PERFORMANCE OF HIGH YIELDING VARIETIES OF FINGER MILLET [*Eleusine coracana* (L.) GAERTN]

By

KISHORE NEERUGANTI
(2017-11-134)

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA

2021

PERFORMANCE OF HIGH YIELDING VARIETIES OF FINGER MILLET [*Eleusine coracana* (L.) GAERTN]

By
KISHORE NEERUGANTI
(2017-11-134)

THESIS

Submitted in partial fulfillment of the requirement for the degree of

Master of Science in Agriculture
(AGRONOMY)

Faculty of Agriculture

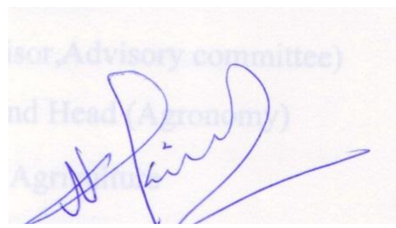
Kerala Agricultural University

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA

2021

DECLARATION

I, Kishore Neeruganti (2017-11-134) hereby declare that this thesis entitled **"PERFORMANCE OF HIGH YIELDING VARIETIES OF FINGER MILLET *(Eleusine coracana* (l.) Gaertn)"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.



Vellanikkara, **Kishore Neeruganti**

Date: (2017-11-134)

CERTIFICATE

Certified that this thesis entitled **"PERFORMANCE OF HIGH YIELDING VARIETIES OF FINGER MILLET [*Eleusine coracana* (L.) Gaertn]"** is a record of research work done independently by **Mr. Kishore Neeruganti (**2017-11-134) under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

10/2/21

Dr. P. Prameela

Vellanikkara

Date:

(Major advisor,Advisory committee)

Professor and Head (Agronomy)

College of Agriculture

Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of **Mr. Kishore Neeruganti (2017-11-134)**, a candidate for the degree of **Master of Science in Agriculture**, with major field in **Agronomy**, agree that this thesis entitled **"PERFORMANCE OF HIGH YIELDING VARIETIES OF FINGER MILLET [*Eleusine coracana* (L.) Gaertn]"** may be submitted by **Mr. Kishore Neeruganti** (2017-11-134) in partial fulfillment of the requirement for the degree.

Dr. P. Prameela
(Chairman, Advisory Committee)
Professor and Head
Department of Agronomy
College of Agriculture,
Vellanikkara

Dr. Meera V. Menon
(Member, Advisory Committee)
Professor
Department of Agronomy
College of Agriculture,
Vellanikkara

Dr.P. Sindhumole
(Member, Advisory Committee)
Assistant Professor (Plant Breeding)
Department of Plant Breeding and Genetics
College of Agriculture,
Vellanikkara

Dr. K.E. Usha
(Member, Advisory Committee)
Professor (Agronomy) and Head
PP &NMU, KAU,
Vellanikkara

ACKNOWLEDGEMENT

No creation in this world is a solo effort, neither is this thesis. I would like to take this opportunity to acknowledge all, who supported me directly or indirectly, bringing in this thesis to a really good shape.

Firstly, I thank the almighty ***GOD*** *for his love and blessings, without which I would not have been able to complete my studies hitherto and present this piece of work*

I am privileged to avail this opportunity to express my deep and heartfelt gratitude and veneration to my major advisor and chairman of the advisory committee, ***Dr. P. Prameela,*** *Professor and Head, Department of Agronomy and chairperson of Advisory Committee for her impeccable and inspiring guidance, untiring patience, encouragement, constructive criticism, precious suggestions and gracious approach throughout the course of study and the period of the investigation and preparation of the thesis, I consider myself being fortunate in having the privilege of being guided by her.*

I, gratefully express my sincere gratitude, retired Professor ***Dr. C. George Thomas,*** *member of my advisory committee for his valuable suggestions, critical assessments and guidance rendered to me for the completion of the research programme and preparation of the thesis,*

I am deeply obliged to ***Dr. Sindhumole, Dr. Meera V. Menon*** *and* ***Dr.K. T Usha****, members of my advisory committee for unfailing support and relevant suggestions throughout the period of the work. I thank them for all the help and cooperation they had extended to me.*

With utmost satisfaction I acknowledge the enormous help of my colleagues ***Ms. Vidhu, Ms. Arya, Ms. Emily, Ms. Sabika, Ms. Athira, Ms. Anasooya,*** *and my juniors* ***Mr. Suhas, Ms. Basila, Ms. Minu Maria, Ms. Liz, Ms. Nengparmoi*** *for their friendly assistance and valuable cooperation during my study.*

It gives me immense pleasure to express my profound thanks to my seniors ***Ms. Vandhana G. Pai, Ms. Jeena, Ms. Akhila, Mr. Rajanand, Mrs. Shobha Rani, Mr. Saravana Kumar, Mr. T.V.Reddy, Ms. Chijina, Ms. Nayana V. R., Ms. Anitrosa Innazent, Ms. Santhiya K., Ms. Jeen Shaji, Ms. Akshatha V., Ms. Sreethu,*** *for their constant encouragement to bring out my best in all endeavours.*

I would like to express heartiest gratitude to my beloved teachers ***Dr. S. Anitha, Dr. Sindhu P. V, Dr. K. P. Prameela, Dr. Girija, Dr. Beena, Dr. Syama S. Menon,*** *and* **Dr. Savitha Antony**

I extend my sincere thanks to **Dr. B. Ajit Kumar**, *Department of Agriculture meteorology, who helped me providing necessary information in successful completion of this humble piece of work.*

I express my thankfulness to **Mrs. Sreela,** *and* **Mrs. Shyamala** *for their timely and invaluable help to carry out the analysis in the lab. Special thanks to staff and non-teaching staff for their timely help and proper guidance during the pursuit of my research work.*

I respectfully acknowledge my gratitude to **Mr. Sijith,** *and* **Ms. Athira** *farm managers and other field staff for their sustained help and cooperation during my research work with utmost satisfaction.*

I express my fidelity and respectable regards to the office staff especially **Mrs. Shakeela** *for her valuable guidance, constant encouragement, constructive criticism, perspicacity and meticulous scrutiny which embellished the study.*

I wish to express my deep gratitude to **Dr. L. Hemalatha**, *Principal Scientist, Agricultural Research Station, Perumallapalli, for her providing material timely and for her amiable suggestions, kind co-operation during the pursuit of my research work.*

I am grateful to **Kerala Agriculture University, Vellanikarra** *for providing me with the opportunity and financial assistance to pursue my post-graduation.*

In explicable in fervent to my parents ***Sri Neeruganti Babu Prasad,*** *and* ***Smt. Alivelamma Neeruganti*** *under who's grooming I learnt the concepts of life. They have been a foundation of inspiration throughout my life. To their feet, I bow with my head with great reverence. I feel elated to express my bountiful thanks to my family members for their undiminishing love, benign care and zealous encouragement throughout this endeavour and also my special thanks to my loving sister* ***Smt. Asha Jyothi****.*

I thank all my well-wishers and others who helped me directly or indirectly not placed here, for their kind cooperation and support rendered to me.

Kishore Neeruganti

CONTENTS

LIST OF TABLES

LIST OF PLATES

APPENDIX

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

%	: Per cent
@	: At the rate
°C	: Degree Celsius
°E	: Degree east
°N	: Degree north
µg	: Micro grams
Ca	: Calcium
CD	: Critical difference
cm	: Centimetre
COH	: College of Horticulture
DAP	: Di ammonium phosphate
DAS	: Days after sowing
day^{-1}	: Per day
et al.	: and co-workers
Evp.	: Evaporation
Fe	: Iron
Fig	: Figure
g	: Gram
g^{-1}	: Per gram
ha^{-1}	: Per hectare
HI	: Harvest index
HYV	: High Yielding Varieties
K	: Potassium
KAU	:Kerala Agriculture University
Kg	: Kilogram
l	: Litre
m^{-2}	: Per square meter
Mg	: Magnesium
mg	: Milligram
MOP	: Muriate of potash
N	: Nitrogen

No.	: Number
NS	: Non-significant
P	: Phosphorous
$Plant^{-1}$	: Per plant
ppm	: Parts per million
r	: Correlation Co-efficient
RDF	: recommended dose of fertilizers
RF	: Rainfall
RH	: Relative humidity
SS	: Sunshine hours
t/ha	: Tonnes per hectare
TDM	: Total dry matter
viz.,	: Namely
Zn	: Zinc

1.Introduction

3. INTRODUCTION

Millets are a group of highly variable small-seeded grasses that were under cultivation from ancient times in arid and semi-arid regions of the world. Among millets, ragi or finger millet is the most commonly cultivated crop grown for human food and as fodder, especially in Eastern and Southern Africa and Southern Asia. Millets are important in climate-resilient agriculture and contribute to global food security as well as nutritional security. Focusing on the importance of millets, the FAO report (2005) states that: “Many outsiders had marveled at how people in Uganda and Southern Sudan could develop such a strapping physique and work as hard as they do on just one meal a day”.

Finger millet or ragi (*Eleusine coracana* (L.) Gaernt.) belongs to the family Poaceae. The term ‘*Eleusine*’ is derived from ‘*Eleusis*’ who is the Greek deity presiding over agriculture. The term ‘*coracana* is derived from *kurukkan*, the Singhali name of the grain. Ragi is mentioned in ancient Sanskrit literature as *Rajika*. The word ragi is derived from “Rajika” meaning red

Being a hardy crop, finger millet is grown in drylands, under the rainfed situation. It has no preferences of soil types, yet, sandy loams and red loams are best. It has a low water requirement and can be grown with a minimum rainfall of 300-400 mm but can withstand up to 1500 mm. It can tolerate salinity to some extent and is sensitive to waterlogging and frost.

In India, this crop is grown in an area of 1.2 million ha with a production of 1.39 million tonnes and productivity of 1649 kg/ha. The major ragi growing state in India is Karnataka which contributes to 58.6 per cent of the area and 63.0 per cent of production between 2015-2016 (Rodriguez 2020). Finger millet is the traditional staple food in Southern Karnataka. It is even grown in hilly regions of Uttar Pradesh and Himachal Pradesh, up to an altitude of 2100 - 2300 m above mean sea level. The crop has high adaptability to harsh climatic conditions, being tolerant of drought and heat stress.

The grains of finger millet are nutritionally rich and superior to many kinds of cereal and hence designated as "*Nutri cereal*". It contains protein (9.2 per cent), carbohydrates (76.32 per cent), and fat (1.29 per cent). It is very rich in minerals (2.70 per cent) such as calcium (452 mg/1000g) and iron (3.90 mg/100g) (Pandey and Kumar, 2005). Ragi grain has a low glycemic index and the absence of gluten makes it an ideal diet food for diabetic and coeliac disease patients. Further, ragi protein is a complete protein biologically as in the case of milk. It is regarded as an antidote for obesity. It is a good infant food as well as geriatric food. The grains have a long storage life also. Due to these qualities, ragi has been termed as "Super grain" by FAO.

Before the green revolution, millets accounted for up to 40 percent of all cultivated grains, but thereafter rice yield doubled and wheat yields tripled causing a shift in crops and cropping systems. Also, it is believed that policies worked against small scale low- input farming systems involving millets because they did not offer any profit to agro-chemical corporates or large food companies. However, recently there has been a change in the wind due to an increase in health consciousness, climate change, food security, and nutritional security schemes and policies promoted by the government. Some of the schemes for bringing more area under millets include INSIMP (Initiative for Nutritional Security through Intensive Millets Promotion) and RADP (Rainfed Area Development Programme) as part of RKVY and Integrated Cereals Development Programmes in Coarse Cereals based Cropping Systems (ICDP-CC. According to the National Food Security Bill (NFSB), coarse cereals have been added to the public distribution system (PDS) in many states. Adding to this, the year 2018 was declared as the "International Year of Millets" by the United Nations. Hence millets are in the limelight once again, and the Government of Kerala also has taken initiatives to promote the cultivation of ragi and other millets.

Crop genotypes show fluctuation in growth and yield attributes when grown in different environments which affect their yield potential. Hence it is crucial to assess the varietal performance under different seasons to identify genotypes suitable for a particular environment. As finger millet is not a main crop of the state, research in this millet has not been taken up seriously and there are no released varieties of this crop from Kerala Agricultural University. Several high yielding varieties of finger millet have been released from various State Agricultural Universities/Research Institutes in India. However, there is a lack of information regarding the suitability of these varieties under Kerala conditions, where the climate is more humid, rainfall is very high and intense, the temperature is high and soils are typically acidic.

Therefore, the present study was formulated to evaluate the performance of different high-yielding varieties of ragi in *Kharif* as well as *Rabi* seasons in Kerala with the following objectives

1. To identify the most suitable varieties for these seasons.
2. To identify the growth and yield attributes of ragi

2.Review of Literature

2. REVIEW OF LITERATURE

The literature related to the research entitles on “Performance of high yielding varieties of finger millet *(Eleusine coracana* (L.) Gaertn)” is reviewed in this chapter. The biometric studies, so far carried out in India, are mainly restricted to major millets and very little work has been done in the past to study the genetic architecture of finger millet concerning yield and its components. However, the available literature is presented under the following heads:

Genetic diversity in ragi

Gupta *et al.* (1989) evaluated 25 early maturing selections of ragi at four locations in Zambia. The results showed that the variety SDRM-3 was the highest yielder with 4.86 t/ha, which accounted for an increase of 42% over the check variety. Based on the overall mean yields, SDFM217 with a grain yield of 3.0 t/ha was found the highest yielder. Eleven ragi varieties were evaluated at Hagari Research Station in Bellary district of Karnataka during 1992-94 by Ibrahim *et al.* (1998), led to the identification of two varieties, KM221 and RAU8, which had the yield potentials of 3.9 and 3.5 t/ha respectively, while the locally cultivated variety Kudlagi Local, had yield potential of 3.2 t/ha. However, RAU8 flowered 10 days earlier than KM221.

