	
T5	Arka Isha		

Experiment No.2: Performance evaluation of coriander types in different growing conditions. The experiment was laid out during *rabi* season in two different growing conditions viz. rain shelter and open field (Plate 3) by following Randomized Complete Block Design (RBD) with five treatments (genotypes/varieties) and four replications.

Plate 1. Varieties used for study

Plate 2. General view of crop in rain shelter



a. Rain shelter

a. Open field

Plate 3. Growing conditions

3.2.1 CROP MANAGEMENT: The experiment No.1 was laid out in four seasons in a year at three months interval in rain shelter and the experiment No.2 was conducted in two different growing conditions viz. rain shelter and open during *rabi* (October-December 2016) season, at the Department of Plantation crops and spices farm. Minimum of 25 plants were maintained per replication.

Seeds were split into two and soaked in water over night before sowing to hasten germination. Soaked seeds were sown in pots and raised beds and covered with soil. One week after germination, excess seedlings were thinned out to keep a plant-to-plant spacing of 15cm. All the management practices in both the experiments were conducted by following the Package of Practices Recommendations of crops, TNAU.

3.2.2 Harvesting: Half of the plants in each replication were harvested by uprooting and remaining half harvested by multi-cut method (Tehlan and Thakral, 2008). All biometrical observations were recorded at two weeks interval. Chlorophyll content, vitamin C and volatile oil content were recorded at the time of leaf harvest.

3.3. COLLECTION OF EXPERIMENTAL DATA

3.3.1. **Sampling Procedure**: Ten plants were randomly selected from each replication of all treatments and tagged with labels. The observations were recorded at two weeks interval during the entire period in different seasons S1, S2, S3 and S4. Observations on the following growth parameters were recorded.

3.3.2: GROWTH AND YIELD PARAMETERS:

3.3.2.1. Days to seed germination

Number of days taken by each treatment (genotypes/varieties) to complete germination were counted and recorded.

3.3.2.2. Days taken to emergence of first leaf

Ten plants were randomly selected after germination and number of days for the emergence or appearance of first leaf was counted. Average number of days was worked out and expressed as number of days.

3.3.2.3. Days taken to the emergence of second leaf

Number of days taken for the appearance of second leaf were counted. Average number of days was worked out and expressed as number of days.

3.3.2.4. Days taken to the emergence of third leaf

Number of days taken for the appearance of third leaf were counted. Average number of days was worked out and expressed as number of days.

3.3.2.5. Plant height

Height of 10 randomly selected and tagged plants were measured from the base of the plant to tip of the main leaf and average height was worked out at 30, 45 and 60 DAS and expressed in centimeters

3.3.2.6. Number of leaves

Number of leaves arising on the main stem was counted on 30 DAS and at the time of harvest, average number is worked and expressed as number.

3.3.2.7. Herbage yield per

Herbage yield from 10 randomly selected plants in each replication was recorded and expressed as grams per plant (g).

3.3.2.8. Biomass yield per plant

The uprooted plants were weighed for fresh biomass yield at the time of harvest and expressed as grams per plant (g).

3.3.2.9. Number of primary branches per plant

Number of primary branches on the main stem were recorded at the time of flowering. Average number of primary branches were worked out and expressed as number.

3.3.2.10. Number of secondary branches per plant

The number of secondary branches on the primary branches was recorded at the time of flowering. Average number of secondary branches were worked out and expressed as number.

3.3.2.11. Days to flowering (if any)

The number of days from germination to flowering was counted. Average number of days were worked out and expressed as number of days.

3.3.2.12. Days to emergence of serrated leaf (if any)

The number of days from germination to the emergence of serrated leaves was counted. Average number of days were worked out and expressed as number of days.

3.3.2.13. Days to seed set (if any)

The number of days from germination to seed set was noted. Average number of days were worked out and expressed as number of days.

3.3.3. QUALITY PARAMETERS

Biochemical analysis for estimation of volatile oil, vitamin- C and chlorophyll content of each variety was done by using standard procedure as given below.

3.3.3.1. Volatile oil content (%)

Volatile oil present in the leaves were extracted in a Clevenger apparatus using hydro distillation (Clevenger, 1982). Hundred grams of fresh leaf sample was fed into a round bottom flask attached to the Clevenger's apparatus with condenser and 300ml distilled water was added. Then the flask was heated gently up to a temperature of 70° C- 80°C and continued for three hours. The oil was collected in the receiver end of the apparatus, cooled to room temperature. A pinch of anhydrous sodium sulphite was added to the oil extracted, in order to remove any excess moisture. The volume of oil collected was expressed as percent volume per unit mass of the sample as follows:

$$\text{Volatile oil (\%)} = \frac{\text{Volume of oil collected(ml)}}{\text{Total weight of sample(g)}} \times 100$$

3.3.3.2. Vitamin C content (mg)

Ascorbic acid content in leaves was estimated by using volumetric method (Sadasivam and Manickam, 1992). Dye solution was prepared by dissolving 42mg Sodium bicarbonate into a small volume of distilled water and then dissolving 52 mg 2,6-dichlorophenol indophenol in it and made up to 200ml. Stock solution of ascorbic acid was prepared by dissolving 100mg ascorbic acid in 100ml of 4 per cent oxalic acid solution in a standard flask. A working standard of ascorbic acid was prepared by dissolving 10ml of standard ascorbic acid solution to 100 ml of 4 per cent oxalic acid. Five ml of the standard solution was pipetted out into a conical flask and 10 ml of 4 per cent oxalic acid was added and titrated against dye solution (V1). The end point was judged by the appearance of light pink color which persists at least for 5 seconds. Similarly, the extract of coriander leaves (5g) was prepared by using 4% oxalic acid and made up to 100ml and was centrifuged. Five ml of the supernatant was pipetted out, 10ml of oxalic acid was added and titrated against the dye (V2).

Amount of ascorbic acid present in the plant sample was calculated as follows

$$\text{(mg/100g sample)} = \frac{\text{Dye factor} \times V_2 \times 100\ \text{mL} \times 100}{V_1 \times \text{Aliquot taken} \times \text{weight of sample}}$$

44

3.3.3.3. Chlorophyll content (mg)

Chlorophyll content in leaves was estimated by using Acetone method (Sadasivam and Manickam, 1992). One gm of finely cut and well-mixed representative sample of leaves were ground to a fine pulp with the addition of 20ml of 80% acetone. It was centrifuged (500 rpm for 5 minutes) and the supernatant was transferred to a 100ml volumetric flask. The residue was ground with 20ml of 80% acetone, centrifuged and the supernatant was collected to the same volumetric flask. The same procedure was repeated until the residue became colourless. The volume was made up to 100ml with 80% acetone. The absorbance of the solution was read at 645nm and 663nm against the solvent (80% acetone) blank. The amount of chlorophyll present in the extract was expressed in mg chlorophyll per gram using the following equations:

(a) mg chlorophyll 'a' g^{-1} of tissue $=12.7(A_{663})-2.69(A_{645}) \times \frac{V}{100 \times W}$

(b) mg chlorophyll 'b' g^{-1} of tissue $=22.9(A_{645})-4.68(A_{663}) \times \frac{V}{100 \times W}$

(c) mg total chlorophyll g^{-1} of tissue $=20.2.9(A_{645})-8.02(A_{663}) \times \frac{V}{100 \times W}$

A=Absorbance at specific wavelengths

V=Final volume of chlorophyll extract in 80% acetone

W= Fresh weight of tissue extracted

3.4. PESTS AND DISEASE INCIDENCE:

Pests and diseases seen during the crop period were noted and recorded

3.5. OTHER PARAMETERS:

Data on mean temperature, rainfall, relative humidity and sunshine hours during the crop period were collected from the Department of Agricultural Meteorology, College of Horticulture, Vellanikkara and monthly mean value of all the parameters were worked out and presented in Appendix I.

3.6. STATISTICAL ANALYSIS

The data was statistically analyzed by using OPSTAT Online Package software, to find out the growth, herbage yield and quality of the varieties in different sowing time (seasons), and different growing conditions. Analysis of correlation of characters were done as Statistical Package for the Social Sciences (SPSS).

Results

4. RESULTS

The investigation entitled "Performance evaluation of leaf coriander (*Coriandrum sativum* L.) types in the plains of Kerala," was undertaken during 2016-17 in four different sowing times (seasons) viz., April-June 2016 (S1), July to September 2016 (S2), October-December (S3) and January-March 2017 (S4) with five varieties of coriander namely CO-1 (T1), CO-2 (T2), CO-3 (T3), CO(Cr-4) [T4] and Arka Isha (T5) and two growing conditions namely, rain shelter and open field during *rabi* season. The data pertaining to the effect of varieties, seasons and growing conditions on growth, herbage yield and quality was analyzed separately. The results obtained were arranged in the order of effect of varieties, season and growing conditions and interaction on growth, herbage yield and quality.

4.1.0. EFFECT OF VARIETIES AND TIME OF SOWING (SEASONS) ON GROWTH AND HERBAGE YIELD OF CORIANDER

4.1.1. Days to seed germination

All the varieties significantly differed for the days taken for seed germination. The variety CO (Cr-4) took significantly lowest number of days (6.75), followed by CO-1 (9.84) and CO-2 (8.23) for germination as shown in Table 1. Arka Isha recorded significantly the highest mean number of days (14.34) to germinate than all other varieties.

The seeds sown in the three different sowing times (S1, S2, and S3) showed no significant difference with respect to the days taken for germination. However, the seeds sown in January-March (S4), recorded significantly higher number of days (9.83) for germination compared to other seasons.

The interaction effect of time of sowing (seasons) x variety for days to seed germination was also significant.

Table 1. Effect of varieties and time of sowing (seasons) on days to seed germination

Seasons /Varieties	S1	S2	S3	S4	Mean(Varieties)
CO-1	9.90	9.90	9.83	9.73	9.84
CO-2	8.30	7.88	8.35	8.40	8.23
CO-3	8.60	8.30	9.45	9.43	8.94
CO(Cr-4)	6.80	6.60	6.70	6.91	6.75
Arka Isha	13.65	14.70	14.33	14.70	14.34
Mean (Seasons)	9.45	9.48	9.73	9.83	
CD (0.05)	0.26	0.71	0.80	0.88	
CD(seasons)	0.30				
CD(varieties)	0.33				
CD(season x variety)	0.66				

S1: April-June sowing

S2: July-September sowing

S3: October-December sowing

S4: January-March sowing

During April-June (S1) sowing all the varieties differed each other. The lowest number of days (6.80) was recorded in CO (Cr-4), followed by CO-2 (8.30), CO-3 (8.60) and CO-1 (9.9), whereas Arka Isha recorded significantly highest number of days (13.65) for germination. During July-September sowing (S2), CO (Cr-4) recorded significantly lowest number of days (6.60), followed by CO-2 (7.88) and CO-3 (8.30) which were on par. CO-1 differed from all other varieties (9.90) and Arka Isha exhibited highest number of days (14.70) for germination. During October-December (S3), lowest days (6.70) was observed in CO (Cr-4), followed by CO-2 (8.35) which differed significantly. The varieties CO-3 (9.45) and CO-1 (9.83) were on par and Arka Isha recorded highest number of days (14.33) for germination. During January-March (S4), CO (Cr-4) recorded lowest days (6.91), followed by CO-2 (8.40) and the varieties CO-3 (9.43) and CO-1 (9.73) were on par and Arka Isha recorded highest number of days (14.70) for germination.

4.1.2. Days to first leaf emergence

The overall mean for the number of days to first leaf emergence differed significantly among the varieties (Table 2). The variety CO (Cr-4) recorded significantly lowest number of days (9.21) for first leaf emergence followed by CO-2 (11.37), CO-3 (12.35) and CO-1 (12.79). Among the varieties, Arka Isha recorded highest number of days (17.18) to first leaf emergence. Plate. 4 shows leaf emergence in coriander.

Different time of sowing (season) had no significant effect on the number of days to first leaf emergence of coriander varieties.

However, the interaction effect of time of sowing (seasons) x variety was significant.

In April-June (S1), CO (Cr-4) was significantly earliest (9.48), followed by CO-2 (11.58) which were significantly different and the varieties CO-3 (12.90) and CO-1 (12.95) were on par. Arka Isha took significantly highest days (16.80) for first leaf emergence. In July-September (S2), CO (Cr-4) was the earliest (9.03), the varieties CO-2 (10.77) and CO-3 (11.28) were on par and CO-1 (12.70) significant different from all varieties whereas, significantly highest days (17.83) was recorded in Arka Isha. During October-December (S3), CO (Cr-4) was the earliest (9.30), followed by CO-2 (10.98) and the varieties CO-1 (12.48) and CO-3 (12.70) were on par. Arka Isha recorded significantly highest days (17.03) for leaf emergence. During January- March (S4), CO (Cr-4) was the earliest (9.03) and the varieties CO-2 (12.15), CO-3 (12.51) and CO-1 (13.03) were on par. Arka Isha recorded significantly highest days (17.06) for first leaf emergence.

4.1.3. Days to second leaf emergence

The varieties differed significantly with respect to number of days to second leaf emergence and CO-(Cr-4) took lowest number of days (12.13), followed by CO-2 (14.17), CO-3 (15.08) and CO-1 (15.79), respectively. Among the varieties, Arka Isha exhibited significantly more number of days (19.72) for second leaf emergence as shown in Table. 2.

The seeds sown in different sowing time (seasons) showed significant difference with respect to the days taken for second leaf emergence. Earliest second leaf (14.72) was in October-December (S3), followed by S2 (15.31) and S1 (15.32). Plants for second leaf emergence recorded significantly more number of days (16.17) in January-March (S4)

The interaction effect of time of sowing (seasons) x variety on the emergence of second leaf was also significant.

During April-June (S1), the variety CO (Cr-4) was the earliest (12.27), CO-2 (14.22) and CO-3 (15.00) were on par. The varieties CO-1 (15.92) and CO-3 (15.00) were also on par. Arka Isha recorded significantly highest days (19.19) for second leaf emergence. During July-September (S2), CO (Cr-4) took significantly lowest number of days (12.29). The varieties CO-2 (13.74) and CO-3 (13.88) were on par and CO-1 (16.15) significantly differed from all other varieties. Arka Isha exhibited significantly highest number of days (20.49) for second leaf emergence. During October-December (S3), all the varieties differed significantly in which CO (Cr-4) was the earliest (11.75) followed by CO-2 (12.85), CO-1 (14.73) and CO-3 (15.08) and highest days were observed in Arka Isha (19.18). During January- March (S4), CO (Cr-4) were the earliest (12.21), the varieties CO-2 (15.88), CO-3 (16.36) and CO-1 (16.39) were on par whereas, significantly highest days (20.01) were recorded in Arka Isha.

4.1.4. Third leaf emergence

There was significant difference with respect to the number of days to third leaf emergence as shown in Table. 2. The variety CO (Cr-4) took significantly lowest days (15.26), followed by CO-2 (16.87), CO-3 (18.01) and CO-1 (18.45) respectively. The variety, Arka Isha exhibited highest number of days (21.78) for third leaf emergence.

The seeds sown in different sowing times (seasons) also showed significant difference with respect to the days taken for third leaf emergence. The growth performance of all the varieties from April-June (S1), July-September (S2) and January-March (S4) were on par, whereas it was earliest in the October-December (S3) where it recorded lowest number of days (16.68) to third leaf emergence (Table 2)

The interaction effect of time of sowing (seasons) x variety on the emergence of third leaf was also significant.

During April-June (S1), CO (Cr-4) was the earliest (16.02), the varieties CO-2 (17.63) and CO-3 (18.64) were on par, so also the varieties CO-3(18.64) and CO-1 (19.10). The variety Arka Isha took significantly highest number of days (21.74) for third leaf emergence. During July-September (S2), CO (Cr-4) was the earliest (15.62), the varieties CO-2 (16.95) and CO-3 (17.21) were on par with the other and

CO-1 (18.80) recorded significant difference from all other varieties. Arka Isha recorded highest days (22.98) for third leaf emergence. During October-December (S3), the varieties CO (Cr-4) (14.20) and CO-2 (14.35), CO-1 (16.90) and CO-3 (17.28) were on par. The variety Arka Isha recorded significantly highest days (20.68) for third leaf emergence. During January-March (S4), the lowest number of days (15.21) was recorded in CO (Cr-4) and highest in Arka Isha (21.73).The varieties CO-2 (18.54), CO-3 (18.89) and CO-1 (19.01) were on par.

4.1.5. Plant height (cm): The growth of coriander varieties were studied by recording the plant height at 30, 45 and 60 DAS and results are presented in Table 3.

4.1.5.1. Plant height at 30 DAS

The varieties exhibited significant difference with regard to the plant height at 30 DAS, and the variety Arka Isha recorded lowest mean plant height (7.68 cm) followed by CO-1 (11.09 cm). The mean plant height of the varieties CO-2, CO-3 and CO (Cr-4) were on par at 30 DAS.

The seeds sown in different sowing times (seasons) showed no significant difference with respect to the plant height at 30 DAS.

However, the interaction effect of time of sowing (seasons) x variety on plant height at 30 DAS was significant.

During April-June (S1), the highest plant height was observed in CO (Cr-4) (11.91 cm) which was on par with CO-2 (11.73cm) and CO-3(11.72 cm), CO-1 (11.28 cm) was on par with CO-3 and CO-2. Significantly lowest height was recorded in Arka Isha (8.78 cm). During July-September (S2), significantly highest plant height (12.55 cm) was recorded in CO-3, followed by CO-2 (11.53 cm). The lowest plant height (7.76 cm) was recorded in Arka Isha and CO-1 (10.23 cm) differed from all other varieties. During October-December (S3), the varieties CO-3 (12.28 cm) and CO-2 (11.86 cm) were on par so also the varieties CO (Cr-4) and CO-1. Significantly lowest plant height was recorded in Arka Isha (6.67 cm). However, during January-March (S4), the highest was observed in CO-2 (12.15) which was on par with CO-1 (11.80 cm) and CO (Cr-4) (11.77 cm). The lowest was observed in Arka Isha (7.51 cm) and CO-3 (11.00 cm) differed from all other varieties.

4.1.5.2. Plant height at 45 DAS

The varieties CO-1 and CO-2, CO-2 and CO-3, CO-3 and CO (Cr-4) were on par with each other with respect to plant height at 45 DAS. The variety Arka Isha recorded significantly lower plant height (15.34 cm). Plant height at 45 DAS differed significantly in different sowing times (seasons) is showed in Table 3.

Upon comparing the CD over four seasons, the mean highest plant height (18.52) was recorded in April-June (S1), followed by October-December (S3) (17.36 cm) and July-September (S2) (16.79 cm). The lowest plant height (15.00 cm) at 45 DAS was recorded in January to March (S4).

The interaction effect of time of sowing (seasons) x varieties on the plant height at 45 DAS was also significant.

During April-June (S1), the varieties CO (Cr-4) recorded highest plant height (19.60 cm) which was on par with CO-3 (19.47 cm) and CO-1 (19.05 cm), whereas CO-1 and CO-2 (18.15 cm) were also on par. Significantly lowest in Arka Isha (16.33 cm). During July-September (S2), highest plant height was observed in CO-3 (18.90 cm), followed by CO (Cr-4) (17.50 cm) and the lowest was recorded in Arka Isha (15.43 cm) which was on par with CO-2 (16.48 cm) and CO-1 (15.63 cm). During October-December (S3), the highest plant height (18.88 cm) was recorded in CO (Cr-4), followed by CO-3 (18.30 cm) and CO-2 (17.49 cm). The lowest in Arka Isha (15.43 cm) which was on par with CO-1 (16.70 cm). During January-March (S4), there was no significant difference among the varieties. CO-2 (16.00 cm) recorded highest plant height and the lowest was recorded in CO-3 (14.02 cm).

Table 2. Effect of varieties and time of sowing (seasons) on days to leaf emergence

Seasons / Varieties	First leaf emergence					Second leaf emergence					Third leaf emergence				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CO-1	12.95	12.70	12.48	13.03	12.79	15.92	16.15	14.73	16.39	15.79	19.10	18.80	16.90	19.01	18.45
CO-2	11.58	10.77	10.98	12.15	11.37	14.22	13.74	12.85	15.88	14.17	17.63	16.95	14.35	18.54	16.87
CO-3	12.90	11.28	12.70	12.51	12.35	15.00	13.88	15.08	16.36	15.08	18.64	17.21	17.28	18.89	18.01
CO(Cr-4)	9.48	9.03	9.30	9.03	9.21	12.27	12.29	11.75	12.21	12.13	16.02	15.62	14.20	15.21	15.26
Arka Isha	16.80	17.83	17.03	17.06	17.18	19.19	20.49	19.18	20.01	19.72	21.74	22.98	20.68	21.73	21.78
Mean	12.74	12.32	12.49	12.75		15.32	15.31	14.72	16.17		18.63	18.31	16.68	18.68	
CD(0.05)	0.81	0.94	0.98	1.051		1.19	0.69	0.68	0.84		1.22	0.62	1.04	1.10	
CD (0.05)															
Seasons	NS					0.37					0.42				
Varieties	0.44					0.41					0.47				
Season ×Variety	0.89					0.82					0.95				

S1: April-June sowing

S2: July-September sowing

S3: October-December sowing

S4: January-March sowing

Table 3. Effect of varieties and time of sowing (seasons) on plant height at different growth stages

Seasons / Varieties	Plant height at 30 DAS (cm)					Plant height at 45 DAS (cm)					Plant height at 60 DAS (cm)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CO-1	11.28	10.23	11.09	11.80	11.09	19.05	15.63	16.70	15.03	16.6	28.10	26.75	27.90	26.70	27.36
CO-2	11.73	11.53	11.86	12.15	11.81	18.15	16.48	17.49	16.00	17.03	24.25	26.60	27.83	22.95	25.41
CO-3	11.72	12.55	12.28	11.00	11.89	19.47	18.90	18.30	14.02	17.67	25.93	25.08	27.95	24.73	25.91
CO(Cr-4)	11.91	11.37	11.66	11.77	11.68	19.60	17.50	18.88	15.8	17.94	25.50	23.80	25.28	24.03	24.65
Arka Isha	8.78	7.76	6.67	7.51	7.68	16.33	15.43	15.43	14.18	15.34	24.04	27.20	28.05	23.73	25.75
Mean	11.08	10.69	10.71	10.85		18.52	16.79	17.36	15.00		25.56	25.89	27.40	24.43	
CD(0.05)	0.52	1.12	0.78	0.75		1.06	1.76	1.05	NS		1.18	1.19	1.30	1.27	
CD (0.05)															
Seasons	NS					0.67					0.51				
Varieties	0.38					0.75					0.58				
Season ×Variety	0.76					1.49					1.16				

S1: April-June sowing

S2: July-September sowing

S3: October-December sowing

S4: January-March sowing

58

4.1.5.3. Plant height at 60 DAS

Among the varieties, CO-2 (25.41 cm), CO-3 (25.91 cm) and Arka Isha (25.75 cm) were on par with each other with respect to plant height at 60 DAS whereas, CO (Cr-4) recorded the lowest plant height (24.65 cm) and CO-1 recorded the highest plant height (27.36 cm) as given in Table 3.

During April-June (S1) and January-March (S4), the highest plant height was observed in CO-1 (28.10 cm and 26.70 cm, respectively). However, during July-September (S2) and October-December (S3), highest plant height at 60 DAS was recorded in Arka Isha (27.20 cm and 28.05 cm, respectively).

The interaction effect of time of sowing (seasons) x varieties on the plant height at 60 DAS was also significant.

During April-June (S1), significantly highest plant height (28.10 cm) was recorded in CO-1. The varieties CO-3 (25.93 cm) and CO (Cr-4) (25.50 cm) were on par and Arka Isha (24.04 cm) recorded the lowest plant height, followed by CO-2 (24.25 cm). During July-September (S2), the highest plant height was observed in Arka Isha (27.20 cm), which was on par with CO-1 (26.75 cm) and CO-2 (26.60 cm). The variety CO (Cr-4) recorded significantly the lowest plant height (23.80 cm) followed by CO-3 (25.08 cm). During October-December (S3), the highest plant height was recorded in Arka Isha (28.05 cm), which was on par with CO-1 (27.90 cm), CO-3 (27.95 cm) and CO-2 (27.83 cm). The variety CO (Cr-4) recorded significantly lowest (25.28 cm). During January-March (S4), significantly highest plant height was recorded in CO-1 (26.70 cm) and the lowest was recorded in CO-2 (22.95 cm) which was on par with Arka Isha (23.73 cm) and CO (Cr-4) (24.03 cm). The varieties CO-3 (24.73 cm), CO (Cr-4) (24.03 cm) and Arka Isha (23.73 cm) were on par.

4.1.6. Number of leaves: The effect of varieties and time of sowing on number of leaves at 30 and at harvest were presented in Table 4.