A total of 16 cultures were evaluated at AICRP on Small Millets, Mandya (Karnataka) by Ravishankar *et al.* (2004) for yield and other yield attributes. Out of these, the progeny of the crosses PR202 x GE-1409-1-6 and PR202 x GE 1409-2-5 were significantly superior in respect of the number of fingers per ear, grain weight per ear, and earhead length and they matured in 114 days. However, culture like MR23-11-5 took 120 days to mature (long duration). Kumar and Rai (2005) evaluated 30 genotypes of finger millet from diverse sources and grouped them into two clusters based on days to maturity and plant height. Kadam (2008) assessed 70 genotypes of finger millet based on 15 characters and grouped them into eight clusters.

Anantharaju and Meenaksiganesan (2008) grouped 50 finger millet genotypes into 14 clusters. Among the characters studied, days to 50% flowering contributed more towards total diversity. Lule *et al.* (2012) evaluated a total of 144 finger millet landraces collected from different finger millet producing regions of Ethiopia and some introduced from Kenya, Eritrea, Zambia and Zimbabwe along with six improved varieties. Wider ranges of variations were observed among the finger millet population for all traits and days to maturity ranged from 143 to 167 days.

Haradari *et al.* (2012) evaluated genetic variability in 1000 accessions of finger millet for 11 quantitative characters including grain yield per plant and found significant differences among all the finger millet genotypes for different characters. Reddy *et al.* (2013) and Sahu and Pradhan (2012) evaluated 30 finger millet genotypes and observed wide variability in days to 50 per cent flowering.

Significant genotypic variation in dry matter accumulation has been reported in ragi and the extent of variation ranged from 67 to 489 g/m row length in various studies (Nagaraj and Mohankumar, 2009).

Devaliya *et al.* (2018) experimented with 68 diverse genotypes of finger millet for yield and yield contributing traits. The analysis of variance showed a wide range of variation in days to 50 per cent flowering, ranging from 71 to 93 days with a mean of 81days.

Genotype × Environment (GXE) interaction in ragi varieties

Kempanna *et al.* (1971) evaluated twenty-two varieties of finger millet in three environments. They observed significant genotype × environment interactions for the number of days to heading, tiller number, and yield. Chaudhary (1989) observed non-significant G × E and G × Y interaction components for productive tillers, length of main ear head and grain yield, but the G × E × Y interaction component was high and significant for most of the characters in 14 varieties of ragi grown over three years. Dhagat *et al.* (1973) observed significant yield differences between varieties, sites, and years in ten varieties of ragi grown at two sites for four years. They also stated that the phenotypic index was the most useful parameter for yield prediction and those varieties which had higher phenotypic indices gave consistently high yields in both locations.

Chaudhary and Acharya (1969) studied fourteen varieties of ragi in eight environments over four years for stability. They observed significant G × E interaction for grain yield. The linear regression of yield on the environmental means indicated that the stability of the number of varieties and the differences in stability were due to non-linear regression.

An assessment of stability for yield in early maturing varieties of ragi by Mallanna *et al*. (1982) at 19 locations revealed that PES172, PES176, CO8 and EC4847, T25-1 and Dibyasinha were stable across environments. T36 B, PPR1791, PR202, and HR374 were better suited to superior environments while VL202 and VL7 were better suited to moderate environments. Kumar (1986) studied 40 elite cultivars of finger millet at GKVK, Bangalore, for stability in four environments. His study revealed that cultivars PES176, PR202, ELL4, Indaf9, U45, and WR9 possessed an average response for yield and yield components. Suitability for favourable environments was indicated by IE1012, MR911, and Indaf5. Varieties PES110, PR1044, WR2, WR17, and Indaf11 were adapted for poor environments while the remaining genotypes were unstable for yield. Sundaram *et al.* (1986) reported that G × E interaction was evident in the dry matter production and 1000-seed weight of ragi types

Rao *et al.* (1993) investigated 21 genotypes of finger millet at three locations and found significant linear interaction of grain yield with soil organic matter and nitrogen content. Kumar *et al.* (1995) observed that the G × E interaction was highly significant for all agronomic traits among fourteen finger millet cultivars. Ramasamy *et al.*, (1996) reported that 48 finger millet genotypes exhibited significant G × E interaction. The relative humidity followed by rainfall contributed more heterogeneity to the G × E sum of squares than any other weather variable in the study conducted over six environments representing four locations.

Phenotypic stability analysis of 18 strains of white ragi under six different environments (two dates of sowing and three seasons) (*Kharif* 1988 and 1989 and *Rabi* 1988-89) at Bhubaneswar showed significant G x E interaction for all the characters except productive tillers per plant (Prusti *et al.*1998)

Mahato *et al.* (2000) found that the Genotype x Environment interactions with all the five characters in 14 varieties tried under four environments were significant. Most of the characters were governed by non-linear components of the environment, except plant height and number of tillers per plant

Bandyopadhyay (2001) studied the performance of 257 finger millet genotypes at high hills (2100 m above mean sea level) of Garhwal during 1994-98. Regression analysis revealed that days to maturity and thermal time for day temperature at post-flowering period registered significant negative and positive regression coefficient values, respectively with grain yield.

In an experiment involving 19 ragi cultivars with white seeded Indaf11 and brown seeded GPU26 and GPU28 as controls across three locations, none of the genotypes were stable across the environments. However, genotypes IE2835 and IE2906 showed stability in straw yield (Sonnad and Kumar, 2008).

AICRP trials conducted at different testing centers of India during the *Kharif* season of 2006, 2007, and 2008 included ten elite genotypes of finger millet at nine locations. Genotypes included were GPU65, GPU66, GPU67, OEB265, OEB211, VR888, OEB57, PR202, VL333, and HR374. Locations were Vizianagaram, Jagadalpur, Ranchi, Bangalore, Mandya. Kolhapur, Berhampur, Coimbatore, and Waghai. Genotype X Environment interactions were highly significant indicating the presence of variability among genotypes over different environments which was attributed to variations in temperature, relative humidity, soil type, sunshine hours, etc. It was observed that the genotype PR202 performed uniformly well over all the locations and years (mean=73.95, CV=7.06), whereas HR374 showed greater variation (mean= 65.07, CV=12.89) for days to 50 percent flowering (Nagaraja *et al.* 2007).

Diversity in growth and yield attributes

a) Growth attributes

Correlation studies on yield components in 21 divergent finger millet genotypes grown in Sikkim revealed that the number of tillers per plant was considered the most important yield contributing character. Shanthakumar and Gowda (1997) observed that grain yield was positively associated with ear weight per plant, productive tillers per plant, fingers per ear, and grains per centimetre length of a finger. Path analysis indicated that the tiller number per plant had the greatest direct effect on grain yield

b) Yield and yield attributes

Large genotypic variations in grain yield of finger millet from 1.58 t/ha to the extent of 6.10 t/ha have been reported (Nagaraj and Mohankumar, 2009). Among the local and improved varieties of finger millet, PR202 and KM225 recorded grain yield of 18.26 q/ha, but they were significantly higher over the local variety which gave 15.33 q/ha (Basavarajappa and Sharma, 2010). Anuradha *et al.* (2017) while studying 25 advanced breeding lines of finger millet found significant variation for all the traits. The mean grain yield was 31.50 q/ha, with a minimum of 29.22 and a maximum of 39.74 q/ha. The number of tillers per plant and number of fingers per ear was observed to be highly associated with yield.

The number of productive tillers per plant varied from one to five and had a direct correlation with grain yield of improved varieties of ragi (Chandrasekhar, 1978; Gurumurthy, 1982; Nagaraj and Mohankumar, 2009). However, the total number of tillers had a negative relationship with grain yield in finger millet crop. Negative correlations between grain yield and number of basal tillers (Dhagat *et al.*, 1973) and the total number of tillers (Kumar *et al,*1986) in finger millet are also documented.

1000-seed weight is another yield parameter and phenotypic and genotypic variations were reported by Reddy and Patil (1982); Nishit (2013), and Srilakshmi (2013).

Quality parameters of ragi grain

a) *Protein content*

The finger millet is a major source of dietary protein for the rural population of India and wide variations in protein content from 5.6 to 12.70 per cent have been reported by various researchers due to the genetic diversity of the crop. Varieties with brown grain are common in cultivation and they are good yielders but poor in protein content. In contrast, the varieties with white grain are poor yielders, but comparatively rich in protein content.

Nath and Sonwal (1982) reported mean protein content of 5.9 per cent in ragi varieties from Uttar Pradesh. Singh *et al.* (1983) studied the proximate composition of refined flour of twelve varieties of ragi and reported that the protein content varied from 3.15 to 5.93 per cent. Seetharam *et al.* (1984) analyzed twenty white grain types and twenty promising brown types of ragi of Indian and African origin and reported that the white grain types had higher protein (11.5 %) than the brown (8.4%) and variability among whites ranged from 8.9 per cent in Indaf -11 to12.9 per cent in WR-9 and among browns, protein content ranged from 4.8 per cent in Indaf8 to 11.3 per cent in RAU5. The protein content of genotypes CO9 and WR 4 were found to be 10 and 11 per cent respectively.

Shukla *et al.* (1985b) recorded protein content in the range of 5.46 to 9.25 per cent, being highest in white ragi variety Hamsa and lowest in brown variety RAU8 among six varieties of ragi from Jabalpur. Chellamuthu *et al.* (1987) studied the effect of the organic and inorganic form of nitrogen on the crude protein content of ragi and reported that the protein content of CO9 and CO7 was 9.13 and 8.68 per cent, respectively, whereas Venkanna *et al.* (1987) reported that the protein content varied from 8.0 per cent in Godavari to 12 per cent in C -157 among six varieties of ragi from Vijayanagaram, Andhra Pradesh. Joshi and Vaidehi (1988) observed protein content of 7.5 per cent in immature ragi and 7.8 per cent in mature ragi in variety Indaf-5 at Bangalore. Katiyar and Bhatia (1991) reported a mean value of 8.1 per cent protein in ragi from the Trans-Himalayan Region. Ravindran (1991) observed protein content of 9.8 per cent in three cultivars of ragi. Vadivoo *et al.* (1988) studied 36 genotypes of ragi having varying seed colour and revealed a wide range of protein and calcium content. White seeded genotypes had higher protein content, while brown seeded types had a wide range of variation for protein content. Utta *et al.* (2015) also reported seven per cent protein in ragi grain.

b) Mineral composition

i) Calcium content

Ragi grains are a rich source of calcium in the human diet. Shukla *et al.* (1985a&b) reported that the calcium content in six varieties of ragi from Jabalpur varied from 383 to 480 mg per 100 g and variety RAU6 had the highest calcium content (480 mg per 100 g), whereas, HR374 had the lowest (383 mg per 100 g). They also observed a range of 331.80 to 542.46 mg calcium per 100 g grain in fourteen varieties of ragi. The calcium content varied from 293.9 to 390.6 mg per 100 g in six varieties of ragi from Vizianagaram as reported by Venkanna *et al.* (1987).

Katiyar and Bhatia (1991) reported a lower calcium content of 97 mg per 100 g in Trans-Himalayan ragi types. However, the mean value was 240 mg per 100 g. Upadhyaya *et al*. (2011) found substantial genetic variability for grain Fe, Zn, calcium, and protein contents. Accessions rich in Zn content had significantly higher grain yield potential than those rich in Fe and protein content. However, according to Solomon *et al*. (2014), there was no significant difference in Ca, Fe, and Zn contents among the genotypes. Genotypes Ateso and Gulu-E had the highest crude fat contents while KNE-479 had the lowest. Utta *et al.* (2015) revealed that the calcium content of 36 genotypes of finger millet ranged from 162 to 487 mg per 100g

ii) Iron content

Shukla *et al.* (1985a) reported that the iron contents of the ragi varieties PR202, HR374, CO9, and WR4 were 9.60, 10.33, 5.70, and 7.68 mg per 100 g respectively. They observed that the iron content varied from 5.76 to12.16 mg per 100 g in fourteen varieties of ragi from Jabalpur.

Samantray *et al.* (1989) noticed that the iron content varied from19.00 to 20.00 mg per 100 g in nine cultivars of ragi from Bhubaneshwar, whereas according to Katiyar and Bhatia (1991) the mean value was 16 mg iron per 100 g of the grain of ragi in Trans-Himalayan region. As per findings of Singh and Srivastava (2006), the iron content of 16 finger millet varieties ranged from 3.61 mg/100g to 5.42 mg per 100g

According to Shashi *et al*. (2007), the calcium content in different genotypes ranged from 264-365 mg/100g and iron from 3.60-7.31 mg/100g whereas bio-availability of iron was more in ML426 and ML322 and also, they had fewer tannins and phytates (0.30 mg/100g and 0.34 mg/100g respectively). The bio-availability of iron appeared to be associated with the high content of antinutritional factors like phytates and tannin. The bioavailability of iron in ML197 was very less due to the presence of more tannins and phytates.

Singh and Srivastava (2006) reported that finger millet could be incorporated up to 60 per cent in iron-rich and cost-effective health formulations (*eg; Namak pare recipe mix*.) in supplementary feeding programs in rural areas. These mixes were nutritious (crude protein 9.3-23.6 per cent, iron 878-1342 μg per 100g, *in-vitro* iron bio-availability 28.6 -42 per cent, calcium 22-517.7 mg per 100g). These mixes also had a good shelf life.

Tahsin and Auti (2017) analyzed 64 landraces from Maharashtra for 8 mineral elements Cu, Zn, Fe, Mn, K, Ca, Mg, and Na by tri-acid digestion method. Results showed substantial genetic variability for the mineral content of grains among the landraces. Content of calcium (159.7-364.6 mg/100gm) and iron (10.2-424.1 mg/100gm) were higher followed by potassium (26-184 mg/100gm) and sodium (107-268.2 mg/kg)

Soil nutrient status and plant nutrient uptake

It is widely recognized that neither organic manures nor chemical fertilizers used separately can achieve the yield sustainability at a higher order under the modern intensive farming, in which the nutrient turnover in the soil-plant system has been quite high.

Organic practices have been shown to be important for P nutrition in finger millet. Based on a long-term field study at Tamil Nadu, India, Hemalatha and Chellamuthu (2011 &2013) found that continuous application of 100% NPK + FYM increased P availability, which agrees with previous findings by Govindappa *et. al.* (2009). This could be due possibly to the solubilisation of P by organic acids released during organic matter decomposition. An earlier study by Subramanian and Kumaraswami (1989) also reported that application of NPK, along with FYM increased the uptake of P by finger millet.

Most of the micronutrient studies related to finger millet have concentrated on zinc (Zn) and boron (B). Based on soil tests with 1617 farmers in the semi-arid tropics of India, Srinivasarao *et al.* (2008) found that Zn and B deficiency ranged from 2%–100% and 0%–100% respectively in farmers' fields, depending on the geographic region

Srinivasarao et al. (2008) and Hemalatha and Chellamuthu (2013) found that application of FYM along with 100% NPK inorganic fertilizer increased the grain yield of finger millet as well as the soil organic C level

Ramakrishnan and Bhuvaneswari (2014) found that finger millet treated with Azospirillium + arbuscular mycorrhizal (AM) fungi + PSB increased plant growth and N, P uptake. Uptake of macro (N, P) and micronutrients (Zn, Cu) by plants was also enhanced when finger millet was treated with AM fungi compared to non-inoculated plants (Tewari et.al., 1993).

Roy *et al.* (1996) reported that highest yields were obtained with cv. A-404 and WR-5 (32.5 and 31.7 q/ha, respectively) and average yield was highest (34.8 q/ha) at the highest level of 60 kg N/ha

3.Materials and Methods

3. MATERIALS AND METHODS

The experiment entitled "Performance of high yielding varieties of finger millet (*Eleusine coracana* (L.) Gaertn" was conducted during the period from July 2018 to January 2019 at Agronomy Farm, College of Agriculture, Vellanikkara, Thrissur. It was undertaken with the objective to assess the performance of different ragi varieties and to assess their performance in *Kharif* and *Rabi* seasons.

The procedure followed and the materials and methods used for the study are described in this chapter.

3.1 Experimental site

The field trial was conducted at the Agronomy farm, College of Agriculture, Vellanikkara, Thrissur, Kerala in the year 2018-19 during both *Kharif* and *Rabi* seasons. The farm is located in the Agro Climatic Zone (ACZ)-II (Mid laterites), ACU-10 (North Central laterites) of Kerala. Two different plots were selected for the research. The farm is located at 10^0 33'07" N latitude and 76^0 16'56" E longitude and is situated 40.3 m above MSL.

3.2 Soil

Soil samples drawn randomly from 0 to 15 cm depth were analysed for physical and chemical properties. The soil was sandy loam and chemical analysis indicate that soil is acidic in reaction, medium in organic carbon, available nitrogen, phosphorus and potassium.

Before the start of experiment soil samples were collected from the experimental field. Similarly, soil samples were also collected plot-wise after harvest. The soil samples were processed and analysed for available N, P, and K which were expressed in kg/ha. Methods adopted for analysis of the soil samples are indicated in Table 1.

Table 1. Soil physical and chemical properties of the experimental site

Particulars	Value		Method adopted
	Kharif	***Rabi***	
a. Soil physical characteristics			
Particle density (Mg/m^3)	2.61	2.60	Pycnometer method (Black *et al*, 1965)
Bulk density (Mg/m^3)	1.45	1.40	Core method (Gupta and Dakshinamoorthy,1980)
b. Soil chemical characteristics			
Soil reaction (pH)	5.26	4.93	pH meter (Jackson, 1958)
Organic C (%)	1.0	0.93	Walkley and Black method (Jackson, 1958)
Available N (kg/ha)	144	124	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P (kg/ha)	24	20	Bray-1 extract ascorbic acid reductant method (Bray and Kurtz,1945; Watanabe and Olsen, 1965)
Available K (kg/ha)	180	204	Neutral normal ammonium acetate extraction and estimation using flame photometry (Jackson, 1958)

3.3 Season and climate

The *Kharif* crop was grown after harvesting of cassava from July to October 2018 while the *Rabi* crop was grown from October 2018 to January 2019, in a different plot where fodder grasses were grown previously. The data on weather parameters (weekly data on maximum and minimum temperature (ºC), relative humidity, rainfall, sunshine hours/day, and evaporation) during the cropping period and presented in Appendix no.1 and Figure no. 2.

During the *Kharif* season, the weekly mean of maximum temperature ranged from 27.2 ºC to 33 ºC with an average of 30.4 ºC, and minimum temperature ranged from 21.6 ºC to 23.2 ºC with an average of 22.4 ºC. The mean of maximum temperature for *Rabi* ranged from 31.6 ºC to 33.6 ºC, with an average of 32.8 ºC. The weekly mean relative humidity was 84% during the *Kharif* crop whereas it was only 65% in *Rabi*. The *Kharif* crop received 2153.7 mm rainfall in 62 rainy days. During the *Rabi* crop period, a total of 318 mm of rainfall was received in 13 rainy days. During the crop period, the weekly mean evaporation (measured using USWB Class-A Open Pan Evaporimeter) ranged from 1.5-3.8 mm/day with an average of 2.7 mm/day during *Kharif*. In *Rabi* mean evaporation ranged 2.6-5.5 mm with an average of 3.7 mm/day.

3.4 Experimental design and layout

The layout plan of the experiment is presented in Figure 1. The crop was raised in two seasons *Kharif* and *Rabi* 2018. Randomized block design was adopted with nine treatments replicated thrice. The plot size was 5 m x 4 m. Spacing of 25 cm x 15cm was followed.

Nine high yielding finger millet varieties (V_1 to V_9) were used in the study, the details of which are furnished below.

Name of variety	Yield potential	Institute which developed the variety	Parentage	Characteristics	Source of seed material
Champavati (VR 708)	20 -25 q/ha	ARS Vijayanagaram, Andhra Pradesh	Pure line selection from VMEC 36	Photo insensitive variety and early maturity	IIMR, Hyderabad, Andhra Pradesh
Vakula (PPR 2700)	25-30 q/ha	ARS, Perumallapalli, Andhra Pradesh	KM 55 x U 22/B	Resistant to leaf blast, tolerant to drought	Perumallapalli, Tirupati Andhra Pradesh
Ratna (GPU48)	25-30 q/ha	AICSMIP, GKVK, Bangalore	GPU 26 x L 5	Purple pigmentation on parts of the plant, early maturity	Project Coordinating Unit, AICSMIP, GKVK, Bangalore, Karnataka
GPU28	35-40 q/ha	AICSMIP, GKVK, Bangalore	Indaf 5 x IE1012	Comparatively broader leaves and thick stem, resistant to biotic and abiotic stresses	
Maruti (PR230)	30- 35 q/ha	ANGRAU, Paleru	Pure line selection from Rangareddy district	Medium tall plants, incurved and medium sized ears	Perumallapalli, Tirupati Andhra Pradesh
Hima (VR936)	28-32 q/ha	ARS, Vizianagaram, Andhra Pradesh	IE 2695 x Godavari	White grains, Purple pigmentation on nodes, resistant to biotic and abiotic stresses	
CO15	25-30 q/ha	Millet Breeding Station, TNAU, Coimbatore	CO 11 X PR 202	Highly responsive to nitrogenous fertilizer, non-lodging, resistant to leaf, neck and finger blasts	AC & RI, TNAU, Coimbatore, Tamilnadu
Godavari (PR202)	30-35 q/ha	ARS, Peddapuram, Andhra Pradesh	Pure line selection from Mettachodi ragi of Araku valley	Orange brown coloured, bold grains	Perumallapalli, Tirupati Andhra Pradesh
KMR 201	35-40 q/ha	VC Farm, UAS (B) Mandya, Karnataka	GPU 26 x GE 1409	Light colour ear head with whitish green glumes	PC Unit, AICSMIP, GKVK, Bangalore, Karnataka

3.5 Cultivation practices

1. Field preparation

The field was ploughed thoroughly with disc plough, followed by cultivator to a fine tilth. Weeds and stubbles were removed and layout was done as in Fig .1

2. Application of lime, manures, and fertilizers

Cowdung was applied basally @ 5 t/ha. Nitrogen, phosphorus and potash were applied as per recommendation *i.e.*, 45:22.5:22.5 N: P_2O_5: K_2O kg/ha. Each nutrient was applied @ 22.5 kg/ha each basally, and a second dose of nitrogen @ 22.5 kg/ha was applied during the time of gap-filling which was done at 20 days after sowing (KAU, 2016).

3. Seeds and Sowing

Sowing of *Kharif* crop was done on 15th July 2018 and that of *Rabi* crop on 1st Oct 2018. *S*eeds were soaked for 12 hrs to enhance the germination and then was inoculated with *Azospirillum brasilense* @ 25g/kg seed. *S*eeds of all varieties were dibbled in lines at a spacing of 25cm x 15cm in each plot as per the layout. Gap filling was done at 20 DAS in both the seasons.

4. Weeding

Manual weeding was done twice at 20 and 35 days after sowing in both the seasons.

5. Plant protection

The incidence of blast was observed during the *Kharif* season which was controlled by application of fungicide Saaf® (Carbendazim 12% + Mancozeb 63%). Minor incidence of leaf eating caterpillars was also observed by the harvesting period hence no control measure taken.

3.6 Observations

Observations on various parameters like growth, yield, and yield attributing characters of ragi were noted and the mean values were worked out.

Sampling procedure

Observations were taken at 30 DAS, flowering, as well and at harvest. Excluding the border plants, five plants were selected randomly and tagged as observation plants. Destructive sampling of five hills was followed for dry matter estimation at 30 DAS, flowering, and at harvest. In case of nutrient uptake estimation, plant samples collected at harvest were dried in a hot air oven at 70 ±5ºC for 48 hours and ground into a fine powder.

1. Crop growth parameters

a. Plant height

Plant height from the ground level till the apex of the top leaf was noted at 30 DAS, flowering and at harvest, and expressed in cm.

b. Days to 50 percent flowering

The total number of days taken for heading of 50 per cent of the plant population in a plot was recorded and an average of three replications was noted for both seasons.

c. Finger length

Five random ears were harvested and finger length was noted. The length of the ear was noted from the base spikelet till the longest finger excluding the odd finger and mean values were calculated.

d. Dry matter production

Dry matter of the plant was recorded at 30 DAS, flowering and harvest, by the destructive sampling of the five random plants. excluding tagged plants and border plants. The samples were air-dried and then oven-dried 70 ±5ºC for two consecutive readings and then mean dry weight was noted as g/plant.

e. Total number of tillers

The total number of tillers per plant was counted from five hills at random at the heading stage and the average was worked out

2. Yield and yield attributes

a. Number of productive tillers per plant

The tillers with ear heads from tagged plants in each plot were counted and the average was worked out.

b. 1000 grain weight

Grain samples were drawn from the harvested net plots and counted for the 100-grain weight for each replication and multiplied by 10 to get 1000 grain weight of each variety and average was worked out for both the seasons

c. Grain yield

The net plot was marked, harvested separately, and dried. After threshing, grains were separated, cleaned, and weighed. Later the grain yield per net plot was expressed on per hectare basis.

d. Straw yield

After threshing and removal of grains, straw from the net plot area was dried and weighed. The straw yield was expressed in kg/ ha for both seasons.

e. Harvest index (%)

Harvest Index (HI) was expressed as the ratio of grain yield to biological yield

3. Quality parameters of ragi grain

a. Crude protein content

Nitrogen content in ragi grain was estimated and the crude protein percentage was calculated by multiplying the percentage of nitrogen with the factor 6.25

b. Calcium and iron content

Calcium and iron content of ragi varieties were estimated using Atomic Absorption Spectrophotometer (AAS) as per the procedure of Lindsay and Novell (1978).

c. Fibre content

The fiber content in grain was estimated by the acid-alkaline digestion method described by Asp *et al* (1983)**.** The powdered sample was added to the sulphuric acid solution, boiled then drained and washed free of acid, followed by washing with sodium hydroxide and then washed with ethyl alcohol and drained and moved to Buncher funnel and ash contents were weighed.