4.1.6.1. Number of leaves at 30DAS

The varieties CO-2, CO-3 and CO (Cr-4) differed significantly with respect to the mean number of leaves at 30 DAS whereas the variety Arka Isha and CO-1 which were on par with each other. The variety CO (Cr-4) recorded significantly highest number of leaves (10.61) and CO-3 exhibited the lowest number (7.20).

Table 4. Effect of varieties and time of sowing (seasons) on number of leaves at different growth stages

Seasons / Varieties	Number of leaves at 30DAS					Number of leaves at harvest				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CO-1	8.58	11.35	8.65	7.83	9.10	14.95	16.48	14.00	11.35	14.19
CO-2	7.65	8.78	8.58	7.15	8.04	13.63	15.20	12.75	8.88	12.61
CO-3	6.75	8.10	7.30	6.65	7.20	11.25	12.90	11.83	8.28	11.06
CO(Cr-4)	9.65	13.23	10.35	9.20	10.61	15.18	18.88	15.48	13.23	15.69
Arka Isha	6.98	10.55	10.79	8.48	9.20	16.41	18.33	16.85	13.45	16.30
Mean	7.92	10.40	9.13	7.86		14.28	16.36	14.18	11.04	
CD(0.05)	0.53	1.23	0.56	0.66		0.88	1.10	0.56	0.938	
CD (0.05)										
Seasons	0.33					0.37				
Varieties	0.37					0.42				
Season ×Variety	0.74					0.83				

S1: April-June sowing

S2: July- September sowing

S3: October-December sowing

S4: January-March sowing

a. Cotyledon leaves

b. First leaf

Plate 4. Leaf emergence

a.Leaves at 30DAS

b. Leaves at harvest stage

Plate 5. Number of leaves at different growth stage

The seeds sown in different sowing times (seasons) exhibited significant difference with respect to the number of leaves at 30 DAS. July-September (S2) sown crop produced significantly highest number of leaves (10.40) followed by October – December (S3) (9.13) and April-June (S1) (7.92). The lowest numbers of leaves (7.86) were present in the January-March (S4) sown crop.

The interaction effect of time of sowing (seasons) x variety on the number of leaves at 30 DAS was also significant.

During April-June (S1), significantly highest number of leaves (9.65) was recorded in CO (Cr-4), followed by CO-1 (8.58) which differed from all other varieties. The lowest number of leaves were recorded in CO-3 (6.75), which was on par with Arka Isha (6.98). During July-September (S2), significantly highest number of leaves (13.23) was in CO (Cr-4), followed by CO-1 (11.35) and Arka Isha (10.55) and the lowest was recorded in CO-3 (8.10) which was on par with CO-2 (8.78). However, during October- December (S3), it was highest in Arka Isha (10.79), followed by CO (Cr-4) (10.35) which were on par. The varieties CO-1 (8.65) and CO-2 (8.58) were on par and the lowest number of leaves were recorded in CO-3 (7.30). During January-March (S4), it was highest in CO (Cr-4) (9.20) followed by Arka Isha (8.48). The lowest was recorded in CO-3 (6.65) and the varieties CO-1 (7.83) and CO-2 (7.15) were on par.

4.1.6.2. Number of leaves at harvest

During April to June (S1), the number of leaves at harvest ranged from 11.25 to 16.41 with a mean value of 14.28 (Table 4). And the variety Arka Isha recorded highest number of leaves and lowest number was observed in CO-3. Similarly, during July- September (S2) the number of leaves ranged from 12.90 (CO-3) to 18.88 (CO (Cr-4) with a mean value of 16.36. The number of leaves at harvest during October-December (S3) ranged from 11.83 (CO-3) to 16.85 (Arka Isha) with a mean number of 14.18. However, during January- March (S4) the number of leaves ranged from 8.28 (CO-3) to 13.45 (Arka Isha) with a mean number of 11.04 days.

The seeds sown in different sowing times (seasons) exhibited significant difference with respect to the number of leaves at harvest. Crop raised from July to September (S2) sown seeds produced highest number of leaves (16.36) which was significantly superior compared to all other seasons. The lowest number of leaves were exhibited by the crop raised during January-March (S4) (11.04), October - December (S3) (14.18) and April-June (S1) (14.28) sown crops performed on par with respect to number of leaves at harvest (Table 4).

The interaction effect of time of sowing (seasons) x varieties on the number of leaves at harvest was also significant.

During April-June (S1), the significantly highest number of leaves were recorded in Arka Isha (16.41), the varieties CO (Cr-4) (15.18) and CO-1 (14.95) were on par and the lowest number of leaves were recorded in CO-3 (11.25) followed by CO-2 (13.63). During July-September (S2), CO (Cr-4) (18.88) recorded highest number of leaves, followed by Arka Isha (18.83). The lowest was recorded in CO-3 (12.90). During October-December (S3), all the varieties significantly varied in which Arka Isha recorded the highest number of leaves (16.85), followed by CO (Cr-4) (15.48) and CO-1 (14.00). The lowest was recorded in CO-3 (11.83), followed by CO-2 (12.75). During January-March (S4), the varieties Arka Isha (13.45) and CO (Cr-4) (13.23) were on par, and CO-2 (8.88) and CO-3 (8.28) were also on par. The variety CO-1 (11.35) significantly differed from other varieties. Plate 5 shows number of leaves at different growth stages.

4.1.7. Herbage Yield per plant

With respect to mean herbage yield, the variety Arka Isha (9.62 g/plant) performed significantly superior followed by CO-1 (8.37 g/plant) compared to other varieties (Table 5).

Table 5. Effect of varieties and time of sowing (seasons) on herbage yield (g) and biomass yield (g)

Seasons / Varieties	Herbage yield(g)					Biomass yield(g)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CO-1	7.76	12.79	9.49	3.45	8.37	10.71	15.48	13.51	6.90	11.65
CO-2	7.44	9.66	8.56	3.44	7.27	10.19	12.63	12.03	7.29	10.54
CO-3	6.87	10.62	8.84	3.31	7.41	9.76	12.60	11.94	6.21	10.13
CO(Cr-4)	7.04	11.54	8.10	3.50	7.55	9.91	14.04	11.86	5.89	10.42
Arka Isha	9.16	14.68	11.07	3.55	9.62	11.85	18.65	14.55	5.85	12.72
Mean	7.65	11.86	9.21	3.45		10.48	14.68	12.78	6.43	
CD(0.05)	0.82	1.58	1.15	NS		0.91	1.92	1.32	0.96	

CD (0.05)	Herbage yield(g)	Biomass yield(g)
Seasons	1.00	0.56
Varieties	0.45	0.63
Season ×Variety	0.50	1.25

S1: April-June sowing

S2: July-September sowing

S3: October-December sowing

S4: January-March sowing

The varieties CO-2, CO-3 and CO (Cr-4) performed on par with each other. Plate 6 shows the herbage yield of two best performing varieties.

The crop raised from the seeds sown in different sowing times (seasons) exhibited significantly different performance with respect to the mean herbage yield. Among the different sowing seasons, crop raised in July-September (S2) produced the highest herbage yield (11.86 g/plant), followed by October-December (S3) (9.21 g/plant) and April to June (S1) (7.65 g/plant) sown crops. January-March (S4) sown crop produced significantly lowest herbage yield (3.45 g/plant).

The interaction effect of time of sowing (seasons) x varieties on the herbage yield was also significant.

During April-June (S1), the highest herbage yield (9.16) was recorded in Arka Isha, the varieties CO-1 (7.76 g/plant), CO-2 (7.44 g/plant) and CO (Cr-4) (7.04 g/plant) were on par. Whereas, lowest herbage yield was observed in CO-3 (6.87 g/plant). During July-September (S2), significantly highest herbage yield was recorded in Arka Isha (14.68 g/plant), followed by CO-1 (12.79 g/plant) and CO (Cr-4) (11.54 g/plant). The lowest herbage yield in CO-2 (9.66 g/plant) which was on par with CO-3 (10.62 g/plant). During October-December (S3), significantly highest herbage yield was recorded in Arka Isha (11.07 g/plant) followed by CO-1 (9.49 g/plant). The lowest was recorded in CO (Cr-4) (8.10 g/plant) which was on par with CO-2 (8.56 g/plant) and CO-3 (8.84 g/plant). During January-March (S4), all the varieties on par in which the highest herbage yield was recorded in Arka Isha (3.55 g/plant), followed by CO (Cr-4) (3.50 g/plant) and the lowest in CO-3 (3.31g/plant).

4.1.8. Biomass yield per plant

The results of the effect of varieties and time of sowing (seasons) on biomass yield of coriander is presented in Table 5. The varieties CO-2 (10.54 g/plant), CO-3 (10.13 g/plant) and CO (Cr-4) (10.42 g/plant) performed on par with each other in mean biomass yield. However, the varieties CO-1 (11.65 g/plant) and Arka Isha

(12.72 g/plant) exhibited significantly different performance between them and from other varieties as well and Arka Isha recorded the highest mean biomass yield.

The crop raised from seeds sown in different sowing times (seasons) exhibited significant difference with respect to the mean biomass yield. July-September (S2) crop produced significantly higher biomass yield (14.68), followed by October-December (S3) (12.78 g/plant), April-June (S1) (10.48 g/plant) and the lowest was observed in January-March (S4) season (6.43 g/plant).

The interaction effect of time of sowing (seasons) x variety on the biomass yield was also significant.

During April-June (S1), Arka Isha recorded significantly highest biomass yield (11.85 g/plant), the varieties CO-3 (9.76 g/plant), CO (Cr-4) (9.91 g/plant) and CO-2 (10.19 g/plant) were on par. Whereas, the lowest was recorded in CO-3 (9.76 g/plant). During July-September (S2), significantly highest biomass yield was recorded in Arka Isha (18.65 g/plant), CO-1 (15.48 g/plant) and CO (Cr-4 (14.04 g/plant) were on par. The lowest was recorded in CO-3 (12.60 g/plant) which was on par with CO-2 (12.63 g/plant). During October-December (S3), significantly highest biomass yield was recorded in Arka Isha (14.55 g/plant) which was on par with CO-1 (13.51 g/plant). The lowest yield was recorded in CO (Cr-4) (11.86 g/plant), which was on par with CO-3 (11.94 g/plant) and CO-2 (12.03 g/plant). During January-March (S4), CO-2 (7.29 g/plant) recorded significantly highest biomass yield, the varieties CO-3 (6.21 g/plant), CO (Cr-4) (5.89 g/plant) and Arka Isha (5.85 g/plant) were on par, so also CO-3 (6.21 g/plant) and CO-1 (6.90 g/plant).

4.1.9. Number of primary branches

The results of the effect of varieties and time of sowing on number of primary and secondary branches is presented in Table 6. With respect to the mean number of primary branches, the variety CO-1 and Arka Isha (3.11 and 3.19), CO-2 and CO-3 (3.45 and 3.47) performed on par with each other. The variety CO (Cr-4) performed

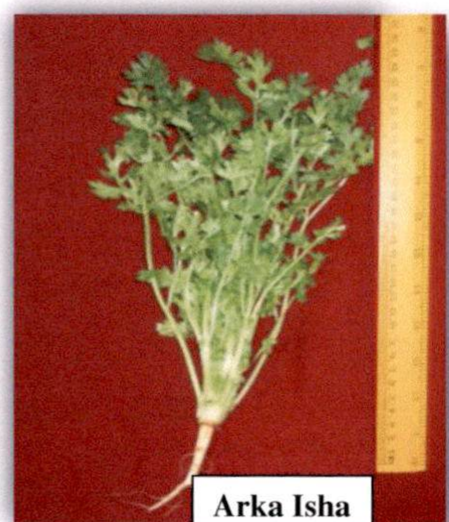


Plate 6. Herbage yield of superior varieties

Table 6. Effect of varieties and time of sowing (seasons) on number of branches

Seasons / Varieties	Number of Primary branches					Number of Secondary branches				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CO-1	2.90	3.35	3.20	2.97	3.11	4.60	8.13	8.10	4.85	6.42
CO-2	3.58	3.53	3.44	3.25	3.45	7.08	7.23	7.53	6.58	7.10
CO-3	3.63	3.35	3.80	3.10	3.47	7.95	7.00	6.75	7.40	7.28
CO(Cr-4)	3.41	4.13	4.28	4.05	4.00	8.28	7.93	6.38	7.90	7.61
Arka Isha	3.10	3.63	3.10	2.93	3.19	7.08	7.15	7.93	6.70	6.93
Mean	3.33	4.00	3.56	3.26		6.99	7.49	7.10	6.69	
CD(0.05)	NS	0.40	0.38	0.27		0.76	0.68	NS	0.73	
					CD (0.05)					
Seasons	0.20					0.52				
Varieties	0.22					0.58				
Season ×Variety	0.44					1.16				

S1: April-June sowing

S2: July-September sowing

S3: October-December sowing

S4: January-March sowing

66

significantly different from other varieties and produced the highest number of primary branches (4.00). The seeds sown in different sowing times (seasons) exhibited significant difference with regard to the mean number of primary branches. July-September (S2) sown crop produced significantly higher number of primary branches (4.00), followed by October-December (S3) (3.56) and April-June (S1) (3.33) sown crops. However, significantly lower number of primary branches (3.26) were observed in January-March (S4) sown crop.

The interaction effect of time of sowing (seasons) x variety on the number of primary branches was also significant.

During April-June (S1), all the varieties performed similar. However, the variety CO-3 recorded highest number of primary branches (3.63) and lowest was observed in CO-1 (2.90). During July-September (S2), significantly the highest number of primary branches (4.13) was recorded in CO (Cr-4) and all other varieties performed at par. During October-December (S3), significantly highest number of primary branches were recorded in CO (Cr-4) (4.28), followed by CO-3 (3.80). The lowest number was recorded in Arka Isha (3.10), which was at par with CO-1 (3.20) and CO-2 (3.44). During January-March (S4), significantly highest number of primary branches were recorded in CO (Cr-4) (4.05), the lowest in Arka Isha (2.93) which was on par with CO-1 (2.97). The varieties CO-2 (3.25) and CO-3 (3.10) were also par.

4.1.10. Number of secondary branches

From the Table 6, it is clear that the varieties differed significantly with respect to the mean number of secondary branches. Among the varieties, CO-2 (7.10), CO-3 (7.28) and CO (Cr-4) (7.61) and the varieties CO-1 (6.42) and Arka Isha (6.93) were on par to each other.

With respect to the influence of time of sowing on mean number of secondary branches, the seeds sown in different sowing times (seasons) exhibited significant difference. The crops raised in July-September (S2) exhibited significantly higher number of secondary branches (7.49) compared to all other sowing times. The crop raised from January-March (S4) recorded significantly the lowest number (6.69), which was on par with April- June (S1) (6.99) and October-December (S3)(7.10) crops.

The interaction effect of time of sowing (seasons) x variety on the number of secondary branches was also significant.

During April- June (S1), highest number of secondary branches were recorded in CO (Cr-4) (8.28) which was on par CO-3 (7.95). The varieties CO-2 (7.08) and Arka Isha (7.08) were on par. Significantly the lowest number of secondary branches were recorded in CO-1 (4.60). During July-September (S2), CO-1 recorded highest number of secondary branches (8.13) which was on par with CO (Cr-4) (7.93). During October-December (S3), the varieties did not varied with respect to this parameter. However, the highest number of secondary branches were recorded in CO-1 (8.10), followed by Arka Isha (7.93) and CO-2 (7.53). The lowest was recorded in CO (Cr-4) (6.38). During January-March (S4), the highest number was recorded in CO (Cr-4) (7.90) and was on par with CO-3 (7.40). The lowest was recorded in CO-1 (4.85), CO-2 (6.58), Arka Isha (6.70) and CO-3 (7.40) were on par.

4.1.11. Days to appearance of serrated leaves

The results pertaining to the effect of varieties and various time of sowing on days to appearance of serrated leaf, days to flowering and days to seed set were presented in Table 7. The varieties CO-1, CO-2 and CO-3 performed on par with each other with respect to the mean number of days required for serrated leaf appearance. Whereas, the varieties Arka Isha and CO (Cr-4) showed significantly different performance and the variety Arka Isha exhibited highest number days for leaf serration (49.29) while CO (Cr-4) observed lowest number of 37.43.

With respect to the influence of time of sowing on days to serration of leaves, the seeds sown in different sowing times (seasons) exhibited significant difference. The crop raised from April-June (S1) (42.41) and January-March (S4) (42.10) were on par with each other and recorded comparatively lower days required for serration of leaves.

July-September (S2) (44.86) and October-December (S3) (44.44) sown crops recorded comparatively higher number of days for serration of leaves.

The interaction effect of time of sowing (seasons) x varieties on the days to appearance of serrated leaves was also significant.

During April-June (S1), it was observed that Arka Isha (48.20) exhibited significantly highest days for leaf serration and lowest in CO (Cr-4) (37.23). The varieties CO-3 (41.85), CO-2 (42.05) and CO-1 were on par. During July-September (S2), all the varieties differed with respect to the number of days for leaf serration. Arka Isha recorded significantly delayed leaf serration (49.88), followed by CO-3 (48.25) and the earliest was CO (Cr-4) (36.83). During October-December (S3), the variety Arka Isha recorded significantly highest number of days for leaf serration (49.93), the varieties CO-2 (45.53), CO-1 (44.45) and CO-3 (44.15) were on par. Significantly lowest days were recorded in CO (Cr-4) (38.13). During January-March (S4), the highest days were recorded in Arka Isha (49.15) and the lowest in CO (Cr-4) (37.53). The varieties CO-2 (43.28), CO-1 (43.05) and CO-3 (41.98) were on par.

4.1.12. Days to flowering

All the varieties showed significant difference with regard to the mean days to flowering (Table.7). The variety Arka Isha exhibited highest days for flowering (54.05) followed by CO-2 (47.36), CO-1 (47.29) and CO-3 (47.19). The performance of the varieties CO-1, CO-2 and CO-3 were on par with each other. The variety CO (Cr-4) recorded the lowest number of days for flowering (40.58).

Table 7. Effect of varieties and time of sowing (seasons) on days to appearance of serrated leaves, flowering and seed set

Seasons / Varieties	Days to appearance of serrated leaves					Days to flowering					Days to seed set				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CO-1	42.73	45.00	44.45	43.05	43.81	46.44	48.88	48.75	45.13	47.29	54.13	58.52	59.48	53.55	56.42
CO-2	42.05	44.33	45.53	43.28	43.80	46.88	47.94	49.52	45.12	47.36	55.00	57.60	59.55	51.50	55.91
CO-3	41.85	48.25	44.15	41.98	44.06	46.25	48.88	48.19	45.48	47.19	55.63	59.20	58.05	54.58	56.86
CO(Cr-4)	37.23	36.83	38.13	37.53	37.43	39.44	41.19	42.88	38.83	40.58	45.69	50.30	49.88	44.90	47.69
Arka Isha	48.20	49.88	49.93	49.15	49.29	52.69	56.5	55.38	51.65	54.05	61.13	64.38	67.08	60.53	63.28
Mean	42.41	44.86	44.44	42.10		46.34	48.68	48.94	45.24		54.31	57.99	58.81	53.01	
CD(0.05)	1.75	0.89	2.25	1.55		0.81	0.82	0.83	1.33		1.04	1.46	1.78	3.27	
CD (0.05)															
Seasons	0.70					0.41					0.86				
Varieties	0.78					0.45					0.96				
Season ×Variety	1.57					0.91					NS				

S1: April-June sowing

S2: July-September sowing

S3: October-December sowing

S4: January-March sowing

The seeds sown January-March (S4) sowing took significantly lowest number of days (45.24) for flowering followed by April-June (S1) (46.34). The sowing times, July-September (S2) (48.68) and October-December (S3) (48.94) were on par to each other.

The interaction effect of time of sowing (seasons) x variety on the days to flowering was also significant.

During April-June (S1), significantly highest days for flowering was recorded in Arka Isha (52.69) and the lowest was recorded in CO (Cr-4) (39.44). The varieties CO-2 (46.88), CO-1 (46.44) and CO-3 (46.25) were on par. During July-September (S2), Arka Isha recorded significantly delayed flowering (56.50), CO-1 (48.88) and CO-3 (48.88) were on par and the lowest days were recorded in CO (Cr-4) (41.19) followed by CO-2 (47.94). During October-December (S3), significantly highest number of days were recorded in Arka Isha (55.38) and lowest in CO (Cr-4) (42.88). The varieties CO-2 (49.52), CO-1 (48.75), so also CO-1 and CO-3 (48.19). During January-March (S4), Arka Isha showed delayed flowering (51.65) and significantly lowest mean value was in CO (Cr-4) (38.83). All other varieties were on par.

4.1.13. Days to seed set

Days to seed set depend on flowering and the prevailing weather conditions. The varieties CO-1 (56.42), CO-2 (55.91) and CO-3 (56.86) did not show significant difference with regard to the days taken for seed set. However, the variety CO (Cr-4) recorded significantly the lowest (47.69) and Arka Isha, the highest number of days (63.28).

The seeds sown in January-March (S4) observed significantly lowest days (53.01) for seed set, followed by April-June (S1) (54.31), July-September (S2) (57.99) and October-November (58.81) crops (Table 7).

The interaction effect of time of sowing (seasons) x varieties on the days to seed set was not significant.

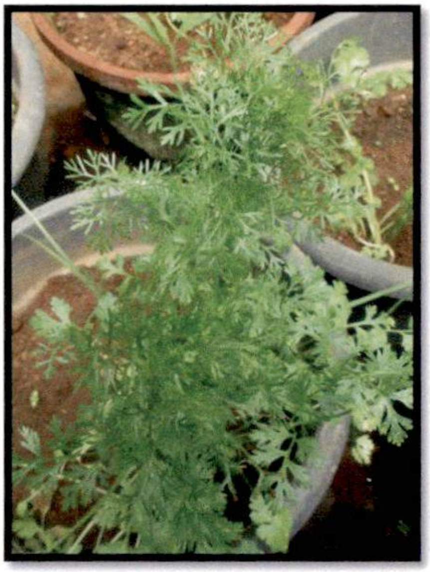
However, during April-June (S1), significantly highest days for seed set recorded in Arka Isha (61.13) and the earliest seed set was recorded in CO (Cr-4) (45.69). The varieties CO-2 (55.00) and CO-1 (54.13) were on par, so also CO-3 (55.63) and CO-2. During July-September (S2), Arka Isha (64.38) recorded significantly delayed seed set from other varieties and CO (Cr-4) (50.30) was the earliest. The varieties CO-1 (58.52) and CO-2 (57.60) were on par. During October-December (S3), the varieties CO-2 (59.55), CO-1 (59.48) and CO-3 (58.05) were on par. The highest days was recorded for Arka Isha (67.08) and lowest in CO (Cr-4) (49.88). During January-March (S4), all the varieties performed on par, except Arka Isha (60.53) and CO (Cr-4) (44.90). Plate 7 shows coriander at serration of leaves, flowering and seed set.

4.2.0. EFFECT OF VARIETIES AND TIME OF SOWING (SEASONS) ON QUALITY OF CORIANDER

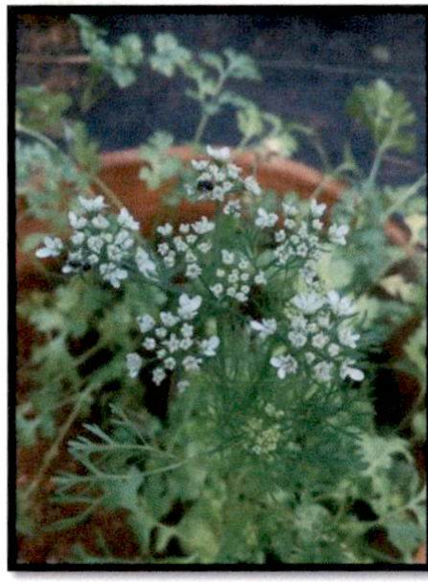
Nowadays, the consumers are focusing more on the quality aspects of any produce and these quality aspects usually changes according to the prevailing weather parameters and other growing conditions. The data pertaining to the quality aspects like volatile oil content, vitamin C and chlorophyll content were analyzed and the results are presented in Table 8.0 and Table 9.0

4.2.1. Volatile oil

The volatile oil content did not show significant variation among different varieties, time of sowing and their interaction. The oil content ranged from 0.05 per cent to 0.06 per cent in various time of sowing. During April-June (S1), October-December (S3) and January-March (S4), CO (Cr-4) recorded the lowest content of volatile oil (0.04% In July-September (S2), the volatile oil was lowest for CO-1, CO-3 and Arka Isha (0.05%). The variety CO-2 was constant in volatile oil yield in all the time of sowing (0.06%) as shown in Table 8.



a. Serration of leaves



b. Flowering

a. Seed set

Plate 7. Coriander at serration of leaves, flowering and seed set

Table 8. Effect of varieties and time of planting on volatile oil and Vitamin C contents in leaves at harvest

Seasons / Varieties	Volatile Oil (%)					Vitamin C(mg/100g)				
	S1	**S2**	**S3**	**S4**	**Mean**	**S1**	**S2**	**S3**	**S4**	**Mean**
CO-1	0.05	0.05	0.06	0.05	0.05	228.77	121.90	124.55	124.19	149.85
CO-2	0.06	0.06	0.06	0.06	0.06	131.78	129.44	129.44	128.95	129.91
CO-3	0.06	0.05	0.06	0.05	0.05	161.31	143.10	164.30	116.60	146.33
CO(Cr-4)	0.04	0.06	0.05	0.04	0.05	68.90	66.25	74.20	69.95	69.83
Arka Isha	0.06	0.05	0.06	0.05	0.05	166.95	153.65	151.00	164.30	158.98
Mean	0.05	0.05	0.06	0.05		151.54	122.87	128.7	120.79	
CD(0.05)	NS	NS	NS	NS		26.83	39.58	41.45	19.62	
	CD (0.05)									
Seasons	NS					13.81				
Varieties	NS					15.44				
Season ×Variety	0.01					30.88				

S1: April-June sowing
S2: July-September sowing
S3: October-December sowing
S4: January-March sowing

4.2.2. Vitamin C

The mean value for vitamin C content ranged from 69.83 mg/100g (CO (Cr-4) to 158.98 mg/100g (Arka Isha). The varieties CO-1 and CO-3 were on par with each other with respect to the mean vitamin C content (Table 8). There was also significant difference in vitamin C content in the variety CO-2 (129.91 mg/100g).

The different sowing times (seasons) showed no significant difference with respect to the vitamin C content in leaves except for the crop in April-June, which recorded significantly highest vitamin C (151.54 mg/100g).

The interaction effect of time of sowing (seasons) x variety for vitamin C content was significant.

During April-June (S1), all the varieties significantly differed for vitamin C content. It was highest in CO-1 (228.77 mg/100g), followed by Arka Isha (166.95 mg/100g), CO-3 (161.31 mg/100g) and CO-2 (131.78 mg/100g) and the lowest in CO (Cr-4) (68.90 mg/100g). In July-September (S2) sowing, all the varieties were on par, except for CO (Cr-4) (66.25 mg/100g) which showed significantly lowest vitamin C content. During October-December (S3), also all the varieties performed on par except for CO(Cr-4) (74.20 mg/100g) and the highest vitamin C was recorded in CO-3 (164.30 mg/100g). However, during January-March (S4), significantly highest vitamin C was recorded in Arka Isha (164.30 mg/100g) followed by CO-2 (128.95 mg/100g) and CO-1 (124.19 mg/100g) which were on par with other, the lowest in CO (Cr-4) (69.95 mg/100g).

4.2.3. Chlorophyll content

The effect of varieties and time of planting on chlorophyll a, chlorophyll b and total chlorophyll of coriander were analyzed and presented in Table 9.

4.2.3.1. Chlorophyll 'a'

The varieties differed significantly with respect to the chlorophyll 'a' content. The variety Arka Isha recorded significantly the highest mean chlorophyll 'a' content (1.56 mg/100g) followed by CO-3 (1.44 mg/100g), CO (Cr-4) (1.41 mg/100g), CO-1 (1.38 mg/100g) and the variety CO-2 showed the lowest value (1.29 mg/100g).

The crop sown in different sowing times (seasons) differed significantly with regard to the chlorophyll 'a' content. The July-September (S2) crop recorded significantly highest (1.51 mg/100g) chlorophyll 'a' followed by the crops of January-March (S4) (1.45mg/100g), October-December (S3) (1.37 mg/100g) and April-June (S1) (1.33 mg/100g).

The interaction effect of time of sowing (seasons) × variety was also significant.

During April to June (Sl) chlorophyll 'a' ranged from 1.16 mg/100g (CO-3) to 1.46 mg/100g (Arka Isha). During July to September (S2), ranged from 1.24 mg/100g (CO-2) to 1.56 mg/100g (CO (Cr-4). During October to December (S3), chlorophyll 'a' ranged from 1.08 mg/100g (CO-2) to 1.56 mg/100g (Arka Isha). But in January to March (S4), it ranged from 1.24 mg/100g (CO (Cr-4) to 1.67 mg/100g (Arka Isha).

4.2.3.2. Chlorophyll 'b'

The varieties differed significantly with regard to the chlorophyll 'b' content. The variety Arka Isha recorded significantly the highest chlorophyll 'b' content (0.67 mg/100g) followed by CO (Cr-4) with 0.62 mg/100g, CO-1 (0.56 mg/100g), CO-3 (0.55 mg/100g), and the variety CO-2 showed the lowest (0.51 mg/100g).

The crop sown in different sowing times (seasons) differed significantly with regard to the chlorophyll 'b' content. Upon comparing the CD, it was clear that those crops sown in July-September (S2) and October-December (S3) were on par with each other and crops of April-June (S1) and January-March (S4) performed on par with each other.

The interaction effect of time of sowing (seasons) was also significant.

During April-June (S1) sowing, the chlorophyll 'b' ranged from 0.50mg/100g to 0.61 mg/100g, during July-September (S2) sowing ranged from 0.46 mg/100g to 0.86 mg/100g. However, during October-December (S3), it ranged from 0.45 m/100g to 0.86 mg/100g and January-March (S4) sowing ranged from 0.46 mg/100g to 0.61mg/100g.

4.2.3.3. Total chlorophyll

The mean values for total chlorophyll ranged from 1.93 (CO-1 mg/100g) to 2.20 mg/100g (Arka Isha). The varieties CO-1 (1.93 mg/100g) and CO-2 (1.95 mg/100g) and the varieties CO (Cr-4) (2.19 mg/100g) and Arka Isha (2.20 mg/100g) were on par with each other.

The crops sown in different sowing times (seasons) differed significantly with regard to the total chlorophyll content. The July-September (S2) crop observed significantly highest (2.27 mg/100g), followed by January-March (S4) (2.19 mg/100g), October-December (S3) (1.92 mg/100g) and April-June (S1) (1.83 mg/100g) crops.

The interaction effect of time of sowing (seasons) × variety was also significant.

During April-June (S1), all the varieties varied among the other. The highest total chlorophyll was recorded in Arka Isha (2.07 mg/100g), followed by CO (Cr-4) (1.92 mg/100g), CO-1 (1.83 mg/100g), CO-3 (1.71 mg/100g) whereas the lowest in CO-2 (1.64 mg/100g). During July-September (S2), the varieties CO-3 (2.28 mg/100g) and Arka Isha (2.28 mg/100g) were on par and CO (Cr-4) (2.16mg/100g) and CO-1 (2.05 mg/100g) were also on par. Significantly highest total chlorophyll was recorded in CO-2 (2.56 mg/100g). During October-December (S3), significantly highest chlorophyll content was recorded in Arka Isha (2.16 mg/100g), which was on par with CO (Cr-4) (2.10 mg/100g). The varieties CO-1(1.92 mg/100g) and CO-3 (1.91 mg/100g) were on par. However during January-March (S4), all the varieties differed significantly and total chlorophyll content ranged from 1.92 mg/100g (CO-1) to 2.56 mg/100g (CO (Cr-4).

Table 9. Effect of varieties and time of sowing (seasons) on chlorophyll content in leaves at harvest (mg)

Seasons / Varieties	Chlorophyll 'a'(mg/100g)					Chlorophyll 'b'(mg/100g)					Total chlorophyll(mg/100g)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CO-1	1.32	1.54	1.33	1.33	1.38	0.52	0.52	0.59	0.59	0.56	1.83	2.05	1.92	1.92	1.93
CO-2	1.37	1.24	1.08	1.46	1.29	0.50	0.46	0.45	0.61	0.51	1.64	2.56	1.53	2.07	1.95
CO-3	1.16	1.67	1.37	1.54	1.44	0.55	0.60	0.54	0.53	0.55	1.71	2.28	1.91	2.10	2.00
CO(Cr-4)	1.33	1.56	1. 51	1.24	1.41	0.59	0.86	0.58	0.46	0.62	1.92	2.16	2.10	2.56	2.19
Arka Isha	1.46	1.53	1.56	1.67	1.56	0.61	0.60	0.86	0.60	0.67	2.07	2.28	2.16	2.28	2.20
Mean	1.33	1.51	1.37	1.45		0.55	0.61	0.60	0.56		1.83	2.27	1.92	2.19	
CD(0.05)	0.006	0.01	0.16	0.12		0.03	0.008	0.07	0.008		0.007	0.008	0.22	0.009	
CD (0.05)															
Seasons		0.03				0.02					0.04				
Varieties		0.04				0.02					0.05				
Season ×Variety		0.07				0.03					0.1				

S1: April-June sowing

S2: July-September sowing

S3: October-December sowing

S4: January-March sowing

79

4.3.0. EFFECT OF GROWING CONDITIONS ON YIELD AND QUALITY OF CORIANDER

The present experiment was conducted in two different growing conditions viz. open field and rain shelter using five varieties of coriander during *rabi* season (October-December 2016). The data pertaining to the effect of different growing conditions on yield and quality of coriander is presented from Table 10 to Table 11 in the order of effect of growing condition, varieties and its interaction.

4.3.1. Days to seed germination

The mean number of days required for seed germination differed significantly in rain shelter (9.73) and open field (8.56). It was clear that seeds sown in open field required significantly lesser number of days for germination (Table 10).

The varieties exhibited the similar trend in days to germination in rain shelter and open field. In both the growing conditions, lowest number of days (6.46) were required by the variety CO (Cr-4). The varieties CO-2 and CO-3 performed on par with each other and CO-1 required 8.96 mean number of days for germination. The highest number of days (14.05) were needed for the variety Arka Isha.

The interaction of variety × growing condition was also found significant. In the rain shelter, significantly the lowest number of days were observed in CO (Cr-4) (6.70) followed by CO-2 (8.35), CO-3 (9.45) and CO-1 (9.83) and the highest number of days for germination were recorded in Arka Isha (14.32)

In the open field, all the varieties differed significantly. The variety CO (Cr-4) recorded the earliest germination (6.22), followed by CO-3 (7.07), CO-2 (7.62) and CO-1 (8.10) and the highest number of days were recorded in Arka Isha (13.77).

Table. 10. Effect of growing conditions on days to seed germination

Varieties	Days to seed germination		
	Rain shelter	**Open field**	**Mean**
CO-1	9.83	8.10	8.96
CO-2	8.35	7.62	7.99
CO-3	9.45	7.07	8.26
CO(Cr-4)	6.70	6.22	6.46
Arka Isha	14.32	13.77	14.05
Mean	9.73	8.56	
CD(0.05)	0.81	0.61	
	CD (0.05)		
Growing conditions	0.30		
Varieties	0.48		
Growing condition× Varieties	0.67		

4.3.2. Days to emergence of first leaf

The data presented in Table 11 revealed that the days required for first, second and third leaf emergence were significantly influenced by growing conditions.

The highest number of days for first leaf emergence (12.49) was recorded in rain shelter which was significantly higher than the open field (11.31). The varieties differed significantly in both the growing conditions with respect to mean number of days required for first leaf emergence. The variety CO (Cr-4) recorded lowest number of days (8.95) and the highest number of days was exhibited by Arka Isha (16.84).

The interaction of variety × growing condition was significant. In the rain shelter, the lowest days (9.30) for leaf emergence was noticed in CO (Cr-4) which was significantly different from all other varieties. CO-1 (12.47) and CO-3 (12.70) were on par whereas, highest number of days for first leaf emergence was recorded in Arka Isha (17.02).

In the open field, all the varieties differed significantly. CO (Cr-4) recorded the lowest number of days (8.60), followed by CO-2 (9.80), CO-3 (10.10) and CO-1 (11.42). The highest number of days were recorded in Arka Isha (16.65).

4.3.3. Days to second leaf emergence

Upon comparing the CD over both growing conditions, it was evident that the highest number of days for second leaf emergence was recorded in rain shelter (14.72) which was significantly higher compared to the open field (13.72).

Upon comparing the CD for varieties in two growing conditions it was clear that the varieties performed significantly different in both the growing conditions. The lowest number of days for second leaf emergence was recorded by CO (Cr-4) (11.25). The variety Arka Isha recorded highest number of days (19.08) followed by CO-1 (14.41), CO-3 (13.77) and CO-2 (12.57).

The interaction of variety × growing condition was significant. In the rain shelter, lowest number of days were recorded in CO (Cr-4) (11.75), followed by CO-2 (12.85), CO-1 (14.72) and CO-3 (15.07). Arka Isha took significantly the highest number of days (19.17).

In the open field, the lowest number of days were recorded in CO (Cr-4) (10.75), followed by CO-2 (12.30) which was on par with CO-3 (12.47), whereas Arka Isha showed significantly highest number of days (19.00) for second leaf emergence.

4.3.4. Days to third leaf emergence

The days to third leaf emergence was significantly influenced by growing conditions as it was evident from Table. 11. More number of days were required in rain shelter (16.68) compared to open field (15.88) which was significantly lower.

The performance of the varieties were significantly different in both the growing conditions with respect to mean number of days required for third leaf emergence. The lowest number of days to third leaf emergence was recorded by CO-(Cr-4) (13.70) followed by CO-2 (14.82), CO-3 (15.82) and CO-1 (16.59). The highest number of days were recorded by Arka Isha (20.46).

The interaction of variety × growing condition was significant. In the rain shelter, significantly lowest number of days for third leaf emergence were recorded in Arka Isha (14.20) which was on par with CO-2 (14.35), whereas significantly highest days was observed in Arka Isha (20.68), followed by CO-3 (17.28) and CO-1 (16.90).

In the open field, all the varieties performed different by CO (Cr-4) recorded significantly lowest number of days (13.20), followed by CO-3 (14.38), and CO-2 (15.30). The highest number of days were recorded in Arka Isha (20.25).

Table 11. Effect of growing conditions on days to leaf emergence

Varieties	First leaf emergence			Second leaf emergence			Third leaf emergence		
	Rain Shelter	Open Field	Mean	Rain shelter	Open field	Mean	Rain Shelter	Open field	Mean
CO-1	12.47	11.42	11.95	14.72	14.1	14.41	16.90	16.28	16.59
CO-2	10.97	9.80	10.39	12.85	12.30	12.57	14.35	15.30	14.82
CO-3	12.70	10.10	11.40	15.07	12.47	13.77	17.28	14.38	15.82
CO(Cr-4)	9.30	8.60	8.95	11.75	10.75	11.25	14.20	13.20	13.70
Arka Isha	17.02	16.65	16.84	19.17	19.00	19.08	20.68	20.25	20.46
Mean	12.49	11.31		14.72	13.72		16.68	15.88	
CD(0.05)	1.05	0.47		0.71	0.59		0.98	0.59	
CD (0.05)									
Growing conditions	0.34			0.28			0.36		
Varieties	0.53			0.44			0.56		
Growing condition× Varieties	0.75			0.63			0.80		

84

4.3.5. Number of leaves

The data pertaining to the number of leaves at 30 DAS and at harvest were analyzed and tabulated and presented in Table 12.

The mean number of leaves at 30 DAS and at harvest differed significantly in two growing conditions. Significantly higher number of leaves were recorded in the rain shelter (9.13 and 14.18) compared to the open (8.46 and 13.85) respectively at 30 DAS and at harvest.

Performance of the varieties were significantly different in both the conditions. Highest numbers of leaves (10.34 and 16.84) were recorded in Arka Isha compared to the other varieties in 30 DAS and at harvest, respectively. The lowest number of leaves were recorded in the variety CO-3 at 30 DAS and at harvest (7.22 and 11.85) respectively.

The interaction effects of variety × growing condition was not significant. In the rain shelter, the highest number of leaves at 30 DAS and at harvest were observed in Arka Isha (10.80 and 16.85) respectively. Among the other varieties, CO (Cr-4) was significantly superior (10.35 and 15.48) respectively at 30 DAS and at harvest.

In the open field condition, highest number of leaves per plant at 30 DAS and at harvest was recorded in Arka Isha (10.34 and 16.82) respectively followed by CO-(Cr-4) (9.82 and 14.70) and the least was observed in CO-3 (7.15 and 11.88) respectively.

4.3.6. Plant height

The data on effect of growing conditions on plant height is presented in Table 13.

It was evident that the growing conditions did not affect significantly the plant height at 30 DAS, however, it was significantly higher (19.11 cm) in rain shelter than in open (17.36 cm) at 45 DAS, so also at 60 DAS, plant height was significantly higher in rain shelter (27.04 cm) than in open field (25.88 cm). Thus it can be seen that coriander varieties recorded more height at rain shelter than in open field.

The performance of the varieties varied significantly at 30, 45 and 60 DAS with respect to plant height. At 30 DAS, the variety Arka Isha recorded lowest height (7.21 cm) and the highest plant height was in CO-3 (12.02 cm). Varieties CO-1(11.39 cm), CO-2 (11.58 cm) and CO (Cr-4) (11.46 cm) were on par. However, this trend of plant height did not remain true for all the varieties at 45 DAS where the lowest plant height (16.19 cm) was in Arka Isha while the highest (20.12 cm) was in CO (Cr-4), the varieties CO-1 (17.96 cm) and CO-2 (17.86 cm) performed on par. At 60 DAS, Arka Isha, which recorded slow growth at 30 and 45 DAS grew actively and recorded the highest plant height (27.83 cm), CO-1 (27.25 cm), CO-2 (27.08 cm) performed on par while the lowest plant height at 60 DAS was in CO (Cr-4) (24.26 cm).

The interaction of variety × growing condition was significant at 30 DAS, however it was not significant at 45 DAS and 60 DAS.

Inside the rain shelter, varieties performed significantly different with respect to plant height at 30 DAS. The highest plant height was observed in CO-3 (12.28 cm) and the lowest in Arka Isha (6.66 cm). The varieties CO-1 (11.08 cm) and CO (Cr-4) (11.66 cm) were on par, whereas the variety CO-2 (11.86 cm) was significantly different.

In the open field also, the varieties recorded significantly different height at 30DAS. CO-3 (11.76 cm) recorded the highest plant height, while the lowest was in Arka Isha (7.76 cm). The varieties CO-1 (11.70 cm), CO-2 (11.29 cm), CO-3 (11.76 cm) and CO (Cr-4) (11.26 cm) were on par.

Plant height at 45 DAS recorded significantly different plant height in the rain shelter. Highest plant height was recorded in CO (Cr-4) (21.36 cm), whereas the lowest was in Arka Isha (16.95 cm). The varieties CO-1 (19.22 cm) and CO-2 (18.22

cm) were on par, whereas, the variety CO-3 performed significantly different with a plant height of 19.78 cm.

Plant height at 45 DAS recorded significantly different plant height in the rain shelter. Highest plant height was recorded in CO (Cr-4) (21.36 cm), whereas the lowest was in Arka Isha (16.95 cm). The varieties CO-1 (19.22 cm) and CO-2 (18.22 cm) were on par, whereas, the variety CO-3 performed significantly different with a plant height of 19.78 cm.

In the open field, the varieties differed significantly with respect to plant height. It was highest in CO (Cr-4) (18.88 cm) whereas, lowest in Arka Isha (15.42 cm). Here also the varieties CO-1 (16.70 cm) and CO-2 (17.49 cm) were on par. The variety CO-3 (18.30 cm) was significantly different.

Plant height at 60 DAS varied significantly among the varieties in the rain shelter. Highest plant height was recorded in Arka Isha (28.46 cm) while the lowest in CO-3 (26.71 cm). The varieties CO-1 (27.74 cm) and CO-2 (27.56 cm) were on par. The variety CO (Cr-4) (24.73 cm) recorded the lowest plant height.

In the open field also, varieties showed significantly different performance in plant height at 60 DAS. The variety Arka Isha showed highest plant height (27.20 cm) while the lowest was in CO (Cr-4) (23.80 cm). The varieties CO-1 (26.71 cm) and CO-2 (26.60 cm) were on par, whereas CO-3 (25.08 cm) was significantly different.

4. 3.7. Herbage yield

The herbage yield and biomass yield per plant over different growing conditions was statistically analyzed and presented in Table 14.

Upon comparing the CD values, significantly higher herbage yield was obtained from plants grown under rain shelter condition (9.21g/plant) compared to open field (8.41 g/plant).

Table 12. Effect of growing conditions on number of leaves at different growth stages

Varieties	Number of leaves at 30 DAS			Number of leaves at harvest		
	Rain shelter	Open field	Mean	Rain shelter	Open field	Mean
CO-1	8.65	7.98	8.31	14.00	13.02	13.51
CO-2	8.58	7.50	8.04	12.75	12.82	12.79
CO-3	7.30	7.15	7.22	11.82	11.88	11.85
CO(Cr-4)	10.35	9.82	10.09	15.48	14.70	15.09
Arka Isha	10.80	9.88	10.34	16.85	16.82	16.84
Mean	9.13	8.46		14.18	13.85	
CD(0.05)	0.56	0.58		0.64	0.86	
CD (0.05)						
Growing conditions	0.23			0.30		
Varieties	0.36			0.48		
Growing condition× Varieties	NS			NS		

Table 13. Effect of growing conditions on plant height at different growth stages

Varieties	Plant height at 30 DAS (cm)			Plant height at 45DAS (cm)			Plant height at 60 DAS (cm)		
	Rain Shelter	**Open field**	**Mean**	**Rain shelter**	**Open field**	**Mean**	**Rain shelter**	**Open field**	**Mean**
CO-1	11.08	11.70	11.39	19.22	16.7	17.96	27.74	26.75	27.25
CO-2	11.86	11.29	11.58	18.22	17.49	17.86	27.56	26.60	27.08
CO-3	12.28	11.76	12.02	19.78	18.30	19.04	26.71	25.08	25.89
CO(Cr-4)	11.66	11.26	11.46	21.36	18.88	20.12	24.73	23.80	24.26
Arka Isha	6.66	7.76	7.21	16.95	15.42	16.19	28.46	27.20	27.83
Mean	10.71	10.75		19.11	17.36		27.04	25.88	
CD(0.05)	0.74	0.99		1.08	1.06		1.10	1.05	
CD (0.05)									
Growing conditions	NS			0.46			0.44		
Varieties	0.56			0.73			0.70		
Growing condition× Varieties	0.79			NS			NS		

89

Among the varieties, Arka Isha recorded the highest herbage yield (10.46 g/plant) followed by CO-1 (8.97 g/plant), CO-3 (8.68 g/plant) and the performance of CO (Cr-4) (7.75 g/plant) and CO-2 (8.19 g/plant) were on par with each other.

The interaction effect of variety x growing condition with respect to herbage yield was not significant. When comparing the varieties within the rain shelter, it was observed that Arka Isha showed the highest herbage yield (11.07 g/plant) while the lowest was in CO (Cr-4) (8.10 g/plant). The varieties CO-1 (9.48 g/plant), CO-2 (8.56 g/plant) and CO-3 (8.84 g/plant) were on par.

When comparing the varieties in open field, it was clear that Arka Isha recorded highest herbage yield (9.84 g/plant), whereas CO (Cr-4) (7.40 g/plant) recorded the lowest herbage yield. The varieties CO-1 (8.46 g/plant), CO-2 (7.82 g/plant) and CO-3 (8.53 g/plant) were on par. Plate 8 shows herbage yield at different growing conditions.

4.3.7.1. Herbage yield (g/plot)

The growing conditions showed significant difference with respect to the herbage yield per plot (Table 15). The higher mean herbage yield (176.56g) was recorded in crops grown in rain shelter compared to the open field (150.54 g).

Irrespective of the growing conditions, Arka Isha showed significantly highest herbage yield (226.21 g) followed by CO-1(180.65) and CO-2 (144.06). However, lowest in CO (Cr-4) (128.54).

The estimated herbage of crops grown in rain shelter and open field is shown in Table 15.

4.3.8. Biomass yield

The biomass yield was significantly lower in open field (11.34g/plant) compared to rain shelter (12.78g/plant). Among the varieties also, a significant difference was observed and Arka Isha was significantly superior (14.13g/plant) followed by CO-1 (12.70g/plant), which was superior over CO-2 (11.56g/plant) and CO-3 (11.37g/plant). The variety CO (Cr-4) was significantly inferior (10.52g/plant) to all other varieties.