4. Plant nutrient uptake

Plant samples collected at harvest were air-dried then in a hot air oven at 70 ±5ºC for 48 hours and ground into fine powder and samples were drawn for NPK analysis. The method followed is given below

Nutrient	Method	Reference
N	Modified micro Kjeldahl method	Jackson *et al*, 1973
P	Vanado-molybdo phosphoric yellow colour method using a spectrophotometer	
K	Flame photometry	

5. Weather parameters

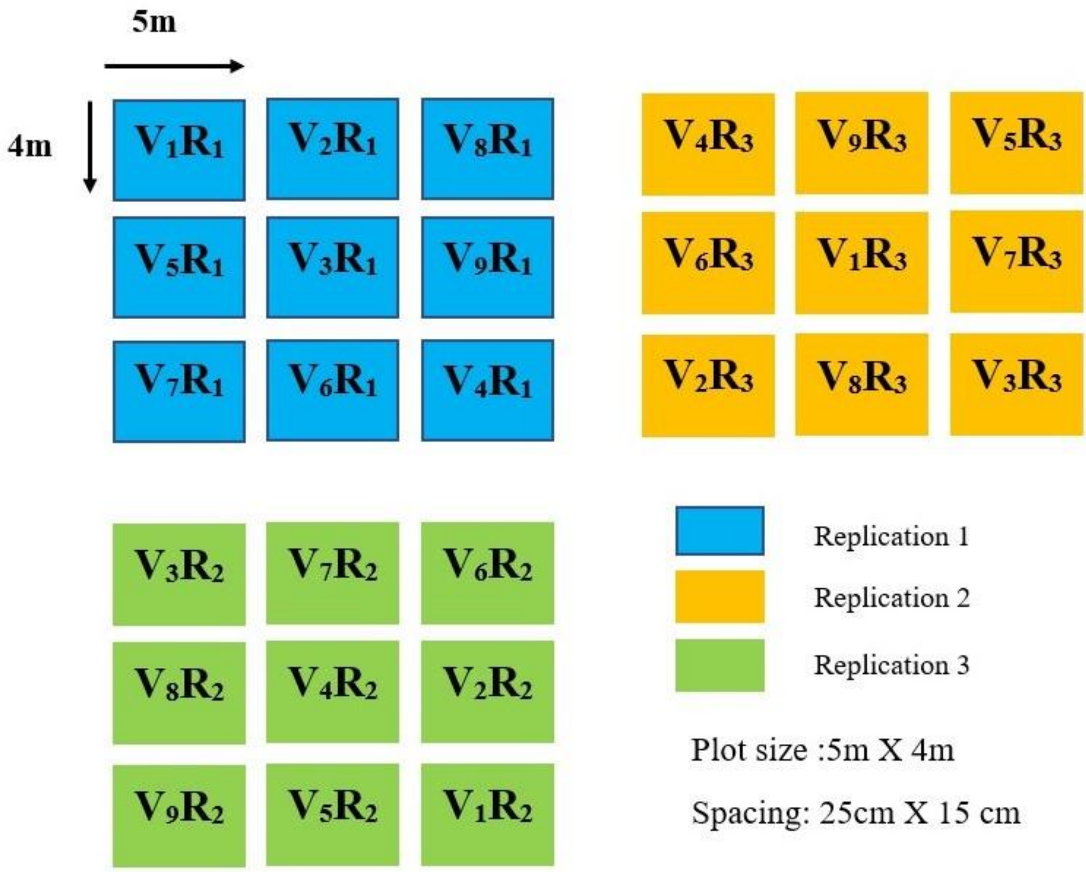
Data on the following weather parameters recorded from June 2018 to January 2019 was collected from the Department of Agricultural Meteorology, College of Agriculture, Vellanikarra.

a. Maximum temperature (℃)
b. Minimum temperature (℃)
c. Relative humidity (%)
d. Rainfall (mm)
e. Bright sunshine hours (hrs)

Data of weather parameters are provided in Figure 2. and Appendix

3.7 Statistical analysis

The data collected were subjected to analysis of variance and computed statistically by choosing the appropriate experimental design and utilizing the statistical package of ‘OP Stat’ (Gomez, and Gomez, 1984). Wherever the variable was found significant, a critical difference was given for effective comparison of the means.



V_1 :-Champavati (VR708)

V_2 :-Vakula (PPR2700)

V_3 :-Ratna (GPU48)

V_4 :-GPU28

V_5 :-Maruthi (PR230)

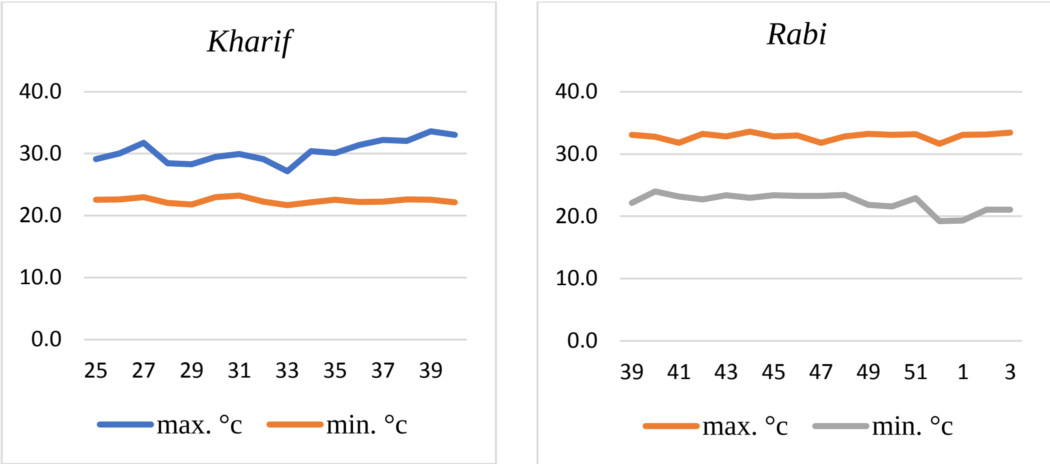
V_6 :- Hima (VR936)

V_7 :-CO15

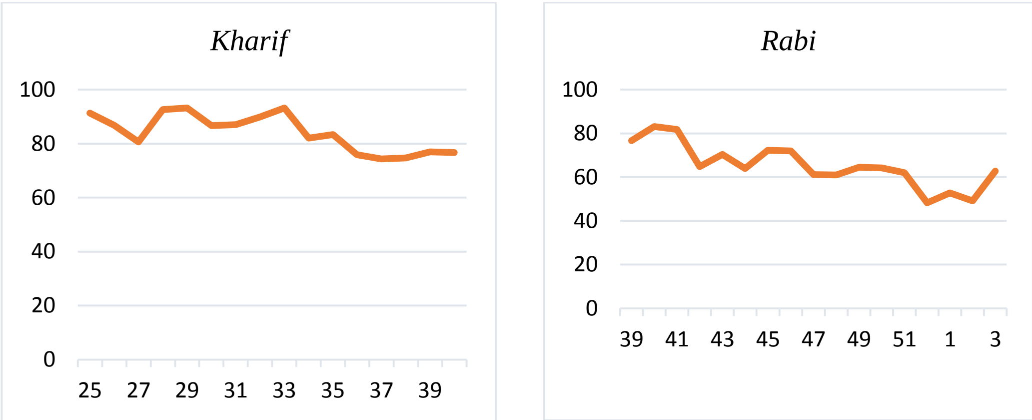
V_8 :-Godhavari (PR202)

V_9 :-KMR201

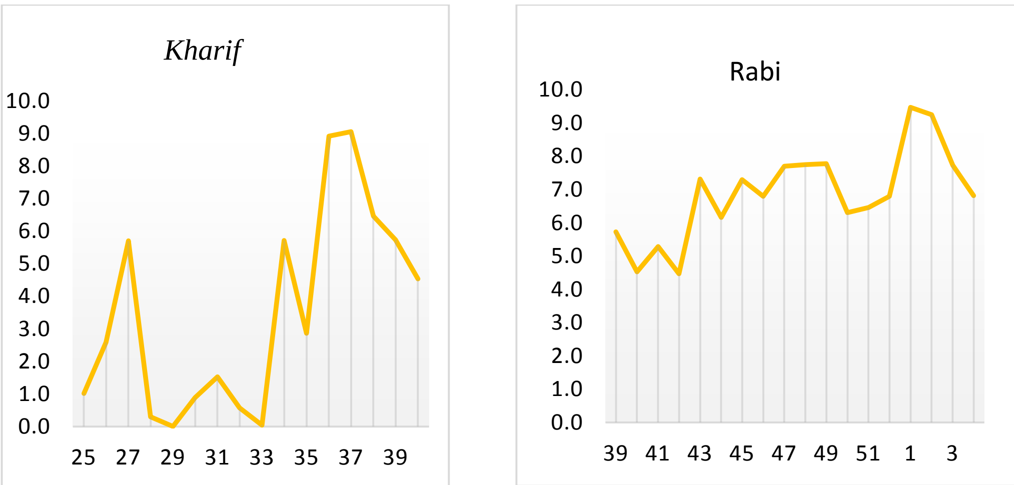
Fig. 1 Layout of the experimental plot



(a)Weekly weather data of Minimum and maximum temperatures (^{0} C)

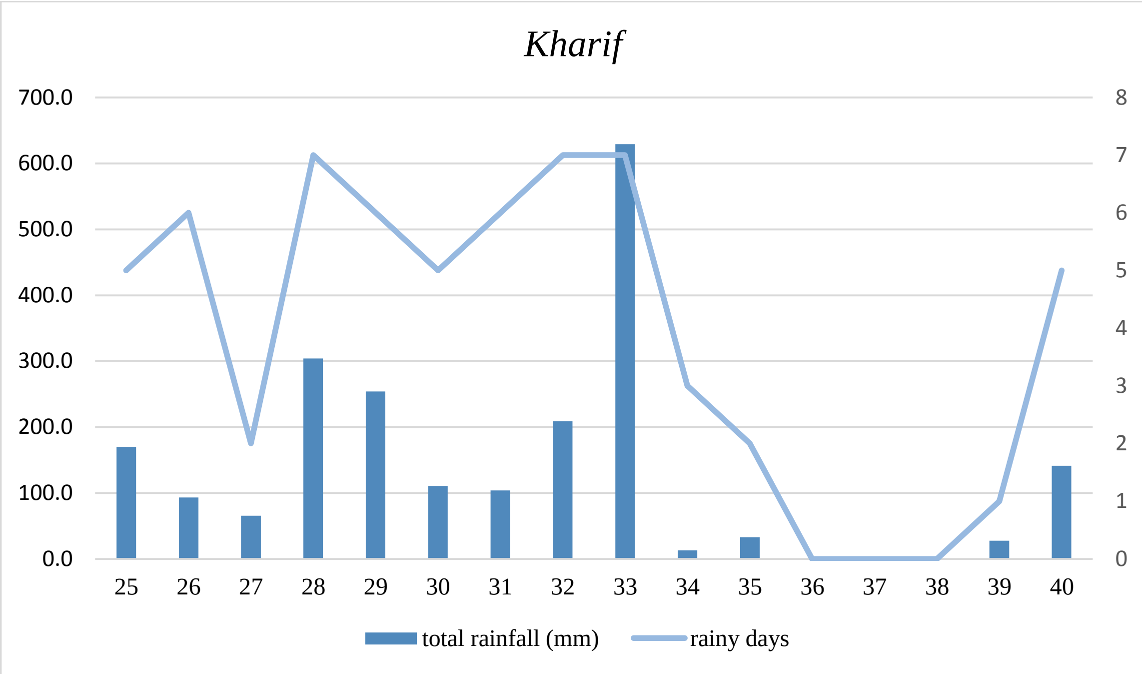


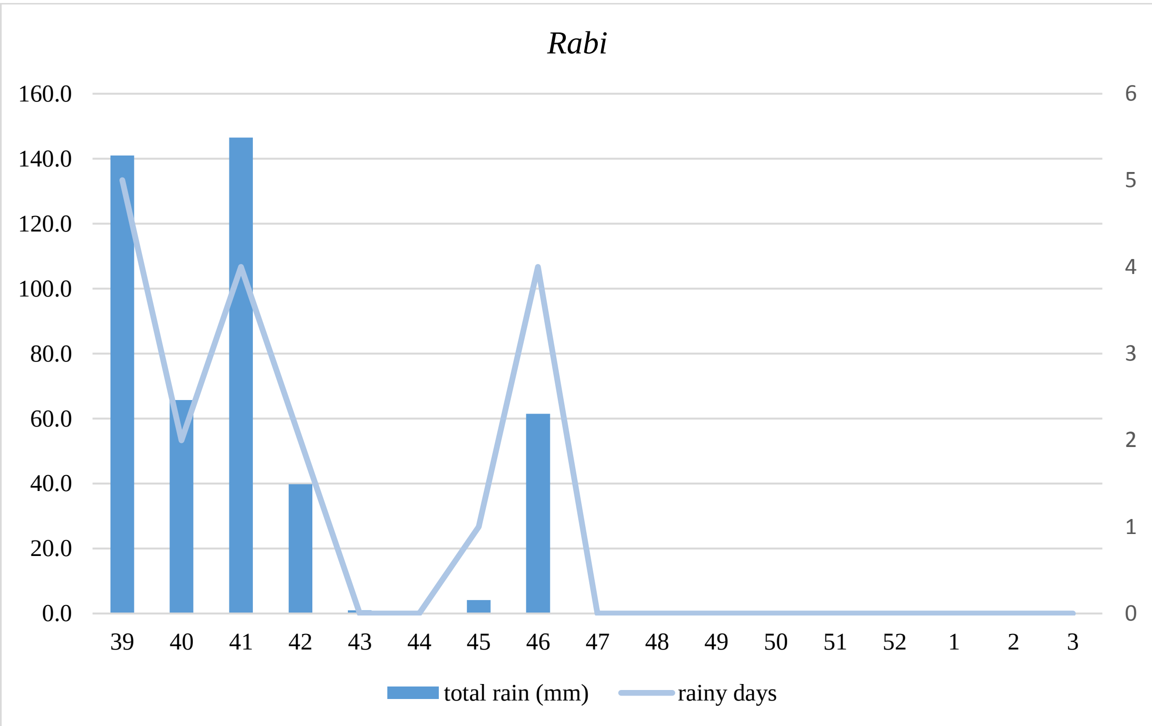
(b)Weekly weather data of Relative Humidity (%)