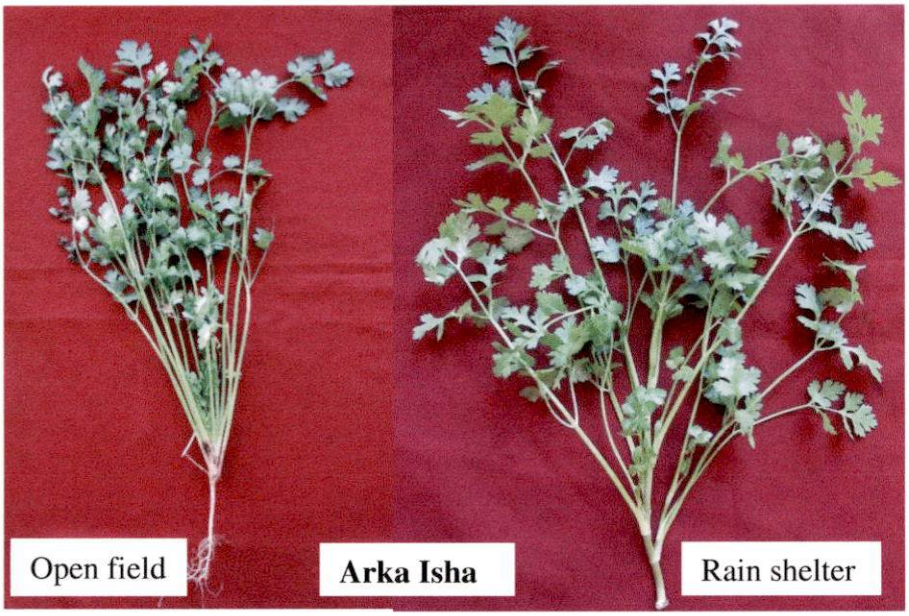
The interaction effect of variety x growing condition was not significant (Table 14). There was significant difference among varieties in the rain shelter. Arka Isha (14.55g/plant) recorded highest biomass yield, followed by CO-1 (13.50g/plant), whereas the lowest in CO (Cr-4) (11.86g/plant). The varieties CO-2 (12.03) and CO-3 (11.93g/plant) were on par (Table 14).

Table. 14. Effect of growing conditions on herbage and biomass yield (g/plant)

Varieties	Herbage yield(g/plant)			Biomass yield(g/plant)		
	Rain shelter	Open Field	Mean	Rain shelter	Open field	Mean
CO-1	9.48	8.46	8.97	13.50	11.89	12.70
CO-2	8.56	7.82	8.19	12.03	11.09	11.56
CO-3	8.84	8.53	8.68	11.93	10.80	11.37
CO(Cr-4)	8.10	7.40	7.75	11.86	9.18	10.52
Arka Isha	11.07	9.84	10.46	14.55	13.72	14.13
Mean	9.21	8.41		12.78	11.34	
CD(0.05)	1.28	1.01		1.28	0.97	
CD (0.05)						
Growing conditions	0.48			0.53		
Varieties	0.77			0.83		
Growing condition× Varieties	NS			NS		

Table. 15. Effect of growing conditions on herbage yield (g/plot)

Varieties	Herbage yield (g/plot)			Estimated yield (t/250m^2)	Estimated yield (t/ha)
	Rain shelter	**Open field**	**Mean**	**Rain shelter**	**Open field**
CO-1	202.21	159.08	180.65	0.05	1.59
CO-2	151.69	136.43	144.06	0.038	1.363
CO-3	146.42	130.16	138.29	0.036	1.30
CO(Cr-4)	137.17	119.91	128.54	0.034	1.19
Arka Isha	245.31	207.11	226.21	0.061	2.07
Mean	176.56	150.54			
CD (0.05)					
Growing conditions	11.91				
Varieties	18.82				
Growing condition× Varieties	NS				



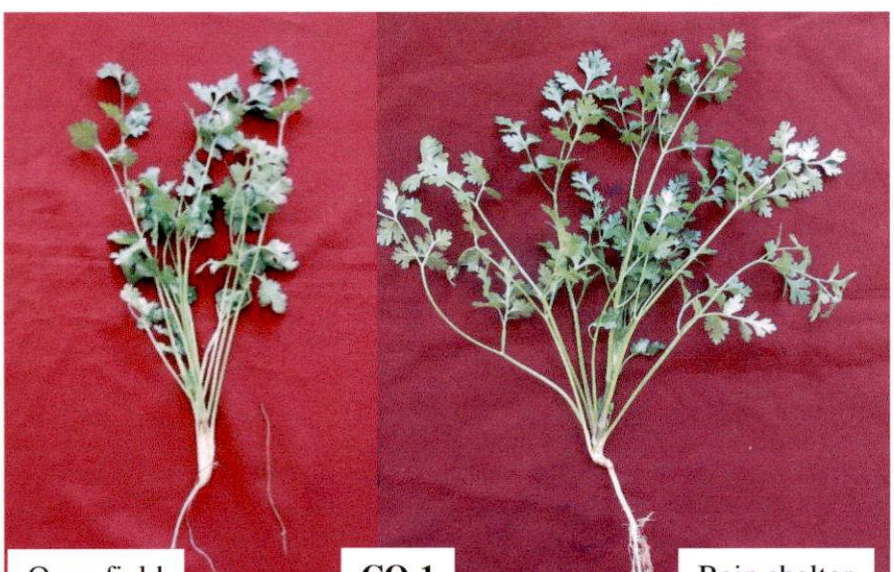


Plate 8. Herbage yield under different growing conditions of superior varieties

In the open field also, biomass yield observed the same trend as in the case of rain shelter Arka Isha (13.72 g/plant) recorded the highest biomass yield which was significantly superior, whereas the lowest was in CO (Cr-4) (9.18 g/plant). The varieties CO-2 (11.09 g/plant) and CO-3 (10.80 g/plant) were on par. Whereas CO-1 (11.89 g/plant) was significantly different from other varieties.

4.3.9. Number of primary branches

The data pertaining to the effect of number of primary and secondary branches is presented in Table 16.

In general, growing conditions had no significant influence on the number of primary branches. However, irrespective of growing conditions, the varieties had significant influence on the number of primary branches per plant. The variety Arka Isha recorded lowest (2.87) number of primary branches while, CO-1 (3.34), CO-2 (3.40), CO-3 (3.39) and CO-(Cr-4) (3.46) were on par among themselves.

The interaction effect of variety × growing condition was also significant. The varieties did not differ significantly in the rain shelter.

However, the varieties differed significantly in the open field. The highest number of primary branches were observed in CO-1(3.79), followed by CO (Cr-4)(3.50) and CO-2 (3.22) which were on par. The lowest number of primary branches were recorded in Arka Isha (2.65) which was on par with CO-3 (3.15).

4.3.10. Number of Secondary branches

In general, the growing conditions had significant influence on number of secondary branches per plant (Table 16). The plants in rain shelter had less secondary branches (7.18) compared to open field (8.47).

Table 16. Effect of growing conditions on number of branches

Varieties	Number of primary branches			Number of secondary branches		
	Rain shelter	Open Field	Mean	Rain shelter	Open Field	Mean
CO-1	2.90	3.79	3.34	7.15	11.01	9.08
CO-2	3.58	3.22	3.40	8.10	7.60	7.85
CO-3	3.62	3.15	3.39	7.52	7.10	7.31
CO(Cr-4)	3.42	3.50	3.46	6.75	9.30	8.02
Arka Isha	3.10	2.65	2.87	6.38	7.32	6.85
Mean	3.32	3.26		7.18	8.47	
CD(0.05)	NS	0.57		NS	1.46	
CD (0.05)						
Growing conditions	NS			0.78		
Varieties	0.41			1.24		
Growing condition× Varieties	0.57			1.75		

95

Among the varieties, CO-1 had highest secondary branches (9.08) which was on par with CO-2 (7.85), CO-3 (7.31) and CO (Cr-4) (8.02). In the rain shelter, the variety CO-2 had highest secondary branches (8.10) per plant which was on par with CO-3 (7.52) and CO-1 (7.15). The variety Arka Isha recorded the lowest mean number (6.85) of secondary branches in the rain shelter.

The interaction effect of variety x growing condition was also significant. However, the varieties did not show significant difference with respect to the number of secondary branches.

In open field, the varieties differed significantly. The highest number of secondary branches (11.01) were recorded CO-1, followed by CO (Cr-4) (9.30). The varieties CO-2 (7.6), Arka Isha (7.32) and CO-3 (7.10) were on par.

4.3.11. Days to appearance of serrated leaves

The data on effect of growing conditions on days to appearance of serrated leaves, flowering and seed set is presented in Table 17.

In the rain shelter, it was observed that appearance of serrated leaves was delayed and more number of days (44.44) were required compared to the open field (43.34). Upon comparing the varieties, it was evident that early appearance of serrated leaf was noticed in CO(Cr-4) (37.24). The varieties CO-1 (43.68), CO-3 (44.38) were on par with each other. Serrated leaf appearance was the most delayed in Arka Isha (49.30) followed by CO-2 (44.84).

The interaction effect of variety x growing condition was not significant. However, in the rain shelter, the varieties differed significantly. It was found that Arka Isha (49.92) required highest number of days, followed by CO-2 (45.52) which were significantly different. The varieties CO-1 (44.45), CO-2 (45.52), CO-3 (45.15) were on par. The lowest number of days for leaf serration was found in CO (Cr-4) (38.12).

Table 17. Effect of growing conditions on days to appearance of serrated leaves, flowering and seed set

Varieties	Days to appearance of serrated leaves			Days to flowering			Days to seed set		
	Rain shelter	**Open field**	**Mean**	**Rain Shelter**	**Open field**	**Mean**	**Rain shelter**	**Open Field**	**Mean**
CO-1	44.45	42.90	43.68	48.75	45.00	46.88	59.48	53.08	56.28
CO-2	45.52	44.15	44.84	49.52	47.00	48.26	59.55	55.88	57.71
CO-3	44.15	44.6	44.38	48.19	48.31	48.25	58.05	54.88	56.46
CO(Cr-4)	38.12	36.35	37.24	42.88	41.69	42.28	49.88	47.57	48.72
Arka Isha	49.92	48.68	49.30	55.38	53.43	54.41	67.08	61.00	64.04
Mean	44.44	43.34		48.94	47.09		58.80	54.48	
CD(0.05)	1.59	1.19		0.88	1.13		1.78	1.31	
CD (0.05)									
Growing conditions	0.64			0.42			0.59		
Varieties	1.01			0.67			0.94		
Growing condition× Varieties	NS			NS			1.33		

In the open field, the varieties differed significantly. Arka Isha recorded highest number of days (48.68), followed by CO-3 (44.60) which were significantly different. The variety CO-2 (44.15) and CO-3 (45.60) were on par, whereas CO-1 (42.90) was significantly different. CO (Cr-4) (36.35) was recorded lowest number of days to serration of leaves.

4.3.12. Days to flowering

Regardless of varieties, the plants grown in the rain shelter took more number of days for flowering (48.94), which was significantly higher than the open field condition (47.09). Irrespective of growing conditions, the cultivar Arka Isha took the lowest number of days for flowering (54.41) followed by CO-2 (48.26). However, CO-2 (48.26) and CO-3 (48.25) were on par with each other. The variety CO (Cr-4) was the earliest (42.28) in flowering (Table 17).

The interaction effect of variety x growing condition was not significant. However, days to flowering recorded significant difference for the varieties for the varieties in the rain shelter. Highest number of days to flowering were recorded in Arka Isha (55.38), followed by CO-2 (49.52) which were significantly different. CO-1 (48.75) and CO-3 (48.19) were on par. The lowest number of days to flowering was recorded in CO (Cr-4) (42.88).

In the open field also, there was significant difference among the varieties. The highest number of days to flowering was recorded in Arka Isha (53.43), followed by CO-3 (48.31) which were significantly different. CO-1 (45.00), CO-2 (47.00) and CO-3 (48.31) were also significantly different. The lowest number of days to flowering was recorded in CO (Cr-4) (41.69).

4.3.13. Days to seed set

In general, the plants grown in the rain shelter took more number of days for seed set (58.80), which was significantly higher than the open field (54.48).

Irrespective of growing conditions, the variety Arka Isha took the highest number of days for seed set (64.04) which was significantly higher than other varieties. The varieties CO-1 (56.28) and CO-3 (56.46) were on par with each other. Earliest seed set (48.72) was observed in CO (Cr-4) (Table 17).

The interaction effect of variety x growing condition was also significant. In the rain shelter, the variety Arka Isha recorded significantly highest number of days (61.00), followed by CO-2 (58.88) which differed significantly. The varieties CO-1 (59.48), CO-2 (59.55) and CO-3 (58.05) were on par.

In the open field, the varieties CO-2 (55.88) and CO-3 (54.88) were on par, CO-1 (53.08) differed significantly. The lowest number of days were recorded in CO (Cr-4) (47.55).

Plate 9 and Plate 10 show the flowering and seed set in open field respectively.

Plate 9. Flowering in open field

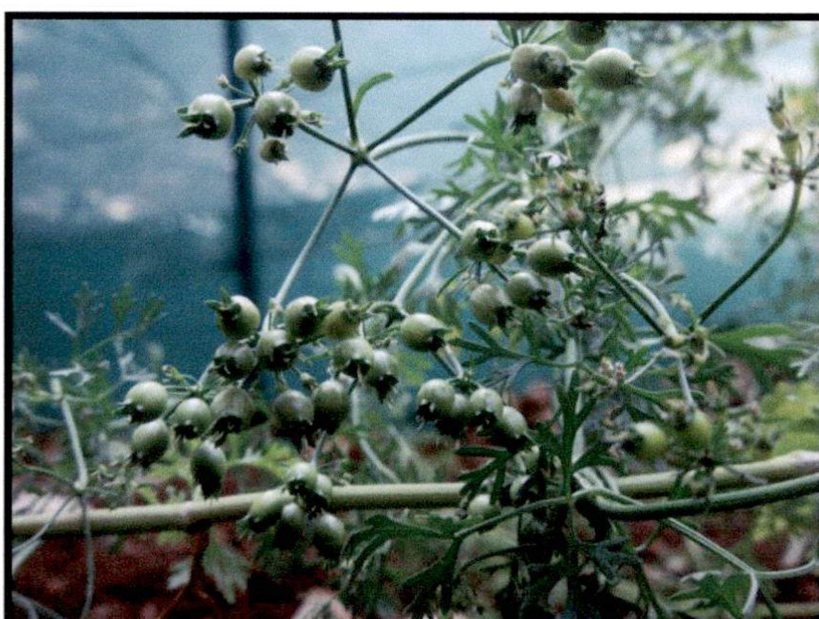


Plate 10. Seed set in open field

4.4. EFFECT OF GROWING CONDITIONS FOR QUALITY PARAMETERS

4.4.1. Volatile oil

The growing conditions did not affect significantly in the volatile oil content. Also the varieties did not differ significantly with respect to the volatile oil content as it is clear from Table 18. Within the rain shelter, varieties did not differ. However, in the open field there was significant difference. And volatile oil ranged from 0.05 per cent-0.06 per cent.

4.4.2. Vitamin C

In general, the vitamin C in leaves was observed significantly high in open field (189.72 mg/100g) compared to the rain shelter (124.55 mg/100g). Also among the varieties, CO-3 (190.80 mg/100g) and CO-1 (166.95 mg/100g) recorded significantly higher vitamin C than other varieties followed by Arka Isha (165.63 mg/100g), CO-2 (147.08 mg/100g) and CO (Cr-4) with 115.23 mg/100g (Table 18).

Vitamin C content of varieties differed significantly within the rain shelter. Highest vitamin C was found in CO-3 (148.40 mg/100g), whereas the lowest was observed in Arka Isha (106.00 mg/100g), followed by CO-2 (116.60 mg/100g). CO-1 (124.55mg/100g) and CO-3 (127.20 mg/100g) were on par.

In the open field also, the varieties showed significant difference for vitamin C. It was highest in CO-3 (233.20 mg/100g), followed by Arka Isha (222.25 mg/100g). The varieties CO-2 (177.55 mg/100g) and CO-1 (209.35 mg/100g) were on par. Lowest vitamin C content was observed in CO (Cr-4) (103.25 mg/100g).

Table 18. Effect of growing conditions on volatile oil and vitamin C contents in leaves at harvest

Varieties	Volatile oil (%)			Vitamin C(mg per 100g)		
	Rain shelter	Open Field	Mean	Rain shelter	Open Field	Mean
CO-1	0.06	0.06	0.06	124.55	209.35	166.95
CO-2	0.06	0.05	0.05	116.60	177.55	147.08
CO-3	0.06	0.06	0.06	148.40	233.20	190.80
CO(Cr-4)	0.05	0.05	0.05	127.20	103.25	115.23
Arka Isha	0.06	0.06	0.06	106.00	225.25	165.63
Mean	0.06	0.05		124.55	189.72	
CD(0.05)	NS	0.01		12.61	38.87	
			CD (0.05)			
Growing conditions	NS			12.45		
Varieties	NS			19.69		
Growing condition× Varieties	NS			27.84		

4.4.3. Chlorophyll content

In general, growing conditions had no significant effect on total chlorophyll content of leaves. However, chlorophyll 'b' was recorded highest in rain shelter condition (0.60 mg/100g) compared to the open field (0.47mg/100g). Total chlorophyll content was recorded more in open field (1.98 mg/100g) than rain shelter (1.92 mg/100g) as presented in Table 19.

In the varieties, the total chlorophyll content ranged from 1.55 mg/100g to 2.33 mg/100g, Chlorophyll 'a' ranged from 1.14 mg/100g to 1.62 mg/100g and chlorophyll 'b' ranged from 0.41 mg/100g to 0.73 mg/100g over both growing conditions in different varieties.

However, chlorophyll 'a', chlorophyll'b' and total chlorophyll significantly differed among varieties in the rain shelter as well as in the open field. It was found that chlorophyll'a' was highest in Arka Isha (1.56 mg/100g), followed by CO (Cr-4) (1.51 mg/100g) in the rain shelter. CO-1 (1.33mg/100g) and CO-3 (1.37mg/100g) were on par. The lowest chlorophyll 'a' was recorded in CO-2 (1.08 mg/100g). Similarly, in the open field, highest chlorophyll 'a' was found in Arka Isha (1.67mg/100g), followed by CO-3 (1.53 mg/100g). CO-1 (1.03 mg/100g), CO-2 (1.19 mg/100g) and CO (Cr-4) (1.24 mg/100g) were on par.

Chlorophyll 'b' was found highest in Arka Isha (0.86 mg/100g) in the rain shelter. CO-1 (0.59 mg/100g), CO (Cr-4) (0.58 mg/100g) and CO-3 (0.54 mg/100g) were on par. Chlorophyll'b'was lowest in CO-2 (0.45 mg/100g). Similar trend was observed in the open field also. Arka Isha recorded highest mean value (0.60 mg/100g). All other varieties differed significantly. All other varieties differed significantly. CO-2 (0.37 mg/100g) recorded the lowest mean value.

Similarly the total chlorophyll content differed in the rain shelter among the varieties. Arka Isha (2.16 mg/100g) recorded the highest total chlorophyll, followed by CO (Cr-4) (2.10 mg/100g) and CO-1 (1.92 mg/100g) were on par. The lowest total chlorophyll was in CO-3 (1.91 mg/100g) in the rain shelter. Similar trend was observed for total chlorophyll content in the open field. CO (Cr-4) (2.56 mg/100g) recorded the highest total chlorophyll, followed by Arka Isha (2.28 mg/100g), CO-1 (1.44 mg/100g) and CO-2 (1.57 mg/100g) were on par, while CO-3 (2.05 mg/100g) was significantly different.

4.5.0 PESTS AND DISEASE INCIDENCE (%)

The variety CO-3 was the only variety susceptible for aphid attack irrespective of seasons. Among the seasons, the CO-3 sown in October-December and January-February were susceptible aphid attack (30% and 50%, respectively). Also, the variety CO-3 in the rain shelter showed more aphid attack (30%) compared to that of open field (20 %) as shown in Table 20. Aphid attack on coriander is depicted in Plate 11.

Table 19. Effect of growing conditions on Chlorophyll content contents in leaves at harvest (mg)

Varieties	Chlorophyll a (mg/100g)			Chlorophyll b (mg/100g)			Total chlorophyll (mg/100g)		
	Rain shelter	Open field	Mean	Rain shelter	Open field	Mean	Rain shelter	Open Field	Mean
CO-1	1.33	1.03	1.18	0.59	0.40	0.50	1.92	1.44	1.68
CO-2	1.08	1.19	1.14	0.45	0.37	0.41	1.53	1.57	1.55
CO-3	1.37	1.53	1.45	0.54	0.52	0.53	1.91	2.05	1.98
CO(Cr-4)	1.51	1.24	1.38	0.58	0.46	0.52	2.10	2.56	2.33
Arka Isha	1.56	1.67	1.62	0.86	0.60	0.73	2.16	2.28	2.22
Mean	1.37	1.33		0.6	0.47		1.92	1.98	
CD(0.05)	0.16	0.30		0.08	0.03		0.23	0.18	
				CD (0.05)					
Growing conditions	NS			0.02			NS		
Varieties	0.08			0.04			0.10		
Interaction	0.11			0.05			0.15		

Table 20. Aphid attack in different time of sowing (seasons) and growing conditions

Varieties	Aphid incidence (%)					
	S1	**S2**	**S3**	**S4**	Rain shelter	Open field
CO-1	0	0	0	0	0	0
CO-2	0	0	0	0	0	0
CO-3	0	0	30	50	30%	20%
CO(Cr-4)	0	0	0	0	0	0
Arka Isha	0	0	0	0	0	0

Plate 11. Aphid incidence

4.6.0. CORRELATION STUDIES

The results of correlation of growth and yield parameters coriander are given in Table. 21.

The herbage yield showed a highly significant and positive correlation with number of leaves (0.744**), biomass yield (0.969**) and days to leaf serration (0.333**). Also showed positive association with plant height (0.172). Number of leaves showed positively significant correlation with biomass yield (0.711**), positive correlation with plant height (0.091) and days to leaf serration (0.099). Biomass yield is positively correlated with plant height (0.173) and significantly positively correlated with days to leaf serration (0.332**). However, plant height was significantly and negatively correlated with days to leaf serration (0.316**).

Table. 21. Correlation of growth and yield parameters of coriander

	Herbage Yield	Number of Leaves	Biomass yield	Plant height	Days to leaf Serration
Herbage yield	1				
Number of Leaves	0.744**	1			
Biomass yield	0.969**	0.711**	1		
Plant height	0.172	0.091	0.173	1	
Days to leaf Serration	0.333**	0.099	0.332**	-0.316**	1

***Correlation is significant at the 0.05 level**

**** Correlation is significant at the 0.01 level**

Discussion

5. DISCUSSION

In Kerala, there is high demand for coriander leaves throughout the year. Even though, scattered cultivation of coriander as herbal spice has been started in Wayanad and Idukki districts, domestic demand for coriander leaves is met from neighboring states of Karnataka and Tamil Nadu. Growth, herbage yield and quality in coriander are influenced by time of sowing (seasons) and growing conditions. Coriander is a tropical crop and can be grown throughout the year (except very hot season) for leaf purpose, but for higher grain yield, it has to be grown in specific season. Therefore, the present investigation entitled "Performance evaluation of leaf coriander (*Coriandrum sativum* L.) types in the plains of Kerala," was undertaken to study the growth and performance of coriander as leaf spice in rain shelter in four times of sowing(seasons) and also to evaluate the performance under different growing conditions viz. open field and rain shelter at the Department of Plantation Crops and Spices, College of Horticulture, Vellanikkara. The data was statistically analyzed to find out the effect of varieties, time of sowing (seasons) and growing conditions on growth, herbage yield and quality of coriander. The results of the study on the effect of time of sowing, effect of varieties and growing conditions on growth, yield and quality parameters of coriander are discussed hereunder.

5.1.0. EFFECT OF VARIETIES AND TIME OF SOWING (SEASONS) ON GROWTH, HERBAGE YIELD AND QUALITY OF CORIANDER

5.1.1: Days to seed germination and leaf emergence

The study revealed that all the varieties had variation with regard to the growth and yield parameters. The sowing of coriander in varying dates creates a changing microclimate condition during the entire period of its growth and development (Guha *et al.,* 2014). Among the varieties, the variety CO (Cr-4) required lowest number of days for seed germination, first leaf, second leaf and third leaf emergence and Arka Isha recorded the highest number of days for these parameters in all the sowing times. The variety CO-1 took minimum number of days to germinate in January-March sowing, and the varieties CO-2, CO-3 and CO (Cr-4) in July-September sowing. However, Arka Isha took significantly lowest number of days to germinate in April-June sowing compared to all other seasons (Fig.1). The seeds sown in April-June months recorded earliest germination compared to other seasons, whereas January-March crop recorded significantly higher number of days for seed germination.

The variety CO (Cr-4) recorded earliest first leaf emergence in April-June sowing and January-March sowing whereas, earliest second and third leaf emergence were observed in October-December sowing. The varieties CO-1 and CO-2 showed earliest second leaf emergence in October-December sowing, CO-3 in July-September and Arka Isha in January-March. With respect to the days to first leaf emergence, no significant difference was observed among the different sowing times.

However, the second and third leaf emergence was the earliest in October to December crop and delayed in January-March crop. This difference may be due to the difference in the microclimate inside rain shelter and genetic character of these varieties. Similar results were obtained by Guha *et al.,* (2013) while conducting research on the time of sowing and its influence on seedling emergence wherein, they recorded that summer months are not ideal for early germination of coriander. It might be due to high temperature and other climatic factors not suitable to speed up coriander seeds to germinate. Similar reports were also recorded by Sarada *et al.,* (2011) and Moniruzzaman *et al.,* (2013) in coriander and Lataye *et al.,*(2016) in fenugreek.

5.1.2. Number of leaves

The number of leaves recorded a highly significant and positive correlation with the herbage yield of coriander. Generally, July-September sowing exhibited highest number of leaves at 30 DAS and also at the time of leaf harvest. However, the lowest number of leaves were observed in January-March crop. This might be

111

because of the high temperature during January-March compared to all other sowing times. At 30 DAS, the variety CO (Cr-4) recorded highest number of leaves during April-June, July-September and January-March. Whereas, Arka Isha had highest number of leaves during October-December. However, at harvest also highest number of leaves were produced by the variety CO (Cr-4)(18.88) in July- September followed by Arka Isha (18.33) (Fig.2). The mean values for all the seasons were recorded highest for Arka Isha (16.30) followed by CO-(Cr-4) (15.69). Similar reports were also recorded by Arif (2014) in which he recorded that the number of leaves in coriander ranged from 7.93 to 22.19 at various stages of plant growth.

5.1.3. Herbage and biomass yield

With respect to the mean herbage and biomass yield, the variety Arka Isha showed superiority irrespective of the sowing times. This might be due to the fact that Arka Isha is a superior genotype suited for high herbage yield as reported by Varalakshmi *et al.,* (2012). For both the parameters, July-September crop was considerably superior followed by October-December crop. The greater leaf number on July-September crop might have helped in the production of more metabolites and consequently accumulation of total solids, which ultimately resulted in the production of higher green leaf yield. Also, it was observed that herbage yield exhibited a highly significant and positive correlation with number of leaves.

The lowest yield was recorded in January-March crop. This might be due to poor growth of the crop due to high temperature (Appendix I). Green leaf production of coriander is affected by extreme weather especially high temperature. It causes bolting which results in less number of cuttings and ultimately lesser green yields. Higher foliage yield in winter months and lower yield in summer months was an important finding from a recent study of Moniruzzaman *et al.*, (2013).

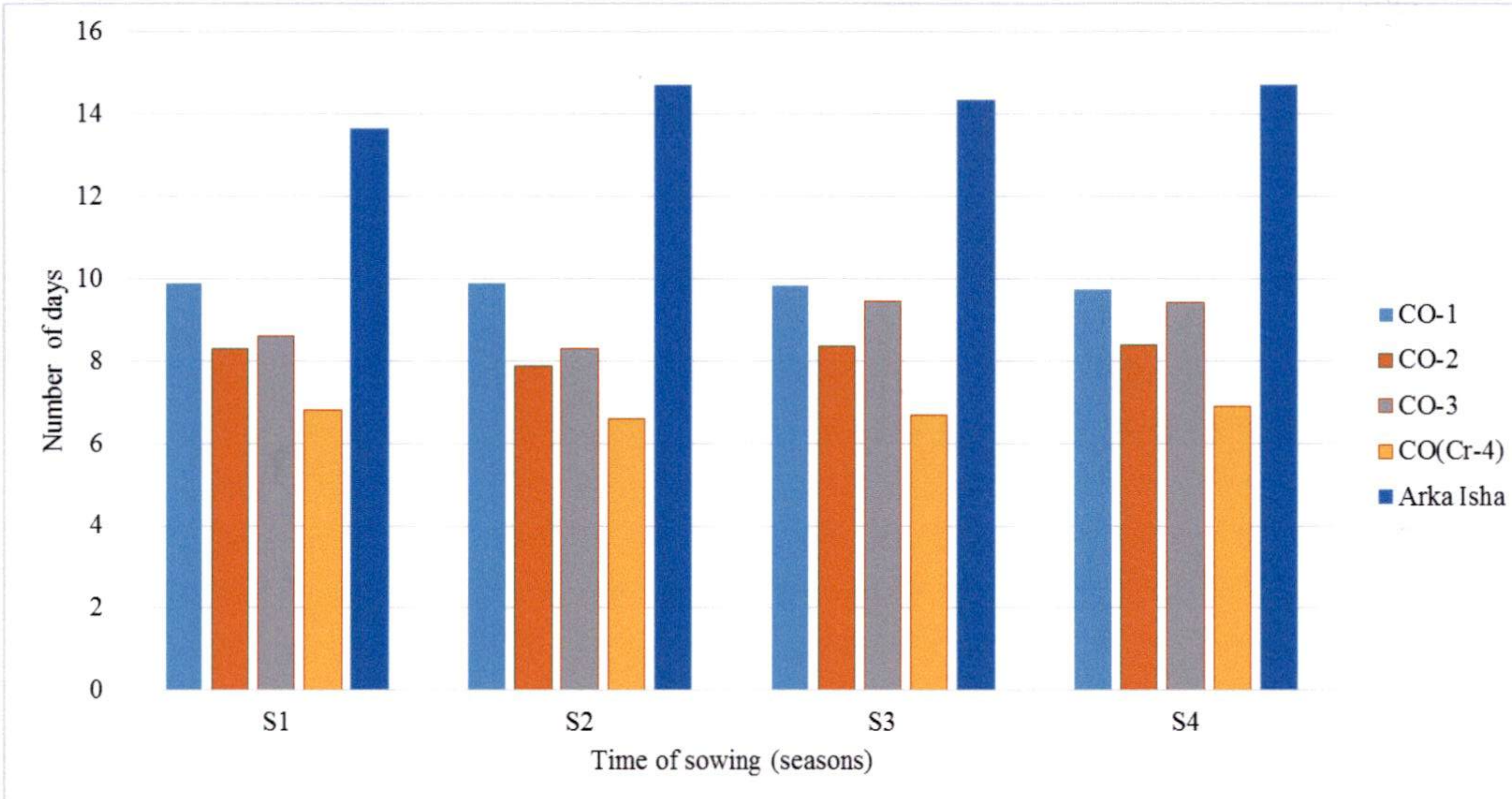


Fig. 1. Effect of time of sowing (seasons) on days to seed germination

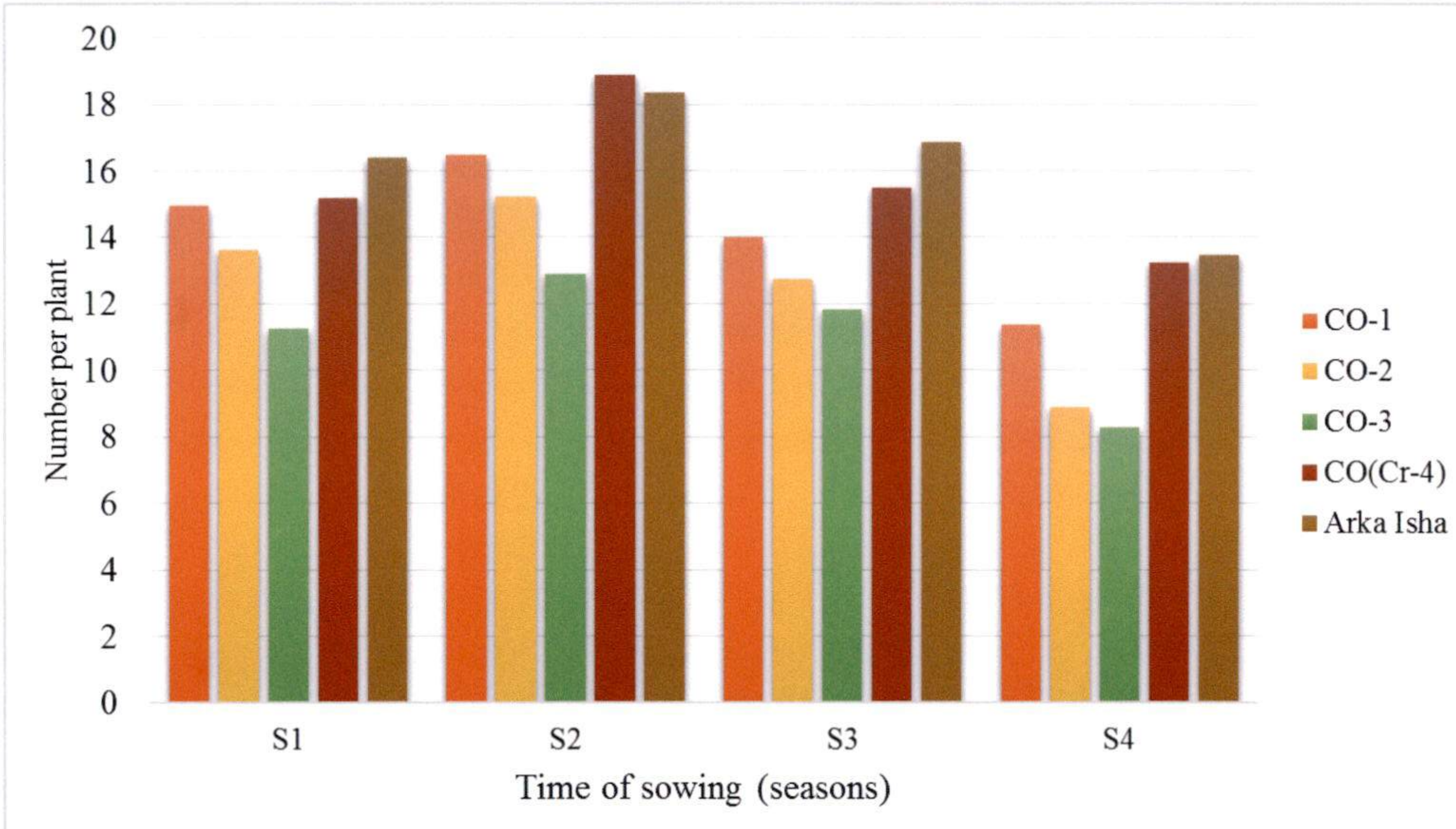


Fig. 2. Effect of time of sowing (seasons) on number of leaves at harvest

The variety CO-3 recorded lowest herbage yield in April- June sowing (6.87 g/plant) and January-March sowing (3.31 g/plant), CO-2 in July-September sowing (9.66 g/plant), and CO-(Cr-4) in October-December sowing (8.10 g/plant) as shown in Fig.3. However, the lowest biomass yield was recorded in CO-3 during April-June crop (9.76 g/plant) and July-September crop (12.60 g/plant), CO (Cr-4) in October-December crop (11.86 g/plant) and Arka Isha during January-March crop (5.85 g/plant). Similar studies were reported by Velayudham (2006), Meena and Malhotra (2006), Salvarajan (2010), Rajaraman *et al.,*(2011), Agarwal *et al.,* (2013) and Devi (2016) in coriander and Lataye *et al.,* (2016) in fenugreek during *rabi* season.

5.1.4. Plant height

With respect to the plant height, it was observed that the growth performance of the varieties varied significantly at various growing stages. At 30 DAS, all the varieties except Arka Isha showed more plant height in all the sowing times. The varieties CO-1 and CO-2 were the highest in January-March crop (11.80 cm and 12.15 cm) and lowest in July-December crop (10.23 cm and 11.53 cm). At the same time, CO-3 was highest in October- December sowing and lowest in January-March crop. But CO (Cr-4) was highest in April-June crop (11.91) and lowest in January-March crop (11.37 cm). However, Arka Isha was significantly highest in April- June sowing (8.78 cm) and lowest in January-March crop (7.51 cm) which was at par with other growing times.

At 45 DAS, all the varieties showed increased plant height during April- June crop and lowest in January-March crop. This might be because of insufficient vegetative growth, wherein the plants immediately respond to photoperiod, ultimately reduced plant height as reported by Mirshekari *et al.,* (2011) and Guha *et al.,*(2016a).

At 60 DAS, highest plant height was noted for CO-1 in April-June crop (28.10), July-September (26.75 cm) and January- March crop (26.70 cm) and the variety Arka Isha during October-December crop (28.05 cm). For CO (Cr-4), highest plant height was observed during April-June crop (25.50 cm) followed by October-December crop (25.28 cm).

The results are in line with the findings of Arif (2014) in which he recorded that the plant heights of coriander varieties of TNAU ranged between 20.45 cm to 25.00 cm. However, Arka Isha which showed slow growth during initial growth stages, showed highest plant height at 60 DAS during October-December crop (28.05) followed by July-September crop (27.20 cm) as showed in Fig.4. It was observed that plant height had positive correlation with number of leaves, herbage yield and biomass yield and negative correlation with days to leaf serration. According to Guha *et al.,*(2013), better vegetative growth of coriander was observed in October sown crop due to more favorable temperature during its growth period.

The difference in plant heights at different sowing dates of coriander were also reported by Shridhar *et al.,*(1990) in which they recorded the plant heights within the range of 30.40cm to 46.20 cm during *kharif* and *rabi* seasons. Similar reports were also recorded by Rajaraman *et al.,* (2011), Unlukara *et al.,* (2016).

5.1.5. Number of branches

The primary branches were higher in CO-3 (3.63) during April-June crop. However, CO (Cr-4) exhibited highest number of primary branches in all other growing times. With respect to the number of secondary branches, the variety CO (Cr-4) recorded highest number during April-June crop, July-September crop and January- March crop. The increased vegetative growth might be due to favourable climatic and soil conditions, which have resulted in more nutrient absorption might be the reason for more number of branches in the July-September crop.

These results are in conformity with the results of Venkatareddy (1986), Easwarareddy *et al.,*(1988), Shridhar *et al.,* (1990), Rajput and Singh (2003), Velayudham (2006), Arif (2012) and Arif *et al.,* (2014).

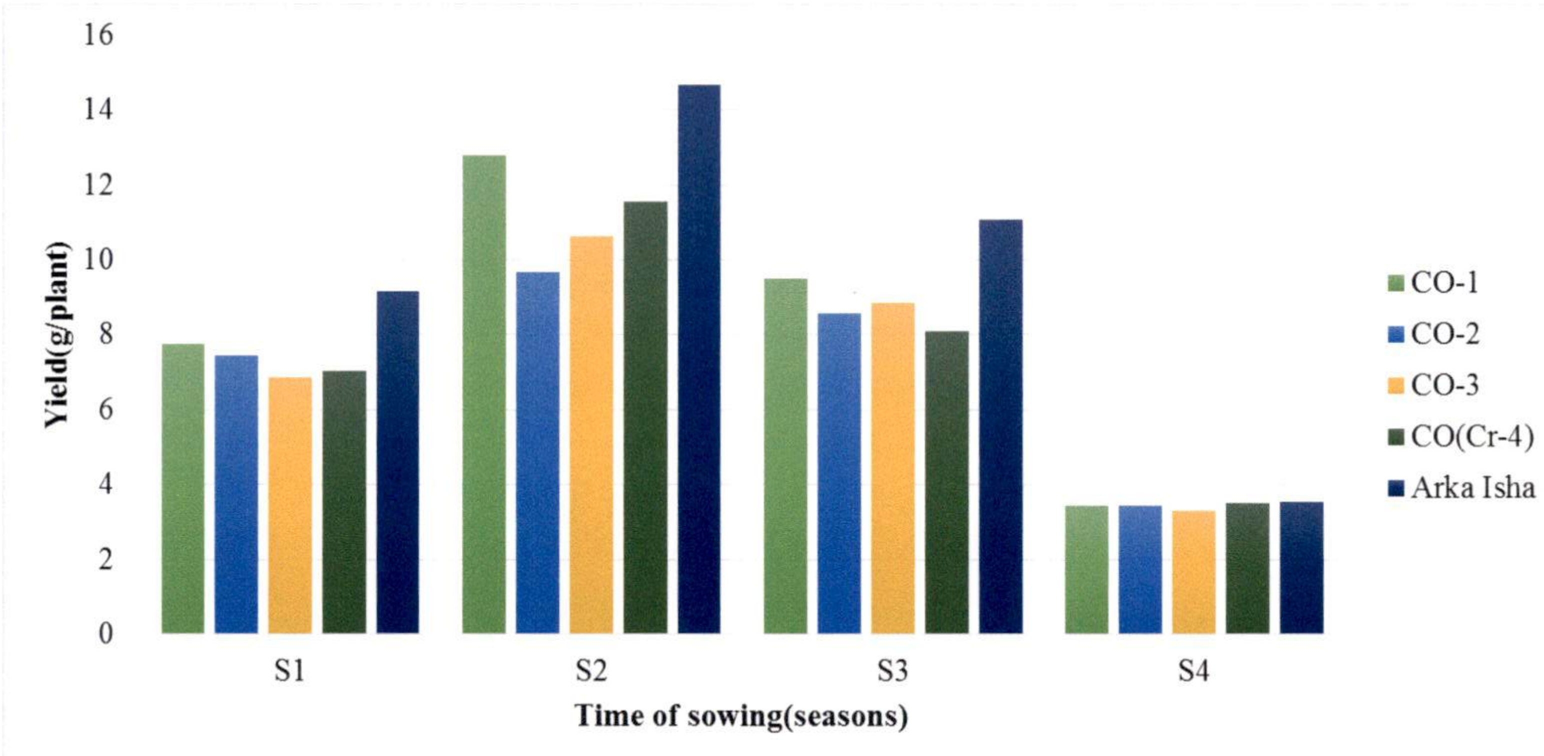


Fig. 3. Effect of time of sowing (seasons) on herbage yield

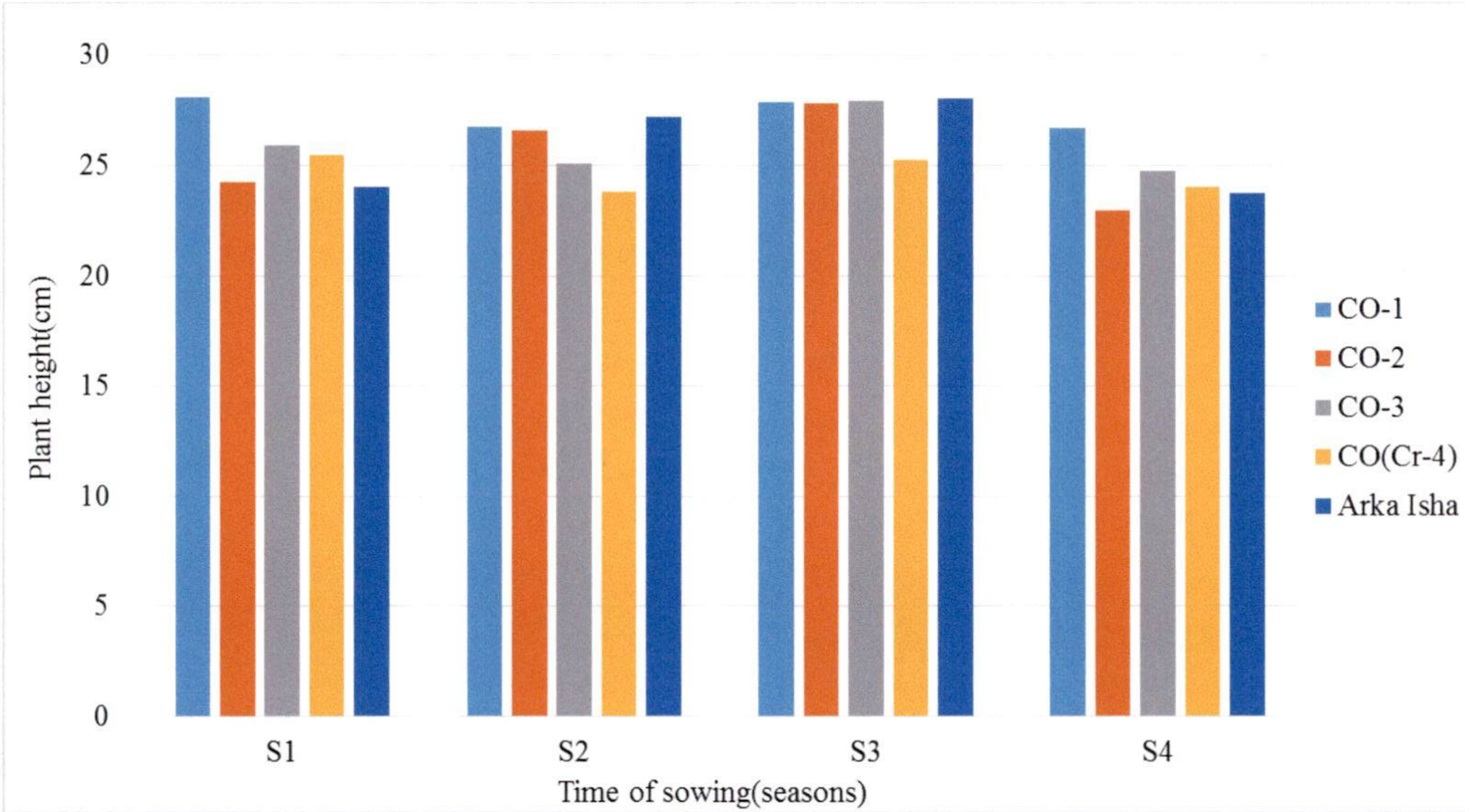


Fig. 4 Effect of time of sowing (seasons) in plant height at 60 DAS

5.1.6. Days to leaf serration, flowering and fruit set

The days to serration of leaves is an indication of flowering. The more is the number of days to serration of leaves, the more will be the vegetative growth of the plant and herbage yield. The days to leaf serration had a highly significant and positive correlation with herbage and biomass yield. The variety CO (Cr-4) was the earliest to show serration of leaves in all the seasons (37.43 days), flowering (40.19 days) and seed set (47.69 days). However, the variety Arka Isha showed delay in serration of leaves (49.29 days), flowering (54.05 days), and seed set (63.27 days). Varalakshmi *et al.*, (2012) and Devi (2016) also reported the late flowering nature of Arka Isha.

During April-June crop, CO-1 exhibited delayed leaf serration (42.73 days) compared to CO-3 (41.85 days) and CO-2 (42.05 days). However, during July-September crop the variety CO-3 showed more days for leaf serration (48.25 days) compared to CO-1 (45.00 days) and CO-2 (44.33 days). But during October-December sowing, CO-2 showed delayed leaf serration (45.53 days) compared to CO-1 (44.45 days) and CO-3 (44.15 days). And in January-March sowing, the variety CO-3 was the earliest (41.98 days) compared to CO-1 (43.05 days) and CO-2 (43.28 days) (Fig.5). The difference in days to leaf serration might be a varietal character. The July-September and October-December crops recorded comparatively higher number of days for serration of leaves. But January-March crops recorded early serration. Later sowing dates offers insufficient time for vegetative growth as the plants enter the reproductive phase at a faster rate as reported by Sharangi and Roychowdhury (2014).

The earliest flowering was recorded in CO (Cr-4) during January-March sowing (38.83 days). However, delayed flowering was recorded in Arka Isha during July-September crop (56.50 days). The mean number of days to flowering and seed set were higher for October-December crop followed by July-September. Lowest mean values for these parameters were observed in January-March crop. This might be due to the fact that the high temperature prevailed during these months leading to insufficient vegetative growth and early transformation into reproductive phase, in turn, early leaf serration, flowering and seed set (Appendix I). Similar studies were reported by Guha *et al.,* (2013) and Arif (2014).

5.1.7. Volatile oil

Generally, coriander leaves possess comparatively less oil content than seeds. No significant effect was observed for different varieties with respect to volatile oil (%). The volatile oil content did not show significant variation among different time of sowing. The essential oil content may be the cumulative resultant of a number of internal cellular factors and it's a varietal character. The essential oil content among the varieties ranged from 0.04 per cent to 0.06 per cent only (Fig. 6). Varalakshmi *et al.*, (2012) reported that the variety Arka Isha yielded an essential oil content of 0.083 per cent. The variation among the varieties for the synthesis of volatile oil might be due to some promotive or inhibiting mechanism through some biochemical reactions (Palanikumar and Rajamani, 2012a). Similar variation in volatile oil was also earlier reported by Bhuiyan *et al.,* (2009), Nadeem *et al.*, (2013), Rajaraman *et al.*, (2011), Ghobadi and Ghobadi (2012) and Guha *et al.*(2016b).