(c)Weekly weather data of Sun Shine hours

Fig. 2 Weekly weather data of weather parameter during the experimental period in both *Kharif* and *Rabi* seasons





(d) Weekly weather data of Rainfall and Rainy days

Plate 1. Land preparation and liming

Plate 2. Gap filling

Plate 3. Hand weeding at 30 DAS

Plate 4. Harvesting

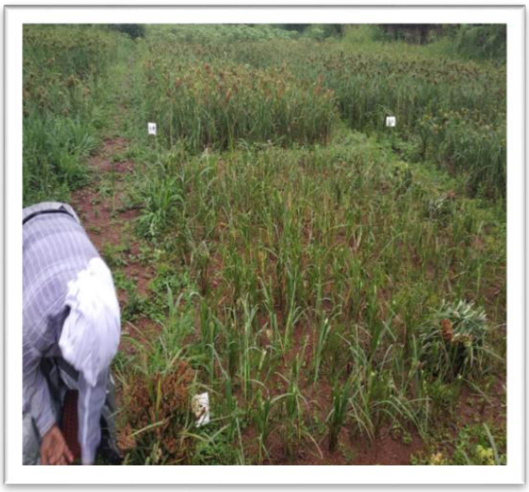


Plate 5. Experimental plot view

4.Results

4. RESULTS

An experiment entitled “Performance of high yielding varieties of finger millet *(Eleusine coracana* (L.) Gaertn)” was undertaken to study the response of different ragi varieties during both the seasons and to identify the most promising variety released from other state universities under Kerala climatic condition. The experiment was conducted during the period from June 2018 to January2019 at the Agronomy field, College of Agriculture, Vellanikkara, Thrissur. The experiment data collected was statistically analysed and the results are presented below.

4.1 Growth parameters

The data on different growth attributes such as plant height, days taken for 50 per cent flowering, finger length, dry-matter production and the total number of basal tillers produced which influence the yield and performance of the varieties and their interaction with the environment during *Kharif* and *Rabi* are presented below.

4.1.1. Plant height

Plant height was recorded at 30 DAS, flowering and at harvest in both the seasons and depicted in Table 2. In general, plants were taller in *Kharif* compared to *Rabi* season. In *Kharif*, at 30 DAS, the average plant height of various varieties was 24.02 cm whereas it was 22.6 cm in *Rabi*. Height of the plants increased to 78.55 cm at flowering stage in *Kharif* and to 74.16 cm in *Rabi*. The corresponding values in *Kharif* and *Rabi* seasons at harvest stage were 91.73 cm and 85.20 cm respectively.

In *Kharif*, at 30 DAS, Vakula (28.30 cm), GPU 28 (29.77 cm) and Hima (27.67 cm) were statistically comparable with respect to plant height and were taller than rest of the varieties. Variety Maruthi was shortest with 21.57 cm. However, four other varieties were statistically at par to Maruthi. By flowering, this trend changed and PR 202 was taller than other varieties with a plant height of 95.55 cm and was significantly superior. Varieties which were taller at 30 DAS were inferior in plant height by flowering stage.

When plant height was recorded at harvest, GPU28 (109.71 cm) and PR202 (111.07 cm) were superior to all other varieties with statistically comparable values. The shorter varieties were GPU48 (77.75 cm) and VR708 (78.39 cm).

In *Rabi,* at 30 DAS the trend in plant height was almost same as in *Kharif* season, with varieties Vakula (23.73 cm), GPU 28 (24.87 cm), Hima (24.73 cm) and CO15 (cm) with comparable values in plant height and were taller. GPU48 (20.83 cm), Maruti (21.37 cm) and PR 202 (20.53 cm) were dwarfer than others. These varieties failed to record superior values at later stages. At flowering, CO15 was the tallest variety with a plant height of 91.19 cm. Vakula (67.04 cm) and Maruthi (67.51 cm) were shorter than others.

At maturity, CO15 continued to register the tallest plants (100.41 cm). However, PR 202 (98.65 cm) also had statistically comparable plant height. VR 708 (72.17 cm), Maruthi (73.99 cm) and GPU48 (72.98 cm) were statistically on par and were inferior to other varieties.

Table 2. Plant height (cm) at 30 DAS, flowering and harvest of ragi varieties during *Kharif* and *Rabi* seasons

Varieties	30 DAS		Flowering		Harvest	
	Kharif	***Rabi***	***Kharif***	***Rabi***	***Kharif***	***Rabi***
V_1 -VR708	21.60	21.07	65.95	65.54	78.39	72.17
V_2 -Vakula	28.30	23.73	64.37	67.04	72.21	81.27
V_3 -GPU48	23.57	20.83	71.83	70.43	77.75	72.98
V_4 -GPU28	29.77	24.87	87.80	72.77	109.71	95.29
V_5 -Maruthi	21.57	21.37	76.94	67.51	92.32	73.99
V_6 -Hima	27.67	24.73	66.93	72.48	75.20	81.29
V_7 -CO15	25.10	23.60	88.85	91.19	100.85	100.41
V_8 -PR202	22.67	20.53	95.55	83.96	111.07	98.65
V_9 -KMR201	24.03	22.30	88.78	76.54	108.03	91.15
SEm (±)	0.991	0.498	1.252	1.132	0.835	0.801
CD (0.05)	2.97	1.51	3.75	3.39	2.50	2.40

4.1.2. Days to 50 per cent flowering and crop duration

The data on the number of days taken for 50 percent ear emergence and the total duration of the crop is given in Table 3. The varieties differed significantly with respect to both flowering and crop duration in both the seasons. In general, *Rabi* crop took more time for 50 per cent flowering as well as crop duration than *Kharif* crop. The average mean of 50 per cent flowering for *Kharif* and *Rabi* were 69.4 days and 71.2 days respectively. Whereas, total crop duration mean was noted as almost similar. (103 days).

In *Kharif* season, PR202 (79 days) took a longer duration for 50 per cent ear emergence of compared to all other varieties, and variety Hima (75 days) was found to be on par with PR202. The variety which took the least duration to 50 per cent flowering was VR708 (56 days). Other varieties took duration ranging between 63 to 71 days. With respect to total crop duration similar trend was observed with PR202 (113 days) having a longer duration which was on par with Vakula (111 days). The Varieties having least duration was noted to be VR708 taking 90 days. Other varieties were statistically comparable and were in between 96 to 109 days.

In *Rabi* season, variety Vakula (81days) took the longest period for 50 per cent ear emergence which was statistically greater than other varieties. The variety Hima (75 days) was found to be on par with Vakula. Two varieties *viz.*, VR708 and KMR201 took the least time for 50 per cent flowering which was 64.3 and 65 days respectively. As for total crop duration, Vakula (121 days) and PR202 (120 days) took a longer period crop duration. The variety with short duration was found to be VR708 (89 days). Three varieties were on par with VR708. viz., Hima (94 days), KMR201 (96 days) and Maruthi (97 days).

Table 3. Days to 50 per cent flowering and crop duration of ragi varieties during *Kharif* and *Rabi* seasons

Varieties	Days to 50 per cent flowering		Total crop duration(days)	
	Kharif	***Rabi***	***Kharif***	***Rabi***
V_1 -VR708	56.3	64.3	90.7	89.7
V_2 -Vakula	71.3	81.0	111.3	121.7
V_3 -GPU48	70.6	71.3	105.0	102.3
V_4 -GPU28	63.3	74.0	100.0	108.0
V_5 -Maruthi	70.3	70.3	96.3	97.3
V_6 -Hima	75.3	75.0	104.7	94.3
V_7 -CO15	67.0	71.6	101.7	100.7
V_8 -PR202	79.3	74.3	113.3	120.3
V_9 -KMR201	67.6	65.0	109.3	96.7
SEm (±)	2.407	2.071	2.846	3.101
CD (0.05)	7.21	6.03	8.53	9.29

4.1.3. Finger length (cm)

Finger length of each variety after harvest and length of the longest finger of each ear were noted and depicted in the table. The length was taken from base to the tip of the finger excluding the odd finger present separately. For the whorled type varieties, the fingers were stretched and observations were taken. It was observed that the mean of all the varieties was 8.2 cm for *Kharif* and 8.6 cm for *Rabi* which were almost same. But the length of fingers was slightly more in *Rabi* compared to *Kharif* season. The data on finger length of both the seasons are given in Table 4.

In *Kharif*, Vakula (11.87 cm) was having a higher finger length and was statistically superior in terms of finger length than other varieties. The variety VR708 recorded shortest finger length of 5.30 cm. Other varieties were having finger length in between 6.6 to 10.1cm. Five varieties *viz.*, GPU28(10.10 cm), CO15 (9.10 cm), KMR201 (8.70 cm) and GPU48 (8.70 cm) had fingers longer than the average of the experimented varieties.

In *Rabi*, a similar trend of finger length was observed in most of the varieties as in case of *Kharif* season. The variety Vakula produced longer fingers of 13.05 cm length on average and shorter finger length was recorded by VR708 (6.11 cm). Two varieties PR202 (6.53 cm) and Maruthi (6.91 cm) were found to be on par with VR708. Other varieties were in the range between 7.5 to 11.3 cm but only three varieties such as CO15 (11.02 cm), Vakula (13.05 cm) and KMR201 (9.88 cm) were having finger length greater than mean of experimented varieties.

Table 4. Finger length (cm) of ragi varieties during *Kharif* and *Rabi* seasons

Varieties	Finger length (cm)	
	Kharif	***Rabi***
V_1 -VR708	5.30	6.11
V_2 -Vakula	11.87	13.05
V_3 -GPU48	8.70	8.58
V_4 -GPU28	10.10	7.26
V_5 -Maruthi	6.63	6.91
V_6 -Hima	7.87	7.94
V_7 -CO15	9.10	11.02
V_8 -PR202	6.60	6.53
V_9 -KMR201	8.70	9.88
SEm (±)	0.353	0.366
CD (0.05)	1.05	1.10

4.1.4. Dry matter production

The data representing total dry matter produced per plant is represented in Table 5. Destructive sampling was done to identify total dry matter content produced by plant and weight of each variety was noted at three stages viz., 30 DAS, flowering and at harvesting stage

In *Kharif* season, at 30 DAS there was no significant difference. A higher dry matter was produced by KMR201 (62.8 g), it was found to be on par with VR708 (53.9 g) and GPU28 (52.9 g). The least dry weight was produced by Maruthi (40 g). Other varieties were in between the range 46 g to 49 g. An almost similar trend continued at the harvest stage, with KMR201 (68 g) having greater dry matter content and Maruthi (44 g) having lesser dry matter produced per plant.

In *Rabi* season, observation taken during 30 DAS was found to be non-significant and not much difference in comparison to *Kharif* was observed. But by flowering CO15 (62.72 g) was found to have greater dry matter produced than other varieties. It was found to be on par with VR708 (59.22 g) and Hima (59.78 g). The least dry matter produced at flowering stage was noted by Maruthi (42.66g). However, change in dry matter between varieties was observed by time of harvesting stage, VR708 recorded maximum dry weight (64.20 g) which was on par with Hima (62.66 g) and GPU 28 (60.2 g). Once again, the least dry weight was recorded by Maruthi (45.60 g). It was observed on average more of dry weight was recorded in *Rabi* season compared to *Kharif* season.

Table 5. Dry matter produced (g/plant) of ragi varieties during *Kharif* and *Rabi* seasons

Varieties	**Dry matter production (g/plant)**					
	30 DAS		**Flowering**		**Harvest**	
	Kharif	***Rabi***	***Kharif***	***Rabi***	***Kharif***	***Rabi***
V_1 -VR708	3.97	2.94	53.96	59.22	59.60	64.20
V_2 -Vakula	4.26	3.86	48.59	43.16	54.24	49.57
V_3 -GPU48	4.01	4.15	46.79	48.17	49.69	52.56
V_4 -GPU28	3.70	3.75	52.93	57.78	53.59	60.24
V_5 -Maruthi	3.93	3.95	40.43	42.66	44.60	45.60
V_6 -Hima	3.92	3.64	52.05	59.74	56.70	62.66
V_7 -CO15	4.29	3.56	49.09	62.72	54.30	55.63
V_8 -PR202	3.59	3.69	48.31	54.79	52.40	55.32
V_9 -KMR201	5.35	4.69	62.64	46.49	68.50	51.04
SEm (±)	0.57	0.76	1.43	1.32	2.04	2.55
CD (0.05)	NS	NS	4.53	3.54	5.47	6.43

4.1.5. Total number of tillers

The data on mean number of total tillers is given in Table 6. The varieties differed significantly with respect to total number of tillers in both the seasons. In general, *Rabi* crop had a greater number of basal tillers than *Kharif* crop. The average number of basal tillers was 5.8 in *Kharif* and 6.78 in *Rabi.*

In *Kharif*, variety VR708 (9.27) was statistically comparable with respect to basal tiller produced and formed more tillers than other varieties. Variety Vakula produced only 3.60 tillers. However, four varieties were statistically on par with Vakula. Other varieties formed a smaller number of basal tillers ranged between 5.60 to 7.80.