5.1.8. Vitamin C content

The mean value for vitamin C content ranged from 69.83 mg/100g (CO (Cr-4) to 158.98 mg/100g (Arka Isha). During April-June crop, the highest vitamin C was recorded in CO-1 (228.77 mg/100g), Arka Isha during July-September crop and January-March crop, CO-3 during October-December crops. April to June crop reported significantly highest vitamin C compared to other seasons and the lowest in January to March crop (Fig.7). The variation in vitamin C content might be a varietal character as reported by Girenko (1982) and Varalakshmi *et al.,* (2012).

5.1.9. Chlorophyll content

The varieties differed significantly for mean chlorophyll 'a', 'b' and total chlorophyll content. The variation of chlorophyll content in coriander genotypes might be due to change in light intensity and other microclimate during various sowing times and it's a varietal character. Generally, Arka Isha showed superiority for mean chlorophyll content. The total chlorophyll content was significantly higher in July-September crop followed by January-March crop (Fig.8). Similar results were reported by Rajaraman *et al.*, (2011), Palanikumar and Rajamani (2012b), Varalakshmi *et al.,* (2012) in coriander, Agarwal *et al.,* (2013) in fenugreek and Tsamaidi *et al,,* (2017) in dill.

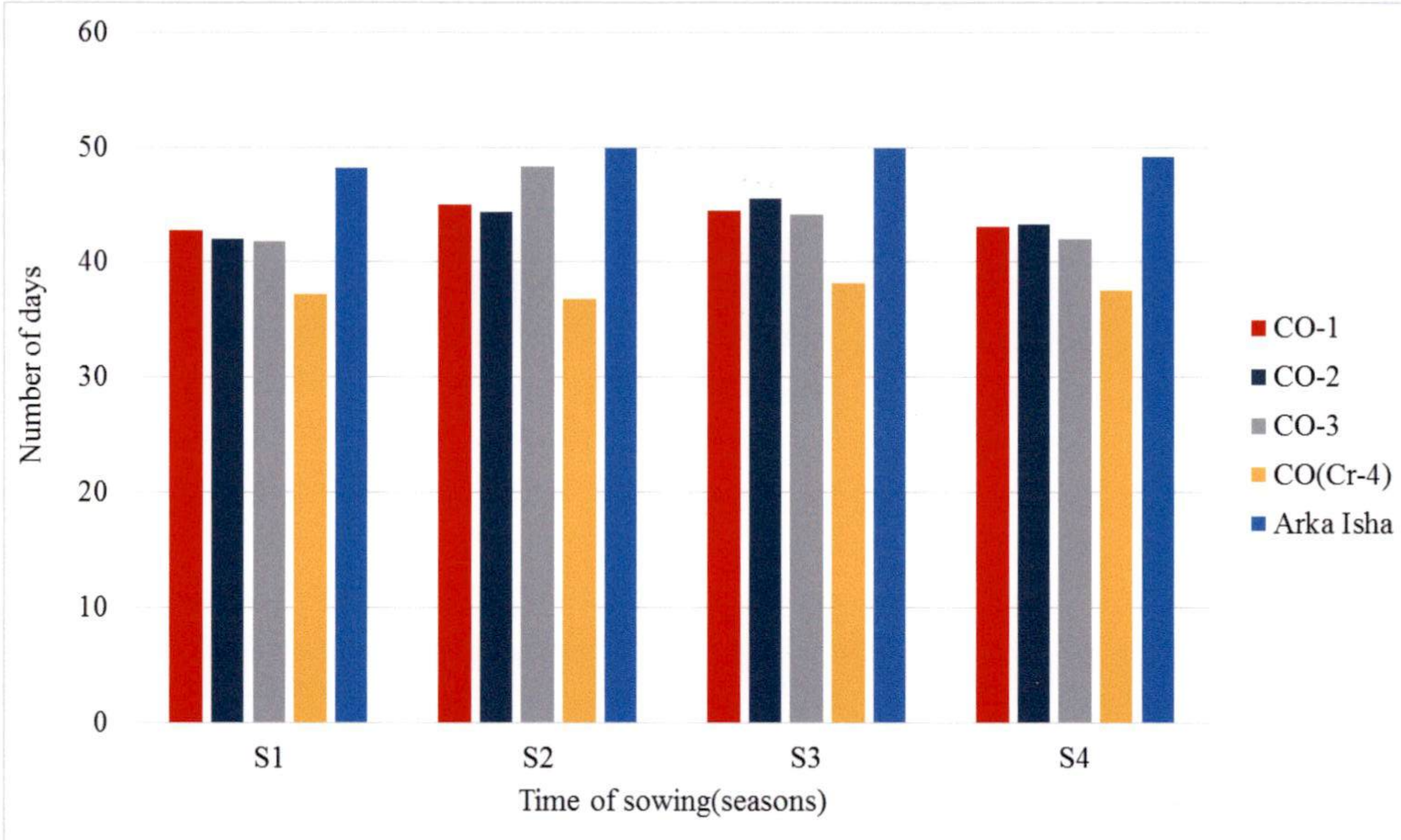


Fig. 5. Effect of time of sowing (seasons) on days to serration of leave

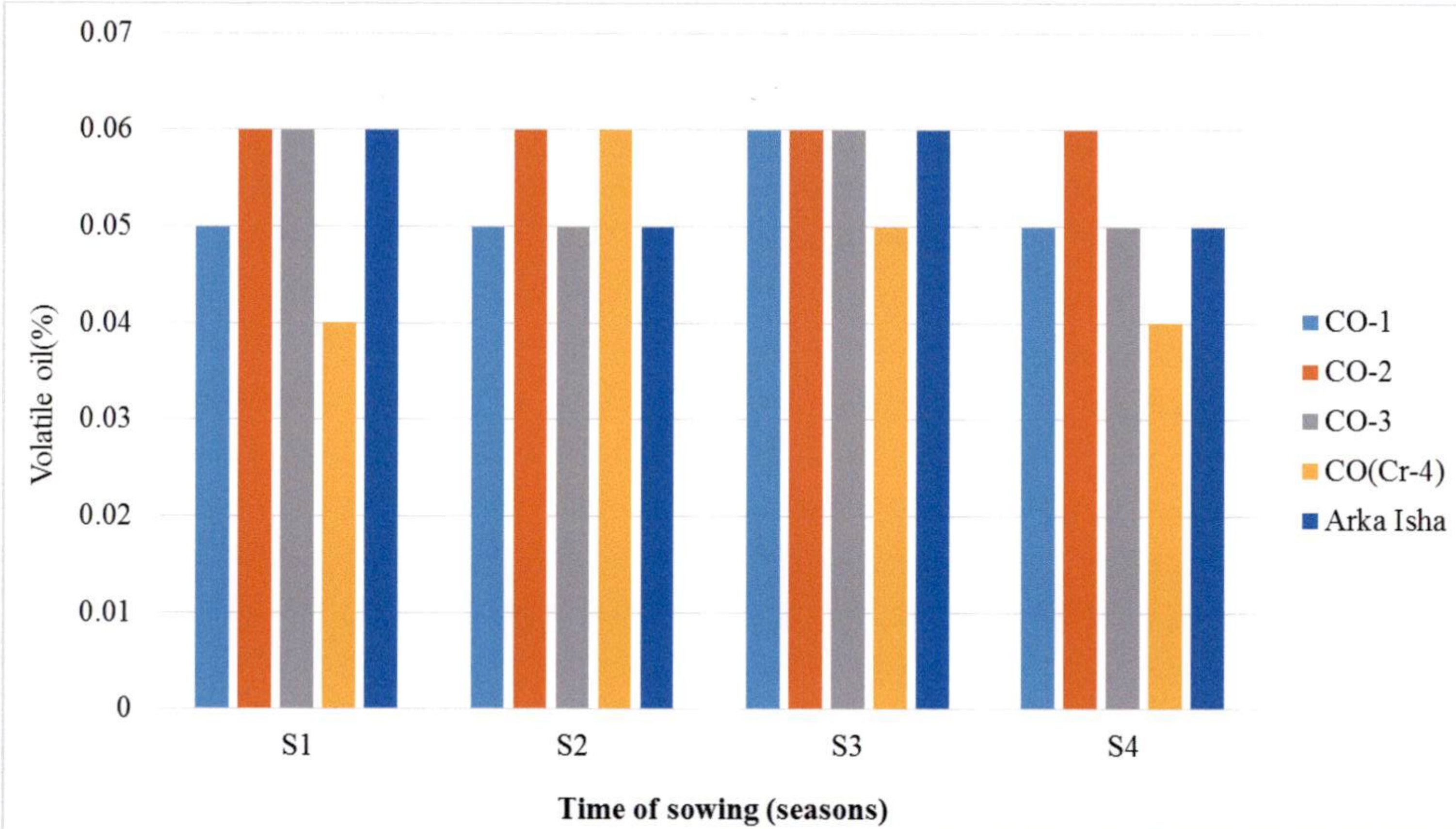


Fig. 6. Effect of time of sowing (seasons) on volatile oil (%)

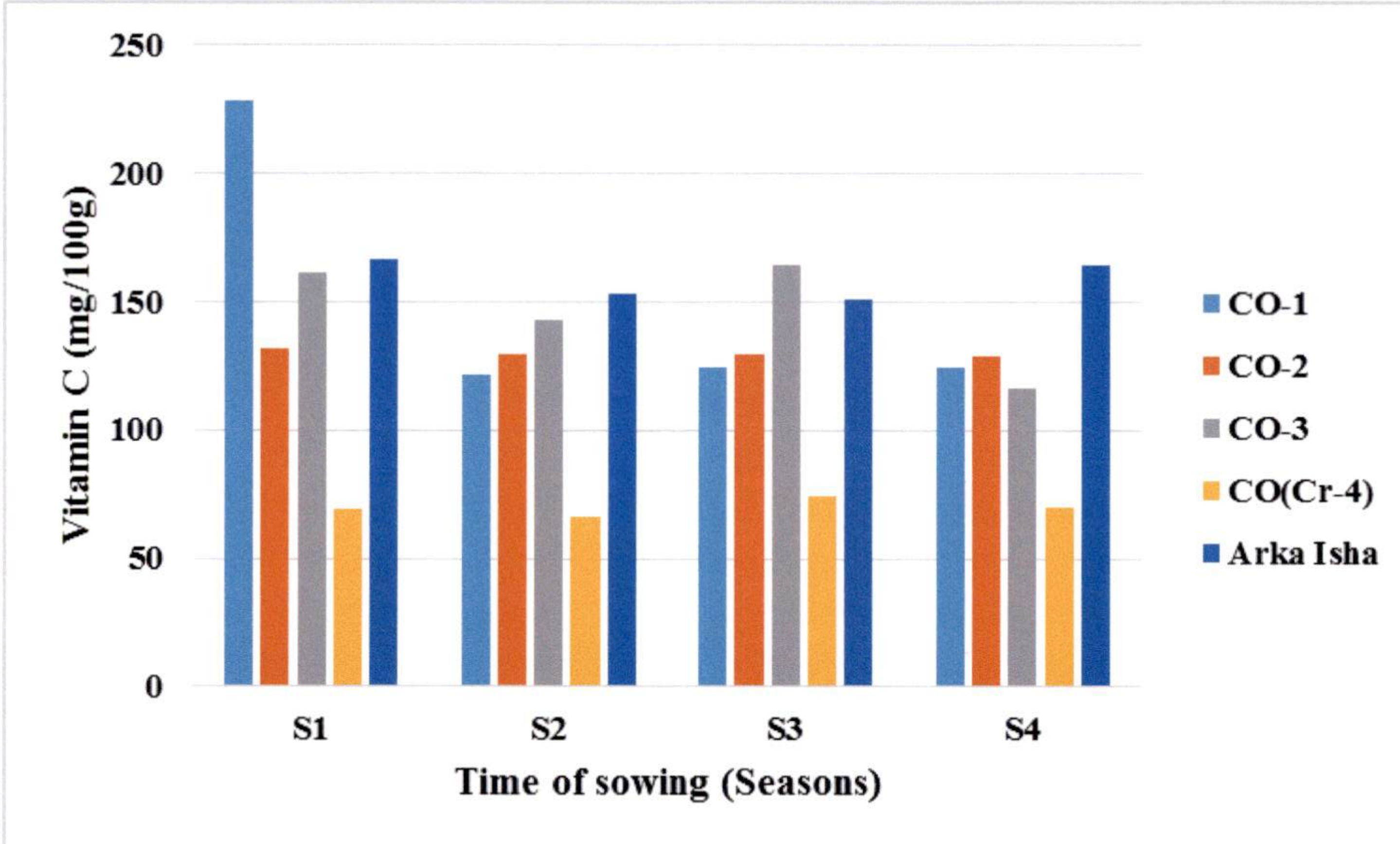


Fig. 7. Effect of time of sowing (seasons) on vitamin C content

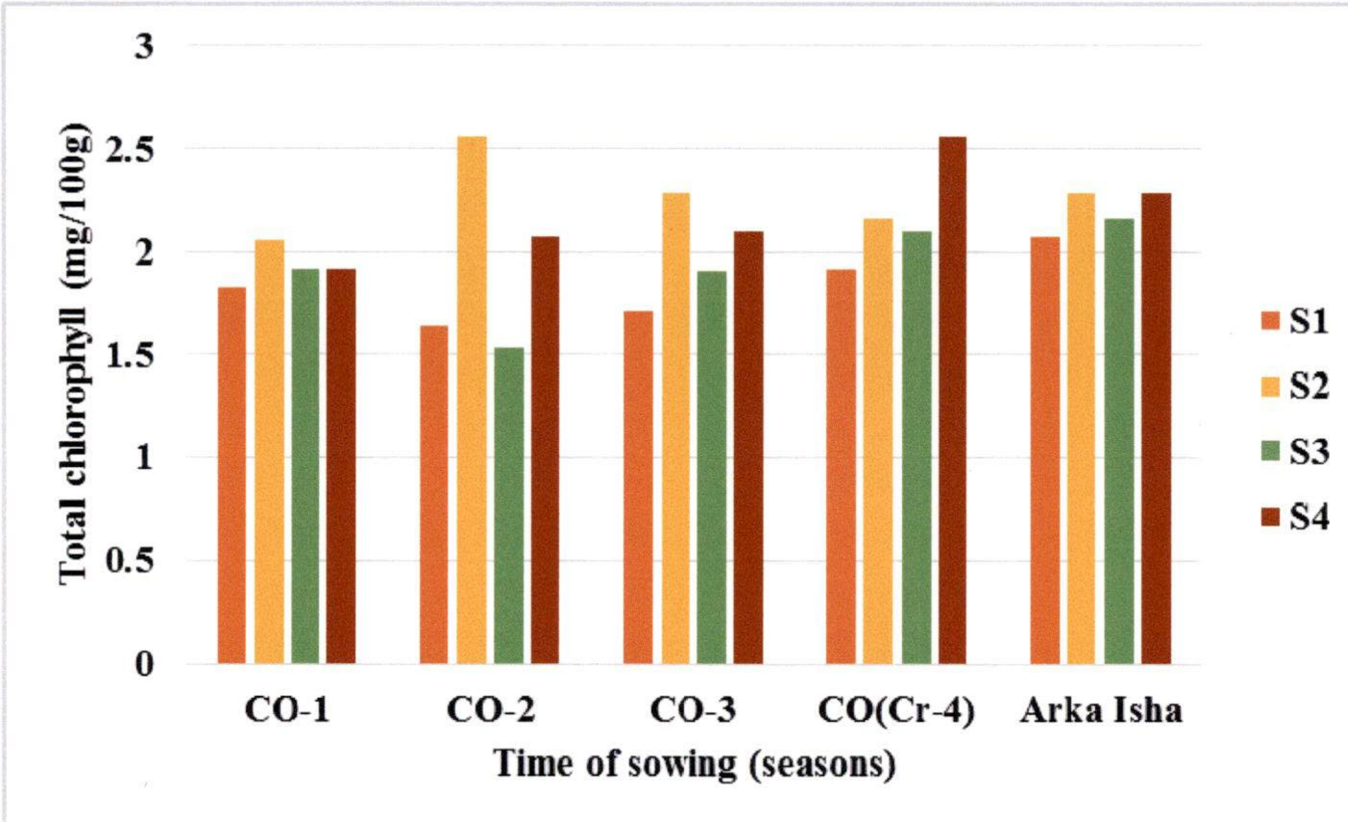


Fig. 8. Effect of time of sowing (seasons) on total chlorophyll content

5.2.0. EFFECT OF GROWING CONDITIONS ON GROWTH, HERBAGE YIELD AND QUALITY OF CORIANDER

5.2.1. Days to seed germination and leaf emergence

The mean number of days required for seed germination, first, second and third emergence were differed significantly between the growing conditions, in which the crops in the open field was earlier for these parameters compared to rain shelter. This might be due to higher temperature and less relative humidity in the rain shelter than in the open field. The early germination of fenugreek seeds in the open field compared to naturally ventilated polyhouse was earlier reported by Karetha *et al.,*(2014).

Both in the rain shelter and open field, CO (Cr-4) was the earliest and Arka Isha showed delayed behaviour for all these parameters. The variation in seed germination might be due to the inherent characters of the individual cultivars. The days taken for seed germination by the varieties in both the growing conditions is shown in Fig.9.

5.2.2. Number of leaves, herbage and biomass yield

Significantly higher number of leaves, herbage and biomass yield were recorded in the rain shelter compared to the open field. In both the growing conditions, highest number of leaves were recorded in Arka Isha followed by CO (Cr-4) and CO-1 (Fig.10). But lowest number in CO-3 under both conditions. The highest herbage (Fig. 11) and biomass yield was recorded by Arka Isha in both the growing conditions.

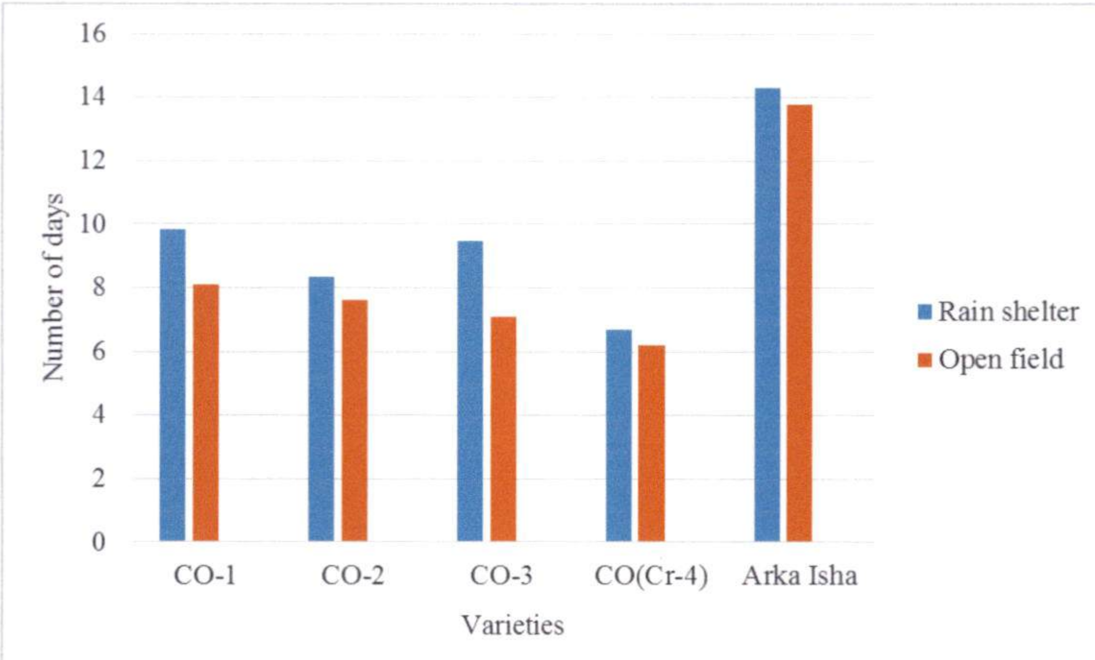


Fig. 9. Effect of growing conditions on days to seed germination

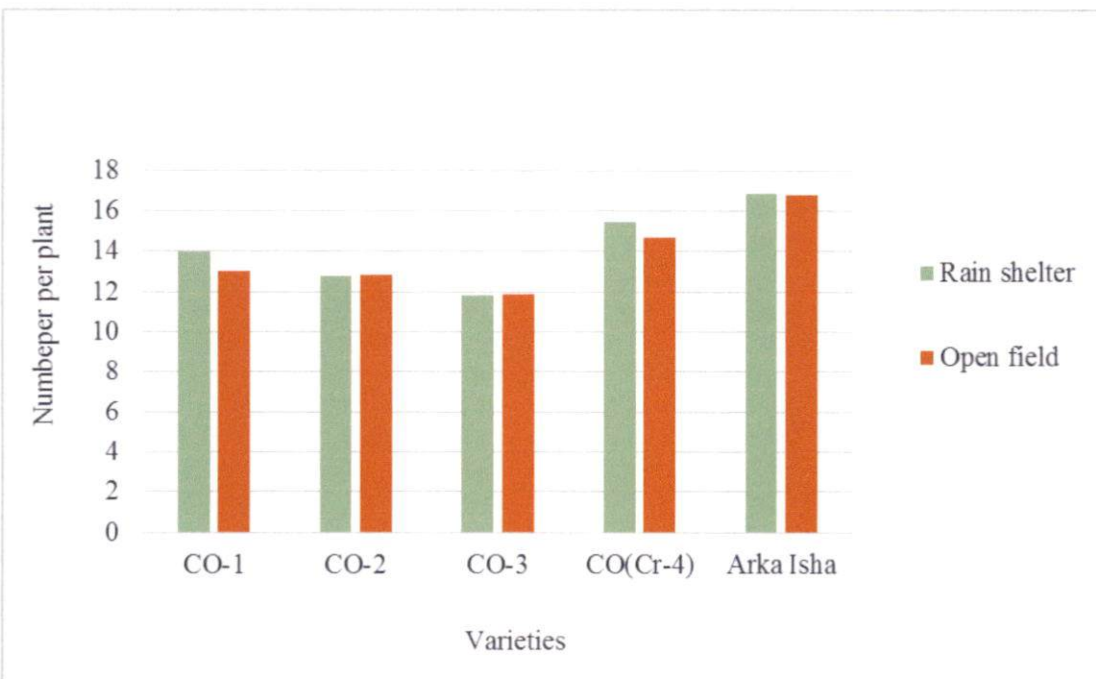


Fig. 10. Effect of growing conditions on number of leaves at harvest

The lowest in CO (Cr-4). An optimum light availability which favored greater photosynthesis and more photosynthate production in the rain shelter as compared to open field might be the reason for high herbage and biomass yield (Augustine, 2016).

5.2.3. Plant height

The varieties showed variation with respect to plant height at various growth stages. At 30 DAS, the variety CO-3 showed highest plant height in both growing conditions. Whereas, at 45 DAS, it was highest for CO (Cr-4). However, highest plant height at 60 DAS was recorded in Arka Isha in both the growing conditions. At 30 and 45 DAS, lowest plant height was recorded in Arka Isha, but at 60 DAS the variety CO (Cr-4) recorded lowest plant height (Fig.12).

At different growing stages, plant height was significantly higher in rain shelter than in open field. This might be due to the shading effect in rain shelter compared to open field. Auxin concentration might have increased under shade condition and resulted in increased plant height because of apical dominance.

According to Mukherjee (1992), the plants grown under protected conditions exhibited better growth and plant height. This might be due to higher concentration of carbon dioxide and optimum light availability, in turn greater photosynthesis and more photosynthate production as compared to open field condition. These findings were in agreement with that of Dixit (2007), Varalakshmi *et al.,* (2012), Rajasekhar *et al.,* (2013) and Karetha *et al.,* (2014).

5.2.4. Number of branches

In general, growing conditions had no significant influence on the number of primary branches. In the rain shelter, the highest number of primary branches per plant were recorded in CO-3 (3.62).

However, in the open field, the highest number was observed in CO-1 (3.79). In both the growing conditions, Arka Isha recorded lowest number of primary branches. However, the crops grown in rain shelter showed more primary branches than that in the open field. The increase in the number of primary branches in the rain shelter might be due to the enhanced rate of growth inside rain shelter.

5.2.5. Days to leaf serration, flowering and seed set

Earliness in serration of leaves is an indication of early transformation to reproductive phase in coriander. Irrespective of growing conditions, the variety CO (Cr-4) was the earliest in this parameter and Arka Isha was late among all the varieties. The crops in the open field showed early serration of leaves (Fig. 13), flowering and seed set compared to the crop in the rain shelter.

This might be due to the fact that the rain shelter might have offered optimum environmental conditions for the growth of coriander. Because of the congenial conditions inside the rain shelter, more carbohydrate reserve might have favoured extended period of vegetative growth, and in turn delayed flowering. The high temperature in open field might be the reason for early bolting of coriander. Similar results were reported by Shoba and Rajamani, (2009).