In *Rabi*, the greater number of tillers were produced by VR708 (10.27) and CO15 (9.93). These had comparable values in basal tiller number and formed more of basal tillers than other varieties. Variety Maruthi (4.67) and Vakula (5.33) formed a lesser number of basal tillers. GPU48 (6.71) and PR202 (5.53) were found to be on par with them. In *Rabi*, the total number of tillers produced was almost the same as *Kharif* season in most of the varieties except for Hima and Vakula.

4.2 Yield and Yield Attributes

The different yield parameter like straw yield and grain yield along with their harvest index. And different yielding attributes like number of productive tillers produced per plant along with the 1000 grain weight which could influence yields of variety were observed. The performance of each variety was analysed to have better understanding of its yield and yielding attributes influence under both *Kharif* and *Rabi* seasons.

4.2.1. Productive tillers per plant

The total number of productive tillers produced is depicted in Table 6. In general, there were more productive tillers in *Kharif* in comparison to *Rabi.* Almost, a similar trend to that of basal tillers was observed in case of productive tillers. There was a significant difference observed among the varieties.

Among the varieties examined in *Kharif* season, VR708 (7.16) was statistically comparable to other varieties and was having a superior number of productive tillers. The least number of productive tillers were observed in case of Vakula (2.44). Three varieties were found to be on par with Vakula *viz.*, Maruthi (2.90), GPU28 (3.62) and Hima (3.94). The average mean number of tillers produced in *Kharif* was 4.6.

In *Rabi* season, once again a similar pattern was observed as in *Kharif* with VR708 (6.29) with highest and Maruthi (2.75) and Vakula (2.16) with least productive tiller number. Other varieties produce productive tiller in the range between 3.36 to 4.61. Variety Hima (3.36) was found to be on par with Vakula. The average number of tillers produced in *Rabi* was 3.84.

4.2.2 1000 grain weight (g)

The data pertaining to 1000 grain weight of ragi is presented in Table 7. The varieties differed significantly in both the seasons. PR 202 (3.53 g) had the highest 1000 grain weight compared to all other varieties in *Kharif* season when statistically comprehended. 1000 grain weight was observed in decreasing in GPU48 (3.39 g), CO15 (3.16 g), GPU28 (2.32 g), respectively. VR708 (2.22 g) was found to be on par with Vakula (2.31g) and KMR201 (2.10 g). The least weight was recorded by Maruthi (1.50 g) followed by Hima (1.78 g)

A similar trend was observed in *Rabi* season with highest and least being GPU28 (3.24 g) and Maruthi (1.51 g) respectively. Whereas, other varieties differ in compared to *Kharif* season like, increase in 1000 grain weight was observed in GPU28 (2.64 g) and Hima (2.23 g) and decrease of weight was recorded in PR202 (3.25 g) to a small extent in *Rabi* season

Table 6 - Total number of basal and productive tillers of ragi varieties during *Kharif* and *Rabi* seasons

Varieties	Total tillers		Productive tillers	
	Kharif	***Rabi***	***Kharif***	***Rabi***
V_1 -VR708	9.27	10.27	7.16	6.29
V_2 -Vakula	3.60	5.33	2.44	2.16
V_3 -GPU48	7.07	6.71	4.48	3.60
V_4 -GPU28	4.13	5.60	3.62	3.87
V_5 -Maruthi	4.00	4.67	2.90	2.75
V_6 -Hima	4.53	6.60	3.94	3.36
V_7 -CO15	7.80	9.93	6.19	4.61
V_8 -PR202	5.60	5.53	5.02	4.13
V_9 -KMR201	5.20	6.33	5.2	4.5
SEm (±)	0.230	0.319	0.383	0.275
CD (0.05)	0.69	0.96	1.15	0.929

. Table 7.   1000 grain weight (g) of ragi varieties during *Kharif* and *Rabi*

Varieties	***Kharif***	***Rabi***
V_1 -VR708	2.22	2.23
V_2 -Vakula	2.31	2.29
V_3 -GPU48	3.39	3.24
V_4 -GPU28	2.32	2.64
V_5 -Maruthi	1.50	1.51
V_6 -Hima	1.78	2.23
V_7 -CO15	3.16	2.58
V_8 -PR202	3.53	3.25
V_9 -KMR201	2.10	2.27
SEm (±)	0.101	0.046
CD (0.05)	0.31	0.139

4.2.3. Grain yield (kg/ha)

The Grain yield after harvest of each variety in both the season is depicted in Table 8. There was a significant difference in terms of grain yield which was observed when the statistical analysis was done. The yield was observed to be aligning the difference in yielding attributes like productive tillers produced, finger length, dry matter, and ear weight altering the performance of grain yield of each variety.

Though *Rabi* grain yields were better in comparison to *Kharif*, the average yield of the varieties was almost similar to 1944 kg/ha in *Kharif* and 1935 kg/ha in *Rabi*.

In *Kharif*, KMR201 (3008 kg/ha) produced the highest yield and significantly superior to other varieties. On the contrast least yield was noted by three varieties VR708 (850 kg/ha), followed by Maruthi (923 kg/ha), and Vakula (930 kg/ha). Other Five varieties were having moderately average yield and greater than the average yield ranging from 2195 kg/ha to 2515 kg/ha. *viz*. GPU28 (2195 kg/ha), PR202 (2311 kg/ha), CO15 (2355kg/ha), GPU48 (2413 kg/ha) and Hima (2513 kg/ha).

In *Rabi*, a significantly different trend was observed in a few varieties. The variety Hima recorded the maximum yield of about (3092 kg/ha) and was statistically superior to other tested varieties. Similar Trend is followed for least yielding varieties as observed in *Kharif* viz. Maruthi (1096.kg/ha), followed by Vakula (1129 kg/ha) and VR708 (1218 kg/ha). A better performance was observed in these three varieties in comparison to the *Kharif*. Other varieties were in the range between 1833 kg/ha to 2737 kg/ha.

Therefore, after close observation there was a change of 10 to 23 percent was observed in yield trend in both the seasons. Hence in order to better understand a correlation coefficient was tabulated. This could help in better understanding of impact of weather parameter on crop straw yield in *Kharif* and *Rabi* season.

Table 8 – Grain yield and straw yield (kg/ha) of ragi varieties during *Kharif* and *Rabi*

Varieties	Grain yield (kg/ha)		Straw yield (kg/ha)	
	Kharif	***Rabi***	***Kharif***	***Rabi***
V_1 -VR708	850	1218	2125	4733
V_2 -Vakula	930	1129	2570	4518
V_3 -GPU48	2413	2051	5953	6072
V_4 -GPU28	2195	2303	5631	5218
V_5 -Maruthi	923	1096	5541	4079
V_6 -Hima	2513	3092	6906	5281
V_7 -CO15	2355	1833	6180	5429
V_8 -PR202	2311	1955	7423	5931
V_9 -KMR201	3008	2737	7203	6855
SEm (±)	138.01	112.57	393.89	235.96
CD (0.05)	413.7	337.4	1180.9	707

4.2.4. Straw yield (kg/ha)

The straw yield was recorded after harvest and sun-dried straw of each variety in both the season. The data recorded were analysed and depicted in table 8. Both varietal phenotypic and genotypic properties as well as weather parameters had a significant effect of straw yield produced by each variety. In general, varieties having prostrate and decumbent growth habit like Vakula and VR708 respectively were poor yielder in comparison to erect types like PR202 and KMR201.

Straw yield was mainly influenced by plant population, weed density, and crop growth stand which had a major impact on straw yield. In general, the better straw yield was obtained in *Rabi* than in *Kharif* among all the varieties experimented. It was observed that there was a significant difference observed in varieties in both the seasons.

In *Kharif*, PR202 (7423 kg/ha) which was having significantly higher straw yield than other varieties. The varieties KMR201(7203 kg/ha), CO15 (6180 kg/ha), and Hima (6906 kg/ha) were found to be on par with PR202. The varieties VR708 (2125 kg/ha) and, Vakula (2570 kg/ha) were having less straw yield and can be considered as poor yielding among all the varieties tested.

In *Rabi,* KMR201 was having higher straw yields and was statistically superior in terms of straw content produced. The least straw yield was noted in Maruthi (4079 kg/ha) and varieties VR708 (4518 kg/ha) and Vakula (4733 Kg/ha) were found to be on par with Maruthi. In comparison to *Kharif*, the *Rabi* crop was having lesser leaf girth and length as well and varieties like VR708 and Vakula were better performing in *Rabi* season and optimum plant density was maintained.

However, when observed straw yield in both the seasons, there was a drastic change observed in varieties like VR708, Vakula, and GPU28 in *Kharif* as well as *Rabi* which could be explained using a correlation between variety yield and weather parameter.

4.2.5. Harvest Index (HI)

The data representing the harvest index derived from tabulating from grain and straw yield is depicted in the Table 8. It was observed that there was a significant difference in harvest index with respect to varieties in both the seasons. However, the observed mean average of all varieties it was 0.261 in *Kharif* and 0.258 in *Rabi*

In *Kharif,* though there was a significant difference found it was almost similar far almost all the varieties except, for Maruthi (0.14) which was comparable low harvest index. Among the other varieties studied, KMR201 (0.29) noted highest harvest index. The average HI was recorded to be 0.26 in *Kharif* season.

In *Rabi,* Hima (0.3) recorded the highest Harvest Index and is comparable to other varieties. The least harvest index was noted by Vakula and VR708. Four varieties were having almost same HI and were on par with VR708. *viz.,* Maruthi (0.21), PR202 (0.24), CO15 (0.25), and, GPU48 (0.25).

4.3. QUALITY PARAMETER OF RAGI SEED

Ragi is found to have high nutritional values and it tend to change to little extent in few varieties. To observe the properties of quality parameters of seeds like protein content, mineral content (calcium and iron) present, as well as total crude fibre content present in the ragi was recorded and tabulated below. The statistically analysed data of both *Kharif* and *Rabi* is recorded.

Table 9 –Harvest Index of ragi varieties during *Kharif* and *Rabi*

Varieties	***Kharif***	***Rabi***
V_1 -VR708	0.285	0.205
V_2 -Vakula	0.268	0.199
V_3 -GPU48	0.291	0.253
V_4 -GPU28	0.28	0.306
V_5 -Maruthi	0.149	0.211
V_6 -Hima	0.268	0.371
V_7 -CO15	0.276	0.252
V_8 -PR202	0.238	0.248
V_9 -KMR201	0.295	0.285
SEm (±)	0.017	0.010
CD (0.05)	0.076	0.058

4.3.1 Protein content

The protein content of different finger millet varieties experimented in both the seasons is represented in the Table 10. There was significant difference when analysed statistically. It was observed between them since the experiment consist of both white as well as brown varieties. Hima, a white seed variety recorded highest protein content and statistically comparable to other varieties in both the seasons i.e, (8.49%, 8.62%).

Other varieties were having almost similar protein content. When only brown seeded varieties were statistically analysed it was noted the difference was non-significant between the varietal protein content. Among varieties, Maruthi in *Kharif* and GPU28 in *Rabi* recorded comparable low protein content.

4.3.2 Calcium and Iron content

The data pertaining calcium content and iron content present in the grain of each variety is tabulated in the Table 11. It was observed from statistical analysis that there was significant difference between varieties with respect to calcium content present. Also changes of calcium content present in variety differed in both seasons. However, with respect to Iron content present there was non-significant difference observed among the varieties.

The calcium content of variety is almost similar in both seasons, but there was significant difference found among each other. PR202 (564 mg/100g and 513mg/100g) had more calcium content and is comparable to other varieties. The least calcium content in seeds was observed in CO15 (277 mg/ 100g and 295 mg/ 100g) in both seasons. Vakula (326 mg/ 100g, 276 mg/ 100g) and KMR201(295 mg/ 100 g ,290 mg/ 100g) were found to be on par with CO15. Other varieties in between the range 349 mg/ 100g to 474 mg/ 100g.

The iron content difference present among ragi varieties is found to be non-significant. On a glance it could be said variety Vakula and CO15 had higher iron content and KMR 201 had less iron content.

Table 10. Protein content of ragi varieties during *Kharif* and *Rabi*

Varieties	***Kharif***	***Rabi***
V_1 -VR708	7.37	7.29
V_2 -Vakula	7.65	7.46
V_3 -GPU48	6.98	7.01
V_4 -GPU28	7.24	6.68
V_5 -Maruthi	6.76	7.03
V_6 -Hima	8.49	8.62
V_7 -CO15	6.91	7.13
V_8 -PR202	7.17	7.15
V_9 -KMR201	7.26	7.04
CD (0.05)	0.73	0.49

Table 11 Calcium and Iron content (mg/ 100g) of ragi varieties during *Kharif* and *Rabi* seasons

Varieties	Iron content		Calcium content	
	Kharif	***Rabi***	***Kharif***	***Rabi***
V_1 -VR708	6.9	6.4	413.4	341.9
V_2 -Vakula	8.9	8.4	326.1	276.3
V_3 -GPU48	7.3	7.4	372.1	362.0
V_4 -GPU28	8.4	7.4	440.8	473.4
V_5 -Maruthi	7.0	7.0	474.4	551.8
V_6 -Hima	7.6	7.4	357.9	429.5
V_7 -CO15	8.7	8.5	277.1	295.6
V_8 -PR202	8.3	7.0	564.0	513.4
V_9 -KMR201	7.3	6.3	297.2	290.8

CD (0.05)	NS	NS	46.6	51.7

4.3.3. Crude Fibre content (%)

The data on crude fibre content in percentage of ragi varieties are given in the Table 12. The varieties had a non-significant difference concerning crude fibre content in both the seasons. In general, on an average *Kharif* crop had more of crude fibre content than *Rabi* crop. The average of *Kharif* was 2.061 in comparison with *Rabi* 2.028. As observed statistically its difference was non-significant.

In *Kharif*, variety PR202 (2.38 per cent) had slightly more amount of crude fibre content compared to other varieties and Vakula had the least amount of crude fibre (1.74 per cent). Though in *Rabi*, a similar trend was followed with PR202 with 2.31 per cent of crude fibre with a greater amount, the least producing variety differed *viz.*, Maruthi had only 1.67 crude fibre content. Other varieties ranged in between 1.89 to 2.14 in *Kharif* and 1.71 to 2.24 in *Rabi*. The pattern of crude fibre produced by varieties was almost identical in both the seasons making the difference non-significant.

4.4. SOIL NUTRIENT STATUS AFTER HARVEST

The data on soil nutrient status after the harvest of ragi of both seasons is depicted in the Table 13.

The influence of varieties on soil organic carbon content was found to be non-significant during both seasons. When compared to organic carbon content prior to plant sowing there was increase was observed. The organic carbon content was as low as 0.88% to as high as 1.5% when observed in both seasons.

Also, when observed for nitrogen, phosphorus, potassium contents there was non-significant difference observed when statically analysed, there was increase of nitrogen and phosphorus but some treatments a decrease in potassium content was observed when compared with nutrient levels prior planting. The maximum and minimum amount each element observed in both seasons viz., nitrogen 140 kg/ha to 166 kg/ha, phosphorus 21.4 kg/ha to 29.3 kg/ha and potassium 202 kg/ha to 251 kg/ha.

4.5. NUTRIENT UPTAKE OF THE PLANT

It was observed nutrient uptake determine the performance of a crop to has linear relation to yield and yielding attributes. The data on nutrient uptake of both straw and grain together in both the seasons is depicted in Table 14. It was found to be having significant difference among the varieties with respect to varieties

Similar patter to yields was observed as observed in yields where KMR201 had more uptake of nutrient and is statistically comparable to all other varieties. VR708, Vakula and Maruthi had lesser nutrient uptake compared to other varieties it was observed uptake of phosphorus is half to compared to nitrogen and potassium. On an average nutrient uptake nitrogen (78.4 kg/ha, 73.7 kg/ha) potassium (105kg/ha,101 kg/ha) and potassium (40.1 kg/ha, 47 kg/ha)

Table 12 – Crude fibre content (%) of ragi varieties during *Kharif* and *Rabi* seasons

Table 13 –Soil nutrient status [C, N, P, K(kg/ha)] after harvest during *Kharif* and *Rabi* seasons

Varieties	Organic Carbon (%)		Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)	
	Kharif	***Rabi***	***Kharif***	***Rabi***	***Kharif***	***Rabi***	***Kharif***	***Rabi***
V_1 -VR708	1.13	1.04	164.9	129.4	29.3	22.9	242.7	237.1
V_2 -Vakula	1.10	1.50	158.6	156.1	28.5	24.0	220.9	218.7

Varieties	*Kharif*	*Rabi*
V_1 -VR708	2.14	2.24
V_2 -Vakula	1.75	1.71
V_3 -GPU48	2.24	2.05
V_4 -GPU28	2.22	2.29
V_5 -Maruthi	1.95	1.67
V_6 -Hima	2.07	1.84
V_7 -CO15	1.89	2.01
V_8 -PR202	2.38	2.31
V_9 -KMR201	1.98	2.14
SEm (±)	0.072	0.067
CD (0.05)	NS	NS

V_3 -GPU48	1.24	1.12	159.9	144.5	26.3	21.4	226.1	230.5
V_4 -GPU28	1.09	0.88	166.4	147.8	25.9	21.0	229.4	247.3
V_5 -Maruthi	1.36	1.34	164.3	140.3	24.5	25.4	231.4	234.5
V_6 -Hima	1.14	1.49	155.2	148.9	27.4	24.5	202.2	251.1
V_7 -CO15	1.17	0.96	152.8	147.3	25.3	21.7	233.1	211.6
V_8 -PR202	1.27	1.22	161.3	139.5	22.8	24.0	215.1	231.4

V_9 - KMR201	1.11	1.38	156.5	152.5	25.9	23.8	228.3	239.5
SEm (±)	0.042	0.069	2.519	2.958	0.593	0.554	4.064	4.668
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 14–Nutrient uptake (kg/ha) by ragi varieties during *Kharif* and *Rabi* seasons

	Nitrogen		**Phosphorous**		**Potassium**	
	Kharif	***Rabi***	***Kharif***	***Rabi***	***Kharif***	***Rabi***
V_1 -VR708	50.6	57.4	25.7	33.7	51.6	83.3
V_2 -Vakula	45.4	54.2	27.9	31.6	49.0	79.1
V_3 -GPU48	86.2	81.4	44.4	51.0	117.1	113.7
V_4 -GPU28	80.2	78.6	41.0	52.5	109.5	105.3
V_5 -Maruthi	59.1	50.2	26.8	29.8	90.5	72.4
V_6 -Hima	95.5	91.7	48.4	65.3	131.8	117.2
V_7 -CO15	87.1	72.8	44.4	45.6	119.4	101.6
V_8 -PR202	96.4	78.7	47.7	49.1	136.2	110.4

V_9 -KMR201	105.8	98.6	54.7	64.4	142.9	134.2
SEm (±)	4.06	5.79	0.98	1.04	2.07	2.59
CD (0.05)	9.70	8.98	4.79	6.85	21.60	12.04

5. *Discussion*

5.DISCUSSION

An experiment entitled "Performance of high yielding varieties of finger millet *(Eleusine coracana* (L.) Gaertn)" was undertaken. The objective of the experiment was to evaluate the performance of some prominent high yielding varieties of ragi suitable for *Rabi* and *Kharif* seasons in central Kerala. Based on the evaluated data and results obtained from the previous chapter the reasons are deducted for the experiment below.

5.1 GROWTH PARAMETERS

The results on growth characters of finger millet had a positive influence on the productivity of the crop. Also, it plays a crucial role in determining the adaptability and success of the cultivar performance and choosing the best available cultivar among them. Comparison of the growth of different finger millet varieties under *Kharif* and *Rabi* found that there was a better performance of growth attributes in *Kharif* like plant height and finger length and *Rabi,* there was more dry matter content and a greater number of tillers.

5.1.1 Plant height

The seasonal influence was noticed in the growth of plants and the plants were dwarfed in *Rabi* compared to *Kharif* season and the databases on the result are depicted in Fig 3. This trend was noticed at all stages of growth *ie*.,30 DAS, flowering, and at harvest. On average, the height difference was only 1.6 cm at 30 DAS, whereas at flowering it was 4.39 cm and at harvest 6.53 cm. The seasonal effect was not very pronounced at the initial stage probably due to higher and comparable growth rate and later as the season advanced, the influence of climatic parameters was more which resulted in comparatively dwarf plants.

In Kerala, the rainfall availability is more in *Kharif* compared to the *Rabi*. The data on climatic parameters during the crop growth period indicate that the crop received 2153.7 mm in *Kharif* whereas it was only 318 mm in *Rabi.* The number of rainy days in *Kharif* season was 62 and in *Rabi* 13. However, the *Rabi* crop was given weekly irrigations to ensure adequate moisture availability for a successful crop stand. It is well documented that moisture availability is an important factor affecting plant height by its direct influence on cell division and elongation. Reduction in cell growth and elongation due to moisture stress is reported earlier by Hussain *et al.* (2003) and Aulakh *et al.* (2003).

A perusal of data on plant height of different varieties shows that the varietal performance was not consistent concerning height at different stages. For example, in *Kharif*, varieties Vakula, Hima, and GPU28 were taller at 30 DAS, whereas at flowering PR 202 was taller. By harvest, GPU28 and PR202 were superior with respect to height. This shows that growth at the seedling stage need not be related to its height at maturity probably due to varietal differences in growth rate in response to growth factors. This might be due to the genetic variation or heritability nature of a variety due to its response to various growth factors Heritability values and genetic advance, if considered together as suggested by Johnson *et al*. (1955) and Swarup and Chaugale (1962), the grain yield, total grain-bearing area, number of effective tillers and plant height offer good scope for the improvement of the crop yields.

The variety PR 202 which was taller (111.07 cm) at flowering continued to register more height at harvest stage also, as there is not much vegetative growth after flowering. GPU 28 was also superior (109.71 cm) at the harvest stage.

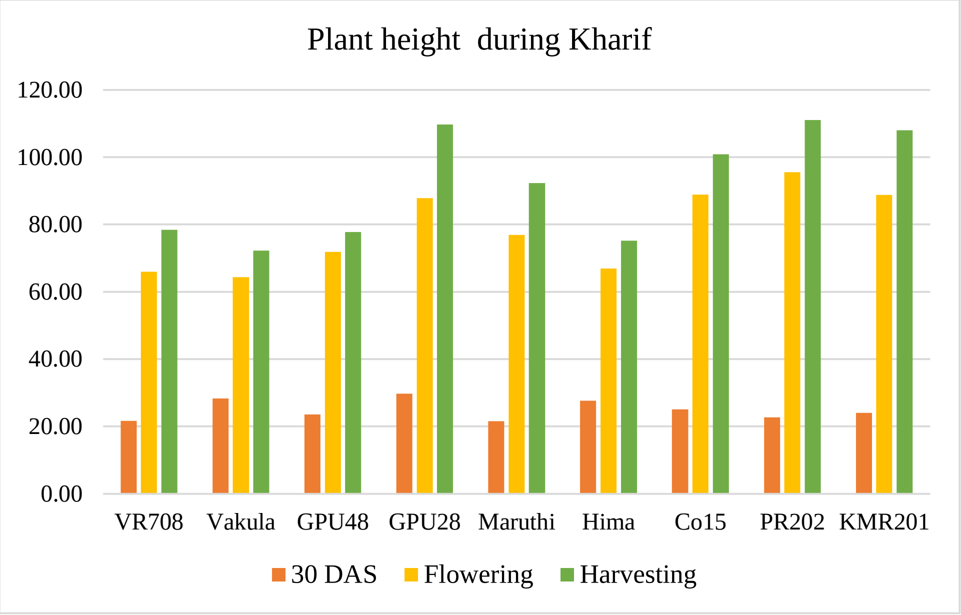
The dwarf varieties were GPU 48 (77.75 cm) and VR 708 (78.39 cm). So, the varietal variation in height was up to 32 cm, which shows the genetic variability in ragi. Anonymous (2016) reveals the genetic constitution of the hybrids expressed differently under the different environmental situation which could explain the genotypic differences.

The height of different varieties in *Rabi* season shows that the varieties which were taller at 30 DAS at *Kharif* continued to register more height in *Rabi* season also. Three varieties-Vakula, GPU 28, and Hima were taller at this stage during both the seasons which indicate their early rapid increase in height. But compared to *Kharif*, variety CO15 was taller in *Rabi* season at all stages of growth probably due to its better adaptability to *Rabi* season. The variety, PR 202 was also taller and showed its consistent growth in both seasons.

The difference between the tallest and the shortest varieties in the *Rabi* was 28.24 cm at maturity, which was similar to the trend observed in *Kharif*. Ravikumar *et al*. (2000) studies concluded that there were differential behaviors in terms of growth and flowering pattern when correlated to study the extent of variation in both seasons. The dwarf statured varieties in *Rabi* season were VR 708, Maruthi and GPU 48 with about 73 cm height and of this, VR 708 and GPU 48 were more dwarf in *Kharif* also (plant height of 78.39 cm and 77.75 cm, respectively) and variety Hima was the dwarfest one (75.20 cm).

The percentage increase in plant height in *Kharif* compared to *Rabi* at maturity in different varieties shows that for VR 708, and GPU 48 increase was 8.61% and 6.53%, respectively. The percentage increase in height of GPU 28 was 14.9%, Maruthi, 24.77%, PR 202 12.59% and KMR 201 18.51%, compared to the *Rabi* crop. The Genotype x Environment interactions could affect the plant varieties which were governed by linear components of the environment, except plant height and number of tillers per plant which was also stated by Mahato *et al.* (2000)

Contrary to the above, there was an increase in plant height in *Rabi* than in *Kharif* by 12% and 8 % for the varieties Vakula and Hima, respectively. Tiwari *et al.* (2005) observed wider intra and inter population variability could impact the qualitative traits like plant height. There was no change in plant height of CO15 over the seasons, indicating its better adaptability to both seasons.