5.2.6 Volatile oil

The growing conditions and varieties did not affect significantly the volatile oil content (Fig.14). It ranged from 0.05 per cent- 0.06 per cent. The essential oil content might be the cumulative resultant of a number of internal cellular factors and it's a varietal character. Also, generally coriander herb possess lesser volatile oil content than in seeds. The results are in line with that of Varalakshmi *et al.,*(2012).

5.2.7. Vitamin C content

In both conditions, highest vitamin C was recorded in CO-3 with a mean value of 190.80 mg (Fig.15). But lowest in Arka Isha in rain shelter (106.00 mg/100g) and CO (Cr-4) in open field (103.25mg/100g).

In general, vitamin C content in leaves was observed significantly high in the open field compared to the rain shelter. There is a mechanism in plants, which converts sucrose, hexose, and other precursors into ascorbic acid. The precursor of ascorbic acid is produced by photosynthesise and, this is then converted to ascorbic acid within the plant. As photosynthetic ability is higher for plants grown in the open field compared to that inside the rain shelter, the vitamin C synthesis is also higher in the open field as reported by Shemon (2014).

5.2.8. Chlorophyll content

Similarly the total chlorophyll content differed in the rain shelter among the varieties. Arka Isha (2.16 mg/100g) recorded the highest total chlorophyll in rain shelter. However, CO (Cr-4) (2.56 mg/100g) recorded the highest total chlorophyll in the open field followed by Arka Isha (2.28 mg/100g) as shown in fig. 16. The total chlorophyll content was observed higher in open field compared to rain shelter.

According to Pandey *et al.* (2015), the increased chlorophyll content may be attributed to the differential synthesis and degradation of chlorophyll in the open field condition, whereas more photo-oxidation of chlorophyll and high chlorophyllase enzyme activity may be attributed to less chlorophyll content inside protected condition.

However, higher amount of chlorophyll 'b' was recorded in the rain shelter compared to the open field. The main function of chlorophyll 'b' is to gather light energy and transfer it to chlorophyll 'a'.

Under high light intensity, plants have a lesser amount of chlorophyll 'b' and a small light harvesting protein complex. Plants grown in the rain shelter (low light intensity) accumulate more chlorophyll 'b' and have a bigger light harvesting protein complex, leading to efficient capture of solar energy, and increased electron transport so as to improve photosynthetic ability as reported by Leong and Anderson (1984) and Biswal *et al.,* (2012).

Thus, it is clear that coriander can be grown for herbage yield in the plains of Kerala during July-September and October-December. However, seasonal variation on varietal performance may be further evaluated. Standardisation of package of practices for leaf coriander may be investigated.

131

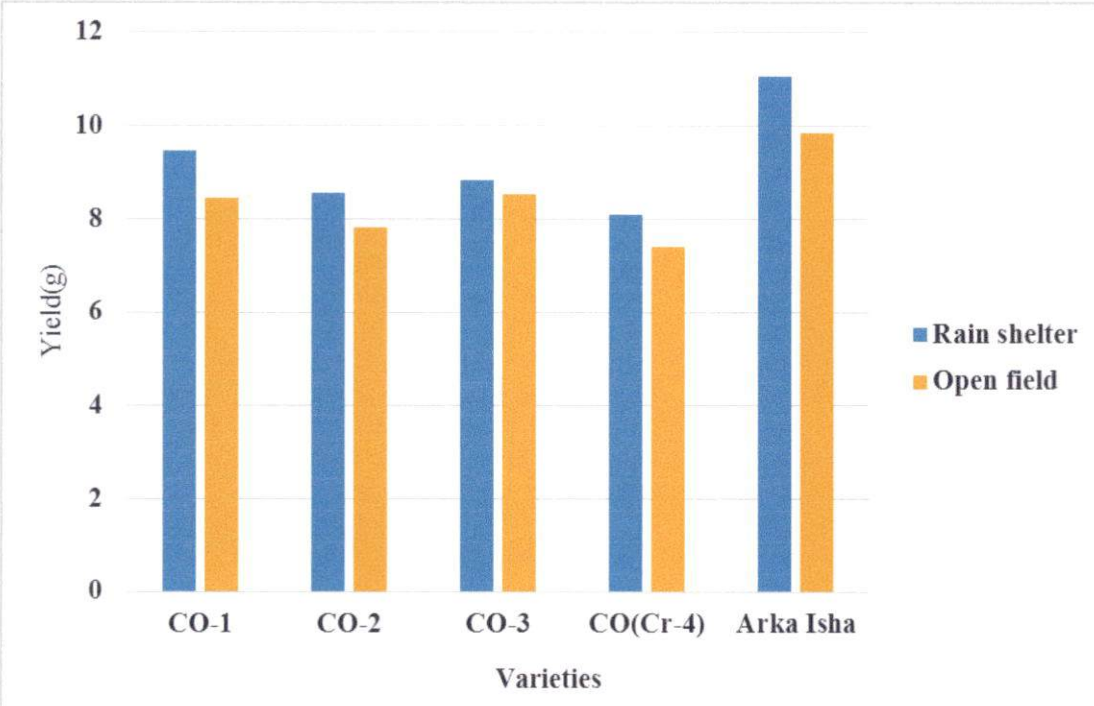


Fig. 11. Effect of growing conditions on herbage yield

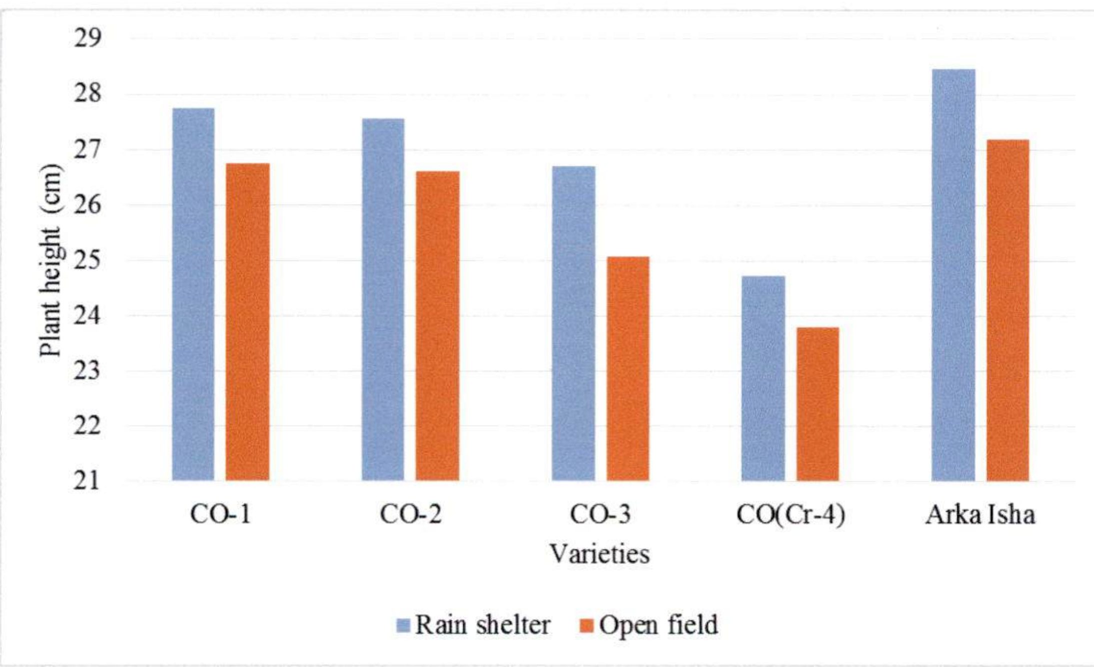


Fig. 12. Effect of growing conditions on plant height at 60 DAS

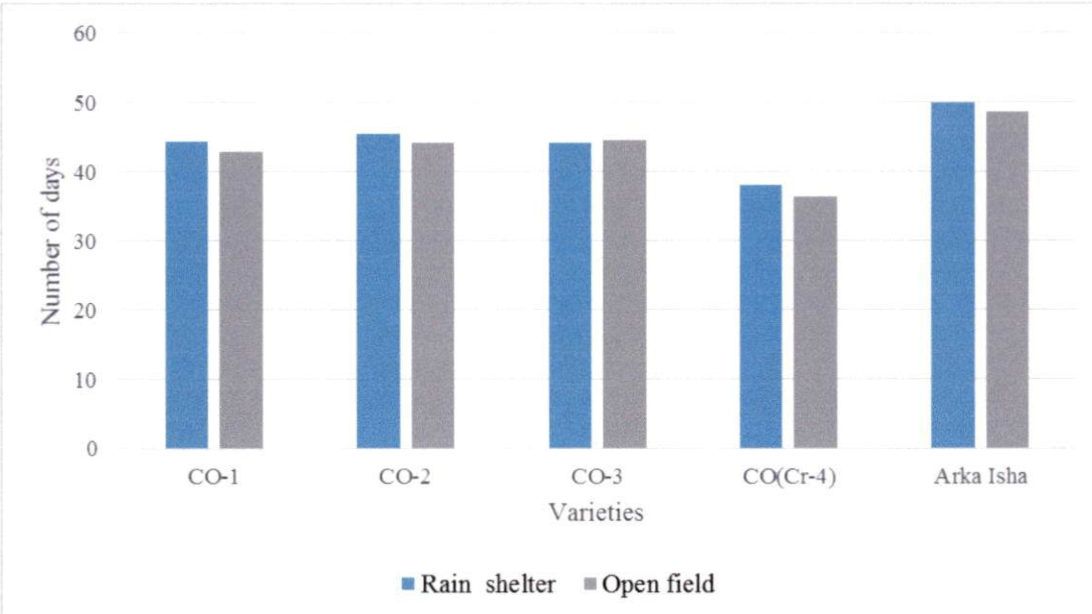


Fig. 13. Effect of growing conditions on leaf serration

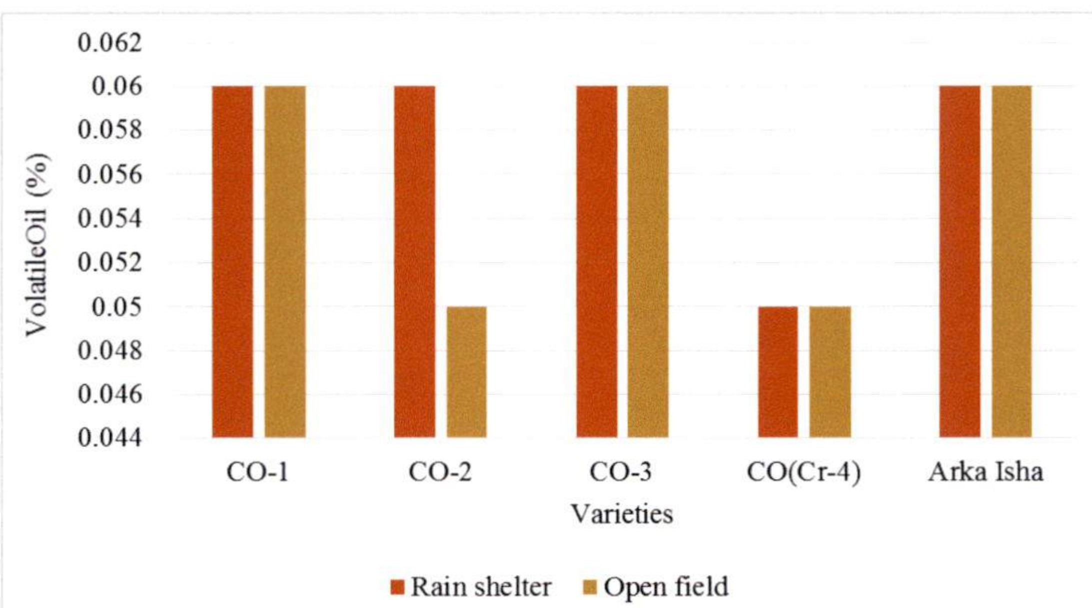


Fig. 14. Effect of growing conditions on volatile oil (%) content

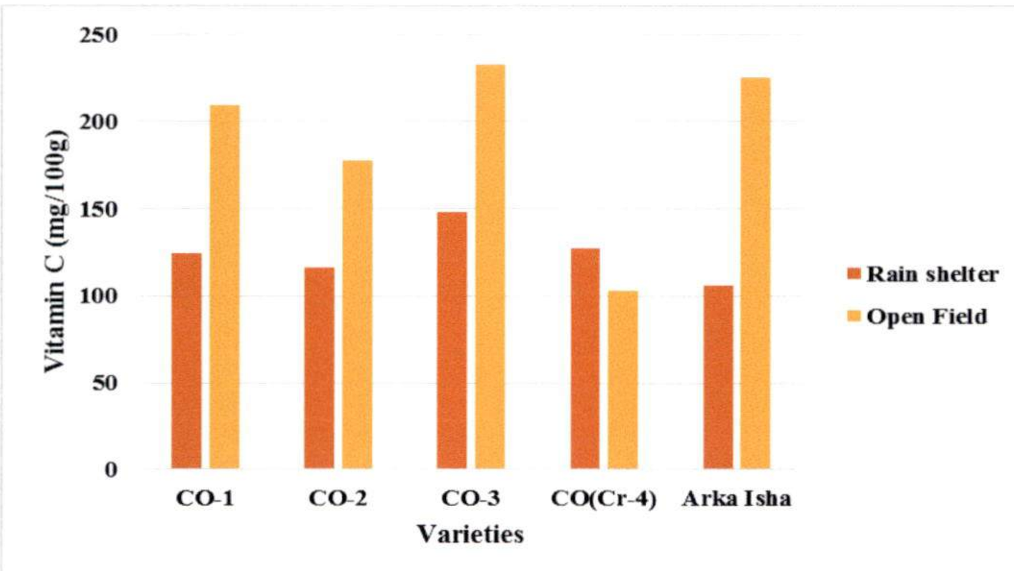


Fig. 15. Effect of growing conditions on Vitamin C (mg/100g) content

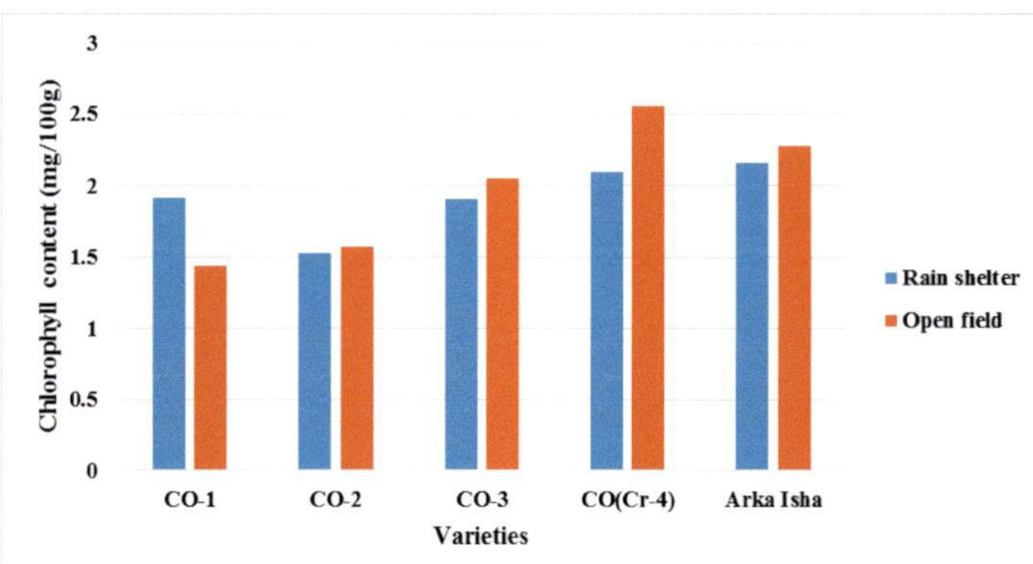


Fig. 16. Effect of growing conditions on Total chlorophyll content (mg/100g)

Summary

6. SUMMARY

An experiment entitled "Performance evaluation of leaf coriander (*Coriandrum sativum* L.) types in the plains of Kerala" was carried out at the Department of Plantation crops and Spices, College of Horticulture, Vellanikkara, Thrissur during the period from 2015 October to 2017 March. The research work consisted of two experiments viz., evaluation of coriander types in the rain shelter condition (during different time of sowing) and performance evaluation of coriander types in different growing conditions (rain shelter and open field during *rabi* season.) The objective of the study was to evaluate the growth and performance of coriander types for herbage yield and quality in different time of sowing and different growing conditions. Five genotypes of coriander namely CO-1, CO-2, CO-3, CO (Cr-4) and Arka Isha were used in the study. The salient findings from the study are summarized hereunder.

- Irrespective of different time of sowing (season), the varieties CO (Cr-4) followed by CO-2, CO-3 and CO-1, recorded the lowest number of days to seed germination, first leaf, second leaf and third leaf emergence whereas, Arka Isha required more number of days for these parameters. The time of sowing showed significant difference with respect to the days to seed germination, second leaf and third leaf emergence, and exhibited no difference for days to first leaf emergence. The earliest seed germination was observed in April-June crop, first leaf and third emergence in June-September crop and second leaf emergence in October-December crop.
- The varieties CO (Cr-4), CO-2 and CO-3 showed early germination in July to September (S2), CO-1 in October-December (S3) and Arka Isha during April to June (S1).
- The variety CO (Cr-4) recorded the earliest first leaf emergence in April-June (S1) and January-March crop (S4) whereas, earliest second and third leaf

emergence in October-December crop (S3). The varieties CO-1 and CO-2 showed earliest second leaf emergence in October-December crop (S3), CO-3 in July-September (S2) and Arka Isha in January-March (S4) crop.

- Plant height at various growth stages showed significant difference among the varieties at different time of sowing (seasons). During April-June (S1) and January-March (S4), highest plant height at 60 DAS was observed in CO-1. In During July-September (S2) and October-December (S3), it was highest in Arka Isha.
- The varieties and time of sowing had significant influence on number of leaves. The varieties in July-September (S2) were superior with respect to the number of leaves at 30 DAS and at harvest. On an average, the variety Arka Isha exhibited higher number of leaves followed by CO-(Cr-4). The variety CO (Cr-4) recorded highest number of leaves at harvest during April-June (S1) and July-September (S2). During October-December (S3) and January-March (S4), Arka Isha showed highest number of leaves at harvest.
- Irrespective of seasons, the herbage yield was highest in Arka Isha, followed by CO-1. Among the seasons, the crop in July-September (S2) had the highest herbage and biomass yield followed by October-December (S3). However, yield was significantly lowest in all the varieties during January-March (S4).
- In biomass yield also, the variety Arka Isha maintained its superiority in all the seasons except during January-March (S4) in which the highest biomass yield was recorded in CO-2, followed by CO-1.
- Generally, the number of primary and secondary branches were highest for the crops raised during July-September (S2) and was lowest in January-March (S4). But varietal difference was observed during all the growing seasons. The primary branches recorded highest in CO (Cr-4) during all sowing times except during April-June (S1), in which CO-3 recorded highest number of primary branches. The number of secondary branches were highest in CO (Cr-

4) during April-June (S1) and January-March (S4) and in CO-1 during July-September (S2) and October-December (S3).

- The delayed leaf serration was observed in July-September crop, delayed flowering and delayed seed set in October-December (S3). These characters were earliest during January-March (S4). Irrespective of seasons, the variety Arka Isha exhibited highest number of days for leaf serration, flowering and seed set, while CO (Cr-4) recorded the lowest days.
- The volatile oil content did not show much variation among the seasons and varieties. Only less volatile oil was observed for all the varieties in all the seasons. However, CO-2 recorded constant volatile oil content throughout different seasons.
- Vitamin C content was highest in CO-1 during April-June (S1), Arka Isha during July-September (S2) and January-March (S4), CO-3 during October-December (S3). Generally, vitamin C content was highest in April-June (S1) and lowest in January-March (S4).
- Total chlorophyll was highest in CO (Cr-4) and CO-2 during July-September (S2) and January-March (S4), and lowest in CO-2 during October-December (S3).
- Irrespective of varieties, the crops in the open field showed early germination, first, second and third leaf emergence compared to the crops in the rain shelter. In both rain shelter and open field, CO (Cr-4) was the earliest and Arka Isha showed delayed behaviour for all these parameters.
- More number of leaves were observed in rain shelter at different stages compared to open field. In both the growing conditions, highest number of leaves were recorded in Arka Isha, followed by CO (Cr-4) and lowest number in CO-3.

- Generally, highest plant height was observed in the rain shelter compared to open field. At 60 DAS, Arka Isha recorded highest plant height in both the growing conditions.
- The higher herbage and biomass yield were observed in the rain shelter than in the open field. Among the varieties, Arka Isha gave superior yield followed by CO-1, and lower in CO (Cr-4) in both the growing conditions. The variety CO-3 recorded higher herbage yield than CO-2 in rain shelter and open field. But biomass yield was more in CO-2 than CO-3 in both the growing conditions.
- The growing conditions showed no influence on number of primary branches. However, both primary and secondary branches were higher in rain shelter than in the open field. In the rain shelter, CO-2 had highest number of branches. In the open field, CO-1 had highest number of branches.
- Generally, days to leaf serration, flowering and seed set was delayed in rain shelter compared to the open field. Irrespective of growing conditions, the variety CO (Cr-4) was the earliest for these parameters and Arka Isha was late. Among the varieties CO-1, CO-2 and CO-3, the variety CO-3 was earlier inside rain shelter. In the open field, the variety CO-1 was the earliest for all these parameters.
- The growing conditions did not affect the volatile oil content in leaves. However, the variety CO-2 recorded higher volatile oil in rain shelter than in the open field.
- With respect to vitamin C content, crops grown in the open field was superior to that grown in the rain shelter. In both the conditions, highest vitamin C was recorded in CO-3.
- Total chlorophyll content was higher in the open field compared to the rain shelter. However, chlorophyll 'b' was recorded higher in the rain shelter. Irrespective of growing conditions, the variety Arka Isha showed highest

chlorophyll content. Among the varieties, CO-2 recorded lowest chlorophyll content in rain shelter. In the open field, the lowest was in CO-1.

- The crops raised during October-December (S3) and January-March (S4) were susceptible to Aphid attack. Also, the crops in the rain shelter shown more aphid attack compared to that of open field. The incidence was recorded only in the variety CO-3 during reproductive phase. In vegetative phase, all varieties were free from aphid attack.
- No disease incidence was observed during the crop period in different time of sowing and growing conditions.

The study clearly revealed that the time of sowing and growing conditions had significant influence on growth, herbage yield and quality of coriander varieties. Among the seasons, July to September sowing was beneficial in the plains of Kerala to get favorable growth and herbage yield. The varieties Arka Isha, followed by CO-1 gave highest herbage yield. The rain shelter grown crops performed better than that in the open field for growth and herbage yield. However, Vitamin C and total chlorophyll was higher in open field. The volatile oil was not affected by time of sowing and growing conditions.

References

7. REFERENCES

Agarwal, K. B., Ranjan, J. K., Rathore, S. S., Saxena, S. N. and Mishra, B. K., 2013. Changes in physical and biochemical properties of fenugreek (*Trigonella sp.* L.) leaf during different growth stages. *Int. J. Seed Spices* 3(1): 31-35.

Agrawal, S., Choudhary, G. R. and Sharma, R. K. 1993. Improving the yield of essential oil in coriander (*Corriandrum sativum* L.) *Indian Cocoa Arecanut and Spices J.* 17 (2): 45-47.

Arif, A. 2012. Studies on genetic variability for herbage and seed yield in coriander (*Coriandrum sativum* L.) under hilly zone of Karnataka. M.Sc. (Ag) thesis, University of Horticultural Sciences, Bagalkot, 160p.

Arif, A. 2014. Evaluation of coriander (*Coriandrum sativum* L.) genotypes for fresh and dry biomass yield under hill zone of Karnataka. *Int. J. Agric. Sci.* 10(2): 747-750.

Arif, M., Khurshid, H., and Khan, S. A. 2014. Genetic structure and green leaf performance evaluation of geographically diverse population of coriander (*Coriandrum sativum* L.). *Eur. Acad. Res.* 2(3): 3269-3285.

Augustine, N. 2016. Performance of African marigold (*Tagetes erecta* l.) under different growing conditions. MSc. (Hort.) thesis, Kerala Agricultural University, Thrissur, 179 p.

Baswana, K. S., Pandita, M. L, and Sharma, S. S. 1989. Response of coriander to dates of planting and row spacing. *Indian J. Agron.* 34(3): 355-357.

Bhat, S., Kaushal, P., Kaur, M., and Sharma, H. K. 2014. Coriander (C*oriandrum sativum* L.): processing, nutritional and functional aspects. *Afr. J. Plant Sci.* 8(1): 25-33.

Bhuiyan, M. N. I., Begum, J., and Sultana, M. 2009. Chemical composition of leaf and seed essential oil of *Coriandrum sativum* L. from Bangladesh. *Bangladesh J. Pharmacol.* 4(2): 150-153.

Biswal, A. K., Pattanayak, G. K., Pandey, S. S., Leelavathi, S., Reddy, V. S., and Tripathy, B. C. 2012. Light intensity-dependent modulation of chlorophyll b biosynthesis and photosynthesis by overexpression of chlorophyllideaoxygenase in tobacco. *Plant physiol.* 159(1): 433-449.

Chaulagain, R., Pant, S. S., Thapa, R. B., and Sharma, M. D. 2011. Performance of coriander cultivars for green leaf production under late sowing condition. *J. Agric. Environ.* 12: .67-73.

Clevengers, J. F. 1982. Apparatus for determination of volatile oil. *J. Am. Pharmacol. Assoc.*17: 346-348.

Devi, A. R. 2016. Evaluation of some local and promising germplasms of coriander in the Gangetic alluvial region. M.Sc. (Hort.) thesis, Bidhan ChandraKrishi Viswavidyalaya, Mohanpur, 56p.

Dhanasekhar, D. 1997. Screening of coriander (*Coriandrum Sativum.* L.) genoypes for green yield and quality. Unpub. Msc. (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore, 67p.

Divya, N. 2007. Studies on evaluation of varieties and nutrition in coriander (*Coriandrum sativum* L.). M.Sc. (Ag) thesis, University of Agricultural Sciences, Dharwad, 69p.

Dixit, A. 2007. Performance of leafy vegetables under protected environment and open field condition. *Asian J. Hortic.* 2(1): 197-200.

Easwarareddy. S., Venkateswarlu. K., and Narayanareddy.,Y. 1988. Studies on the sowing time and efficacy of certain coriander cultivars in biomass production. *Indian Cocoa Arecanut Spices J.* 11(3): 110-112.

Ebrahimia, N. S., Hadian, J., and Ranjbar, H. 2010. Essential oil compositions of different accessions of *Coriandrum sativum* L. from Iran. *Nat. Prod. Res.* 24(14). 1287-1294.

Ghobadi, M. E. and Ghobadi, M. 2012. Effects of late sowing on quality of coriander (*Coriandrum sativum* L.). *World Acad. Sci. Eng. Technol.* 67: 432-435.

Girenko, M. M. 1982. Initial material and basic trends in breeding of some uncommon species of vegetables (in Russ. Eng. Detr.). Bull. VIR Vavilova, 120: 33-37.

Giridhar, K., Suryakumari, S., and Naid, N. L. 2015. In search of ideal multicut coriander. *Spice India* 28(10): 10-16.

Guha,S., Debnath. S., and Sharangi, A. B. 2016a. Impact of different levels of cutting and dates of sowing on growth of coriander under open and protected cultivation. *Bioscan* 11(3): 1615-1620.

Guha, S., Debnath S., and Sharangi, A. B. 2016b. Influence of growing conditions on yield and essential oil of coriander during year-round cultivation. *Int. J. Agric. Sci.* 8(5): 1021-1026.

Guha, S., Sharangi, A. B., and Debnath, S., 2014. Phenology and green leaf yield of coriander at different sowing dates and harvesting times. *J. Food Agric. Environ.* 12 (3&4): 251-254.

Guha, S., Sharangi, A.B., and Debnath, S., 2013. Effect of different sowing times and cutting management on phenology and yield of off season coriander under protected cultivation. *Trends Hortic. Res.* 3(1): 27-32.

Hariharan, K. 1996. Studies on genetic variabilities in fenugreek (*Trigonella foenumgraecum* L.). Unpub. Msc. (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore.

Hiwale, B. G., Dhokle, G. C., Naik, P. G., Phad, G. N., and Suryawanshi, A. B. 2009. Performance of different varieties of coriander for growth and yield under Marathwada conditions. *Asian J. Hortic*. 4(2): 455-457.

Hussien, M. S. 1995. Response of growth, yield and essential oil of coriander and dill to different nitrogen sources. *Egyptian J. Hortic.* 22(1): 1-10.

Kalra, A., Patra, N. K., Singh, H. P., Mengi, M., Naqvi, A. A., and Kumar, S. 1999. Evaluation of coriander (*Coriandrum sativum* L.) collections for essential oil. *Indian J. Agric. Sci*. 69: 657-659.

Kalra, V. K., Sharma, S. S., and Tehlan, S. K. 2006. Population dynamics of *Hyadaphis corianderii* on different cultivars and varieties of coriander and seed yield losses caused by it. *J. Med. Aromat. Plant Sci*. 28(3): 377-379.

Karetha, K. M., Jat, G., and Ladumor, A. R. 2014. Effect of different date of sowing and growing conditions on coriander (*Coriandrum sativum* L.) cv. Gujarat coriander-2. *Int. J. Agric. Sci.* 10 (2): 524-528

Katar, D., Kara, N., and Katar, N. 2016. Yields and quality performances of coriander (*Coriandrum sativum* L.) genotypes under different ecological conditions. *Turkish J. Field Crops* 21:79- 87.

Kotadia, H. R., Patil, S. J., Bhalerao. P. P., Gaikwad, S. S., and Mahant, H. D. 2012. Influence of different growing conditions on yield of leafy vegetables during summer season. *Asian J. Hortic*. 7: 300-302.

Kumar, N., Khader, A., Rangaswam, P., and Irulappan. I. 1997. *Introduction to Spices, Plantation crops, Medicinal and Aromatic Plants* (Indian Reprint, 2011). Oxford and IBH publishing Co., New Delhi, 239p.

Kumar, R., Singh, M. K., Kumar, V., Verma, R. K., Kushwah, J. K. and Pal, M. 2015. Effect of nutrient supplementation through organic sources on growth, yield and quality of coriander (*Coriandrum sativum* L.). *Indian J. Agric Res.* 49: 278-281.

Lal, G. and Singh, R. 2016. Comprehensive evaluation of coriander (*Coriandrum sativum* L.) varieties under different organic modules. *Indian J. Agric. Sci.* 86(1): 31-36.

Lal, G., Singh, B. and Maheria, S.P. 2015. Influence of protected environments and irrigation methods on plant growth and seed yield of coriander (*Coriandrum sativum* L.). *Indian J. Agric. Sci.* 85(10): 1308-1312

Lataye, P. T., Bharad, S. G., Kale, V. S., Nandeshwar, V. N. and Kholia, A. 2016. Varietal performance of fenugreek under Akola conditions. *Int. J. Minor Fruits Med. Aromat. Plants* 17 (4): 8-10.

Leong, T. Y and Anderson, J. M. 1984. Adaptation of the thylakoid membranes of pea chloroplasts to light intensities. Study on the distribution of chlorophyll–protein complexes. *Photosynth. Res.* 5: 105–115.

Malhotra, S. K. and Vashishtha, B. B. 2007. Response of Indian dill (*Anethum sowa*) and European dill (*Anethum graveolens*) varieties to different agro-techniques. *Indian J. Agric. Sci.* 77(8): 519-522.

Malik, T. P. and Tehlan, S. K. 2013. Performance of coriander (*Coriandrum sativum* L.) varieties for growth and seed yield. *Int. J. Seed Spices*. 3: 89-90.

Mandal, S. and Mandal, M. 2015. Coriander (*Coriandrum sativum* L.) essential oil: chemistry and biological activity. *Asian Pac. J. Tropical Biomed*. 5(6): 421-428.

Maurya, K. R. 1990. Effect of dates of sowing on yield and essential oil content of coriander (*Coriandrum sativum* L.). *Indian Perfumer* 34(2): 160-163.

Meena, B. S., Dhaka, B. L., and Poonia, M. K. 2013. Assessment of yield, quality and economics of coriander (*Coriandrum sativum* L.) genotypes in south-eastern plains of Rajasthan under irrigated condition. *Int. J. Seed Spices*. 3: 58-60.

Meena, S. S. and Malhotra, S. K. 2006. Effect of sowing time, nitrogen and plant growth regulators on green leaf yield of coriander. *Haryana J. Hort. Sci.* 35 (3&4): 310-311.

Meena, S. S., Sen, N. L., Meena, R. S., and Singh, R. K. 2006. Quality of coriander (*Coriandrum sativum* L.) as influenced by sowing dates, nitrogen and plant growth regulators under Rajasthan climatic conditions. *J. Med. Aromat. Plant Sci.* 28(4): 544-546.

Megeji. N. W. and Korla. B. N. 2002. Genetic variation in coriander. *Haryana J. Hort. Sci.* 31(3&4): 292-293.

Menon, R. and Khader, M. A. 1997. Effect of leaf plucking on the growth and grain yield of coriander. *Indian Cocoa Arecanut Spices J.* 21(3): 74-75.

Mirshekari, B., Hamidi, J., and Zadeh, A. R. 2011. Phenology and yield of cumin at different sowing dates and planting patterns. *J. Food Agric. Environ.* 9(1): 385-387.

Moniruzzaman, M., Rahman, M.M., Hossain, M. M., Karim, A. S., and Khaliq, Q. A. 2013. Evaluation of coriander (*Coriandrum sativum* L.) genotypes for foliage yield and its attributes. *Bangladesh J. Agric. Res*. 38(1): 175-180.

Mukherjee, D. 1992. Greenhouse cultivation of flowers for export. In: Prakash, J. and Bhandary, K. R. (eds), *Floriculture – Technology, Trades and Trends*. Oxford and IBH Publishing Co., New Delhi, pp. 443-451.

Nadeem, M., Anjum, F. M, Khan, M. I., Tehseen, S., El-Ghorab, A., and Sultan, J. I. 2013. Nutritional and medicinal aspects of coriander (*Coriandrum sativum* L.) *Rev. Br. Food J.* 115(5): 743-755.

Nandal, J. K., Dahiya, M. S. and Gupta, V. 2007. Response of sowing time, spacing and cutting of leaves on growth and seed yield of fenugreek. *Haryana J. Hort. Sci.* 36(3&4): 374-376.

NHB [National Horticulture Board]. 2015. Indian Horticulture Data Base [on-line], Ministry of Agriculture, Gurgaon, Haryana.

Padalia, R. C., Karki, N., Sah, A. N., and Verma, R. S. 2011. Volatile constituents of leaf and seed essential oil of *Coriandrum sativum* L. *J. Essential Oil Bearing Plants* 14(5): 610-616.

Palanikumar, M., and Rajamani, K. 2012a. Evaluation of coriander (*Coriandrum sativum* L.) genotypes for fresh, dry biomass yield and oil content under different seasons. *Crop Res.* 44 (1 & 2): 194-202.

Palanikumar, M. and Rajamani, K. 2012b. Physiological and biochemical analysis of coriander (*Coriandrum sativum* L.) genotypes under different seasons. *Crop Res.* 44 (1/2): 208-216.

Pandey, S., Singh, J., Singh, S., and Mourya, I. B. 2015. Influence of growing environment on growth, yield and chemical composition of strawberry (*Fragaria* × *ananassa*) fruits under open vs naturally ventilated polyhouse conditions. *Indian J. Agric. Sci.* 85(12): 1540-1545.

Prabhu, T. and Balakrishnamurthy, G. 2006. Evaluation of coriander (*Coriandrum sativum* L.) accessions under irrigated conditions for growth, yield and quality. *Proceedings of National Seminar on Emerging Trends in Production, Quality, Processing and Export of Spices,* 28-29 March 2006, Coimbatore, pp. 13.

Priyadarshi, S. and Borse, B. B., 2014. Effect of the environment on content and composition of essential oil in coriander. *Int. J. Sci. Eng. Res.* 5(2): 57-65.

Rajagopalan, A., Manavalan, R. S. A., Khader, M. A., Azhakiya, R. S., and Khair, M. D. A. 1996. Evaluation of coriander cultivars for yield and quality. *Indian Cocoa Arecanut Spices J.* 20(1): 13-14.

Rajan, F. S., Vedamuthu, P. G. B., Khader, M. A., and Jeyarajan, R. 1990. Screening coriander lines against grain mould disease. *S. Indian Hortic.* 38(3): 168-169.

Rajaraman, G., Paramaguru, P., Aruna, P., Sudagar, I. P., and Ragothaman, G. 2011. Fertigation studies on leaf area and chlorophyll content in coriander (*Coriandrum sativum* L.). *Asian J. Hortic.* 6(1): 46-49.

Rajasekhar, M., Arumugam, T., and Rameshkumar, S. 2013. Influence of weather growing environment on vegetable growth and yield. *J. Hort. and forestry.* 5(10): 160-167.

Rajput S. S. and Singh. D. 2003. Variability in coriander (*Coriandrum sativum* L.,) for yield and yield components. *J. Spices Aromat. Crops.* 12(2)162-164.

Rao, V. K., Rao, T. K., Shivashankara, K. S., and Varalakshmi, B. 2004. A comparative study of whole herb and leaf essential oils of coriander. *J. Essential Oil Bearing Plants* 7(1): 49-55.

Sadasivam, S. and Manickam, A. 1992. (2nd Ed.). *Biochemical methods*. New Age International (P) Limited Publishers and Tamil Nadu Agricultural University, Coimbatore, 256p.

Sarada, C., Giridhar, K., and Rao, N. H. 2009. New high yielding coriander variety Sudha for rainfed black soil. *Indian J. Arecanut Spices Med. Plants* 11(1): 18-22.

Sarada, C., Kalidasu, G., Reddy, T.Y., and Reddy, P. V. 2011. Weather modification for off-season production of coriander (*Coriandrum sativum* L.) for leaf. *J. Agrometeorol*. 13(1): 54-57.

Salvarajan, M., Chezhiyan, N., Muthulakshmi, P., and Ramar, A. 2002. Evaluation of coriander genotypes for growth and yield. *S. Indian Hortic*. 50 (4&6): 458-462.

Sharangi, A. B. and Roychowdhury, A. 2014. Phenology and yield of coriander as influenced by sowing dates and irrigation. *Bioscan* 9(4): 1513-1520.

Sharangi, A. B., Chatterjee, R., Nanda, M.K., and Kumar, R. 2011. Growth and leaf yield dynamics of cool season coriander as influenced by cutting and foliar nitrogen application. *J. Plant Nutr*. 34(12): 1762-1768.

Sharma, R. N. and Israel, S. 1991. Effect of date of sowing and levels of nitrogen and phosphorus on growth and seed yield of coriander (*Coriandrum sativum* L.). *Indian J. Agron*. 36: 180-184.

Shemon, J. 2014. Identification of non- bolting genotypes and planting time in amaranthus (*Amaranthus tricolor* L.). M.Sc.(Hort.) thesis, Kerala Agricultural University, Thrissur, 70p.

Shoba, N. and Rajamani, K. 2009. *Production of leafy type coriander in off season (summer) in shade net house.* National Seminar on Production System

Management in Adverse Conditions for Higher Productivity in Andaman and Nicobar Islands, p. 38.

Shridhar, Sulikeri. G. S., and Hulamani. N. C. 1990. Performance of coriander (*Coriandrum sativum* L.) genotypes. *Karnataka J. Agric. Sci.* 3(3-4): 213-217.

Singh, H. P., Patra, N. K., Kalra, A., Singh, H. B., Kumar, B., Singh, S. P., and Singh, A. K. 2002. Genetic distance in coriander (*Coriandrum sativum* L.) for essential oil yield and yield traits. *J. Spices Aromat. Crops* 11(2): 101–105.

Singh, S., Choudhary, M. R., Mahala, P., Yadav, T. V., Garhwal, O. P., and Ujjainiya, P. 2015. Effect of bio-fertilizers and inorganic sources of NP on quality and yield of kasuri methi (*Trigonella corniculata*). *J. Plant Sci. Res.* 31(1): 17-20.

Sinta, I., Vijayakumar, A., and Srimathi, P. 2015. Effect of micronutrient application in coriander (*Coriandrum sativum* L.) cv. CO-4. *Afr. J. Agric. Res.* 10(3): 84-88.

Sohoo, M. S. and Bhardwaj, B. L. 1986. Association analysis of components of forage yield in fenugreek. *J. Res. Punjab Agric. Univ.* 23 (1):5-7.

Srivastava, S. B. L., Kamaluddin, S. M., Tripathi, and Srivastava, J. P. 2000. Genetic divergence in coriander (*Coriandrum sativum* L.) [abstract]. In. Abstracts, *Centennial Conference on Spices and Aromatic Plants*. 20-23 September, 2000, Indian Institute of Spice Research, Calicut, pp. 68-70.

Sunilkumar, H. T., 2010, Evaluation of genotypes and nutritional studies in coriander (*Coriandrum sativum* L.). M. Sc. (Ag) Thesis, University of Agricultural Sciences, Dharwad, Karnataka, 78p.

Tehlan, S. K. and Thakral. K. K. 2008. Effect of different levels of Nitrogen and leaf cutting on leaf and seed yield of coriander (*Coriandrum sativum* L.) *J. Spices Aromat. Crops* 17(2):180-182.

Tehlan, S. K., Thakral, K. K., Partap, P. S., and Malik, T. P. 2007. Hisar Surbhi: a high yielding variety of coriander. *Haryana J. Hortic. Sci.* 36(3/4): 410-411.

Thapa, U. 1999. Nutrient Management of some leaf vegetables. Ph.D. (Ag) thesis, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, 158p.

Tripathi, Kamaluddin, S. L., Srivastava, and Srivastava, J. P. 2000. Variability, heritability and correlation studies in vegetable amaranthus. *S. Indian Hortic.* 42 (6): 361-364.

Tsamaidi, D., Daferera, D., Karapanos, I. C., and Passam, H. C. 2017. The effect of water deficiency and salinity on the growth and quality of fresh dill (A*nethum graveolens* L.) during autumn and spring cultivation. *Int. J. Plant Prod.* 11(1). 33-46.

Unlukara, A., Beyzi, E., Ipek, A., and Gurbuz, B., 2016. Effects of different water applications on yield and oil contents of autumn sown coriander (C*oriandrum sativum* L.). *Turkish J. Field crops*. 21(2): 200-209.

Varalakshmi, B. and Reddy. V. P. 1994. Variability, heritability and correlation studies in vegetable amaranthus. *S. Indian Hortic*. 42(6): 361-364.

Varalakshmi, B., Rao, V. K., Rao, D. S., Tiwari, R. B., and Prabhakar, M. 2012. High-yielding multicut coriander variety, Arka Isha. *J. Hort. Sci.* 7(1): 91-93.

Velayudham, A., Hanamshetti, S. I., Madalgeri, M. B., and Wali, M. C. 2006. *Evaluation of coriander genotypes during 2003-04 kharif and rabi seasons.* Proceedings of National Seminar on Emerging Trends in Production, Quality, Processing and Export of Spices, 28-29 March, Coimbatore, p-11.

Venkateswarlu, K., Reddy, S. E, and Reddy, Y. N. 1993. Nitrogen uptake by coriander cultivars sown at different dates. *Indian Cocoa, Arecanut Spices J.* 16 (2): 72-73.

Venkattareddy, P., Sriramrao, T., Narasimharao, S. B. S, and Narisirddy, A. 1986. Genetic variability in coriander in coriander. *Indian cocoa Arecanut Spices. J.* 10(3): 90-92.

Verma, P. and Sen, N. L. 2008. The impact of plant growth regulators on growth and biochemical constituents of coriander (*Coriandrum sativum* L.). *J. Herbs Spices Med. Plants.* 14(3-4):144-153.

Vijayalatha, K. R. and Chezhiyan, N. 2004. Correlation and path analysis studies in coriander (*Coriandrum sativum* L.). *S. Indian Hortic.* 52 (1): 245-251.

Wierdak, R. N. 2013. Essential oil composition of the coriander (*Coriandrum sativum* L.) herb depending on the development stage. *Acta Agrobotanica.* 66(1): 53-60.

Yeganehpoor, F., Salmasi, Z. S., Kolvanagh, S. J., Golezani, G. K., and Dastborhan, S. 2016. Changes in growth, chlorophyll content and grain yield of coriander (*Coriandrum sativum* L.) in response to water stress, chemical and biological fertilizers and salicylic acid. *Int. J. Advanced Biol. Biomedical Res.* 5(1): 228-236.

Appendix

Appendix I. Monthly mean weather data during the period from April 2016 to March 2017

Months	Temperature		Relative Humidity (%)	Rainfall (mm)	Rainy days	Sunshine hours	Mean sunshine hours
	Mean Max	Mean Min					
April	35.8	26.2	69	25.8	2	238.2	7.9
May	34.0	24.2	78	270.7	2	182.2	5.9
June	29.8	21.7	89	654.7	9	49.3	1.6
July	29.9	21.6	85	390.4	22	71.2	2.3
August	30.4	23.2	83	183.5	19	152.4	4.9
September	30.3	23.6	82	086.0	10	144.5	4.8
October	31.5	22.7	81	037.3	4	170.3	5.5
November	32.9	22.2	69	013.8	1	174.7	5.8
December	32.4	22.3	69	0529	3	200.7	6.5
January	34.1	22.9	53	0.0	0	235.2	7.6
February	36.0	23.2	51	0.0	0	243.0	8.7
March	36.1	24.7	67	13.2	1	29.9	7.4

PERFORMANCE EVALUATION OF LEAF CORIANDER (*Coriandrum sativum* L.) TYPES IN THE PLAINS OF KERALA

By

SURYA RAJ
(2015-12-021)

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the requirements for the degree of

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANTATION CROPS AND SPICES
COLLEGE OF HORTICULTURE
KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA
2017

ABSTRACT

Coriander (*Coriandrum sativum* L.), belongs to the family Apiaceae, is an important annual spice herb, mainly cultivated for its fruits as well as for its tender green leaves. Recent understanding of the neutraceutical and medicinal properties of the leaves elevated the status of this herb.

The present study entitled 'Performance evaluation of leaf coriander (*Coriandrum sativum* L.) types in the plains of Kerala' was conducted in the Department of Plantation crops and Spices, College of Horticulture, Vellanikkara during October 2015 to March 2017 with the objectives of evaluating five coriander varieties namely CO-1, CO-2, CO-3, CO (Cr-4) and Arka Isha in the rain shelter during different time of sowing viz., April-June 2016 (season S1), July to September 2016 (S2), October-December (S3) and January-March 2017 (S4) and in different growing conditions viz. rain shelter and open field for their growth, herbage yield and quality.

The study reported that all the varieties showed difference with respect to the growth and herbage yield. Irrespective of time of sowing, the varieties CO (Cr-4) followed by CO-2, CO-3 and CO-1, recorded the lowest number of days to seed germination, first leaf, second leaf and third leaf emergence whereas, Arka Isha took more number of days for these parameters. The varieties Arka Isha and CO (Cr-4) yielded highest mean number of leaves in all the time of sowing (16.30 and 15.69). Generally, the crop grown during July-September (S2) exhibited maximum number of leaves (16.36) at harvest. Irrespective of time of sowing, the variety Arka Isha performed better with respect to the mean herbage and biomass yield per plant with highest yield during July-September (S2) and the lowest during January-March (S4).

The variety CO (Cr-4) was the earliest to show serration of leaves in all the four time of sowing (37.43 days), flowering (40.19 days) and seed set (47.69 days). Whereas, the variety Arka Isha showed delay in leaf serration (49.29 days), flowering

(54.05 days), and seed set (63.27 days). The quality aspects like vitamin C and total chlorophyll were observed highest in Arka Isha (158.98 mg/100g and 2.20 mg/100g, respectively). With respect to the total chlorophyll, July-September (S2) sown crop (2.27 mg/100g) was superior. However, volatile oil content (0.05 per cent -0.06 per cent) was not affected by time of sowing.

When grown in different growing conditions, the crops under rain shelter took significantly more days for germination (9.73 days), first leaf (12.49 days), second leaf (14.72 days) and third leaf (16.68 days) emergence, days to leaf serration (44.44 days), flowering (48.94 days) and seed set (58.80 days) compared to that in the open field. Also, the crop grown under rain shelter exhibited higher number of leaves at harvest (14.18), herbage and biomass yield (9.21g/plant and 12.78g/plant). In both the growing conditions, Arka Isha and CO-1 yielded more herbage (10.46g/plant and.8.97g/plant, respectively). The quality aspects like vitamin C and total chlorophyll (189.72 mg and 1.98mg) was found higher in the open field.

The result indicated that July-September (S2) sowing was beneficial in the plains of Kerala to get favourable growth and herbage yield. The varieties Arka Isha followed by CO-1 gave maximum herbage yield. The rain shelter grown crops performed better than that in the open field for growth and herbage yield. However, vitamin C and total chlorophyll was higher in open field. The volatile oil was not affected by time of sowing and growing conditions.