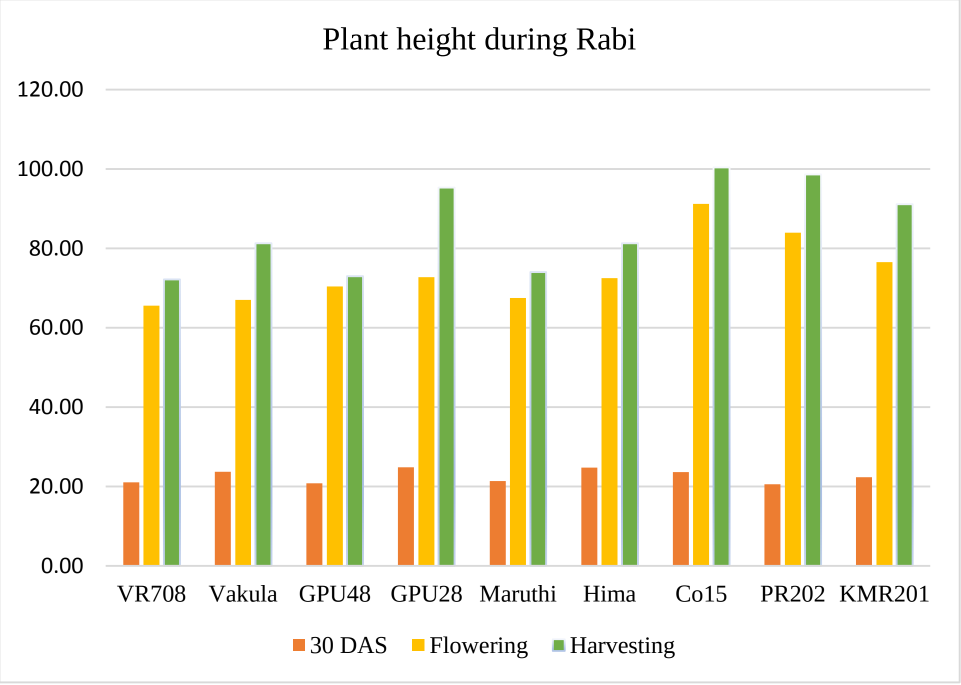


Fig. 3 Plant height at 30 DAS, flowering and harvest of ragi varieties during *Kharif* and *Rabi* seasons

5.1.2 Days to 50 percent flowering

Mahato *et al.* (2000) revealed that days to 50 percent flowering had significant positive correlation with the seed yield. However, it was revealed by Sahu *et al.* (2012) that days to flowering and maturity contribute to genetic divergence. Also, high heritability coupled with high genetic advance was revealed by Karad *et al.* (2013)

As mostly the selected varieties for the following experiment were short to medium duration varieties. As observed from Fig. 4 days to ear head emergence in ragi varieties varied from 56 days to 79 days in *Kharif* and from 64 to 81 in *Rabi*. Similar results were reported by other researchers. The variability of days to 50 percent flowering ranges reported by Dhanalakshmi *et al.* (2013) was 50.88– 90.88 days, Karad *et al.* (2013) was 72-107 days, Ulaganathan *et al.* (2013) was 77-107 days, and Suryanarayana *et al.* (2014) was 59.4 – 80.1 days, respectively.

The optimum temperature for ragi is 11- 27 ^{0} C as reported by Duke (1978). Millets being climate-resilient crops, it can tolerate a wide temperature range and hence seasonal influence on flowering is not very conspicuous. Temperature and sunshine hours are two major factors affecting flowering and during the study period, the maximum temperature 33^{0} C in *Kharif* 31 ^{0} C in *Rabi*, the minimum temperature was 24 ^{0} C and 23.4 ^{0} C in both seasons respectively. The sunshine hours were on an average of weekly basis was 3.5 hrs in *Kharif* and 7.1 hrs in *Rabi*

A close look of the data shows that *Kharif* crop took fewer days to 50 percent flowering and complete crop stand in most of the varieties. This could be due to heavy rain during early flower initiation stages and this behaviour change was also observed by Wet (2006). Also, some varieties loke Maruthi, Hima and GPR48 were not affected by sunshine hours and duration variation were non-significant, which could mean that they might be photo-insensitive. Similar observations were noted by Goitseone M. *et al.* (2014) on observing 35 genotypes conducting seasonal trails, genetic effect contributes 16.2% of evaluated accessions, concluding not all finger millets to be photosensitive.

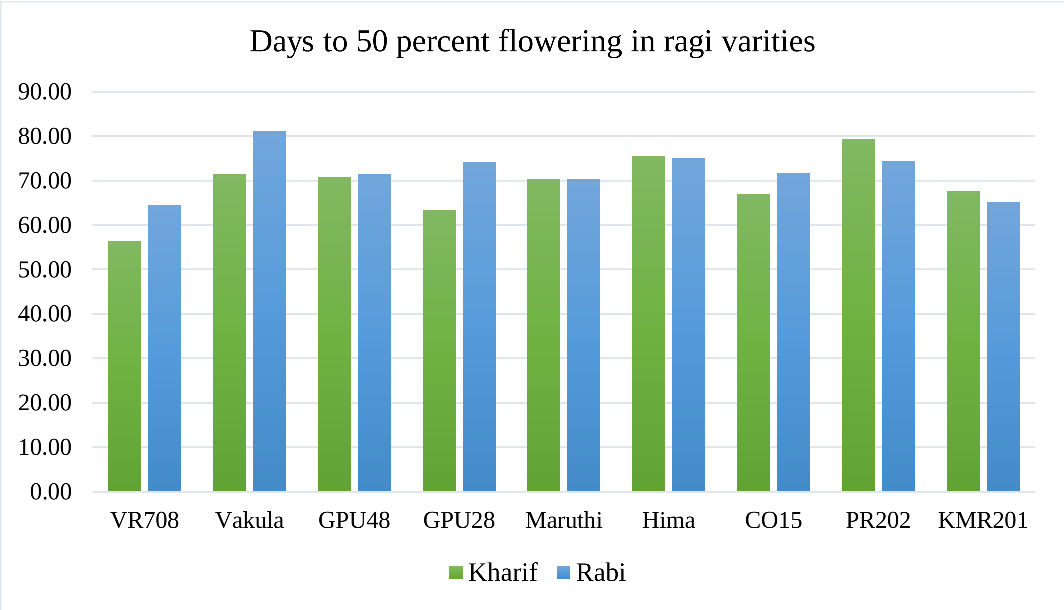


Fig 4. Days to 50 per cent flowering of ragi varieties during *Kharif* and *Rabi* seasons

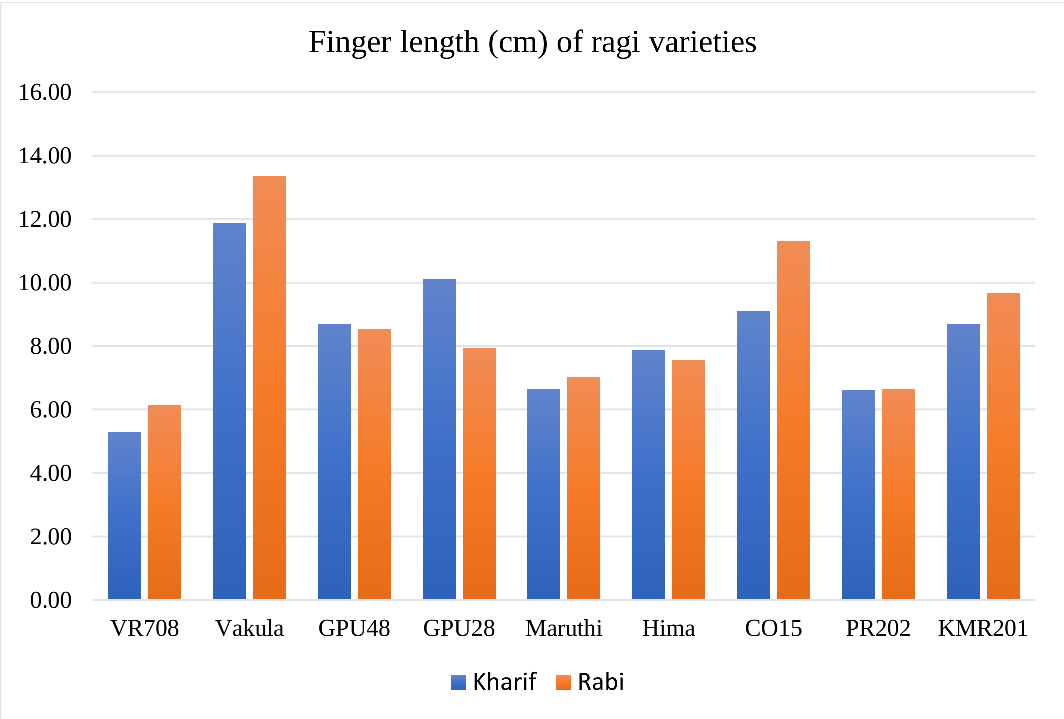


Fig 5. Finger length of ragi varieties during *Kharif* and *Rabi* seasons

5.1.3 Finger length

Chaudhary and Acharya (1969) found that finger length, finger width and the number of fingers per plant could hold a key role in determining the yield of varieties. Bhagat *et al*. (1972) noted that there was a moderate association between yield and finger. Also, Anantharaju and Meenaksiganesan (2008) stated that finger length had an indirect effect on yield through days to 50 per cent flowering and tiller produced according to the particular variety selected. Variability differs in the finger length hence the length of variety and the difference is noted in Fig 5. Wider variability in finger length was observed among the nine varieties tried.

Generally, the finger length was slightly higher in *Rabi* compared to *Kharif*. The range in finger length was 5.30 cm to 11.87 cm in *Kharif* and 6.23 to 11.97 cm in *Rabi* which shows the genetic divergence in this crop. Similar observations were found by Patnaik *et al.* (2009) in his studies and concluded heritability played a major role. All the varieties of ragi included in the present study are high yielding types released from various SAUs, by the process of selection or hybridisation.

The perusal of data shows the superiority of variety Vakula concerning finger length in both seasons with a finger length of about 12 cm in both seasons. During *Kharif* Vakula (11.8cm) produced the longer fingers per ear followed by GPU28 (10.1cm) and the shorter finger length was produced by VR708 and the other finger length like CO15 (9.1cm) and 8.70cm (PR202 and GPU28) were superior to average mean. Similar results were obtained by Aparna *et al.* (2017) and Reddy *et al*. (2009) and VR708 had shorter fingers with just the half-length (6.60 cm) compared to the superior variety Vakula. Dhamdhere *et al.* (2011) and Ganapathy *et al.* (2011) observed similar results in their research and finger length when correlated against weather parameters had less change in seasonal influence.

5.1.4 Dry matter content

Dry matter production is an important factor determining the yield along with its performance of a variety of any crop which is determined by dry matter production and resource allocation of the genotype. Aparna *et al* (2017) noted that there was a two-three fold increase of dry matter production per plant and this growth trend was specific to each variety. It mostly occurs between 15- 75 day after sowing. In the later stage, the dry matter production tends to decrease by the maturity of the crop.

Similar observations were noted in the present study conducted irrelevant of variety though significant changes were observed among the varieties. This difference was observed in both seasons. These changes were prior noted in ragi studies by Ali and Maqsood (2007).The change in the dry matter could be caused due to difference in their growth habit, branching patterns and tiller branching, affecting their photosynthetic rates. This had a direct effect on leaf expansion which was explained by Gifford *et al.* (1981).

Also, Chaudhury (1989) recorded that dry matter production at post-anthesis involves in remobilisation od photosynthates to enhance productive structures resulting in the reduction of vegetative parts. This could explain the less increase in dry matter production post-flowering to harvest stage.

The difference in dry matter production in both seasons could due to variation of moisture content. This water deficit could be demarcated by crop grown by rain-fed and irrigated by stress-related studies by Mostajeran and Rahimi-Echi (2009). Venkat (2014) recorded that changes in the dry matter could be due to a difference in moisture content during growth phases.

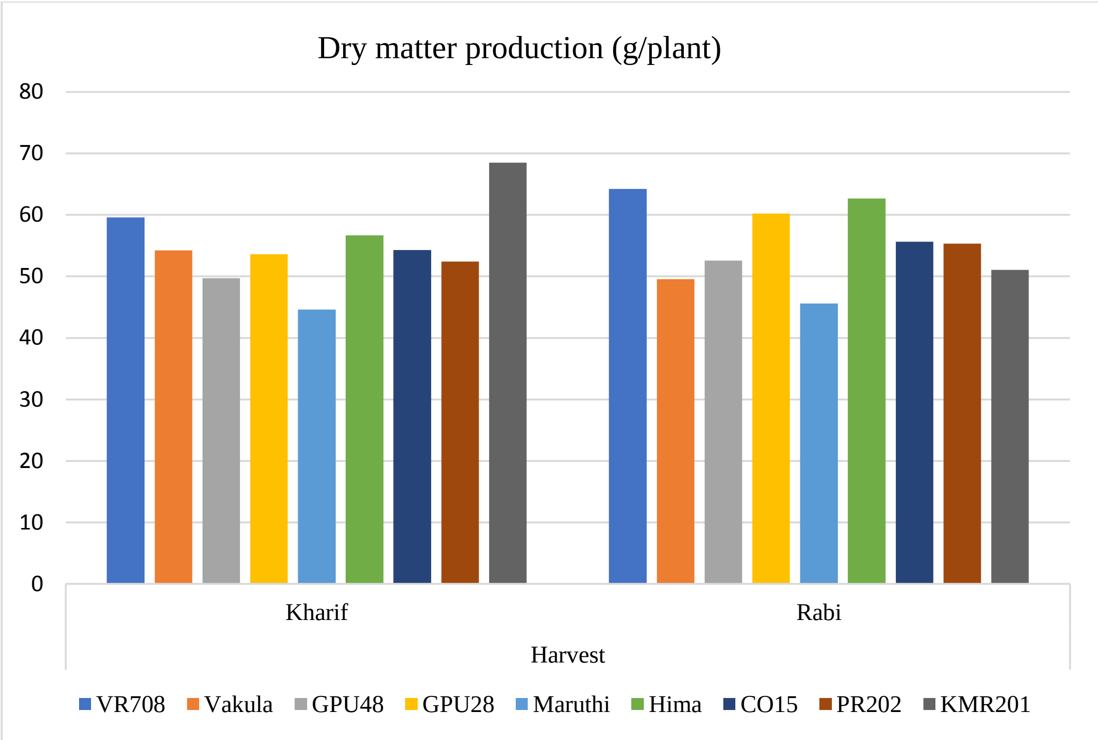


Fig. 6. Dry matter produced of ragi varieties during *Kharif* and *Rabi* seasons

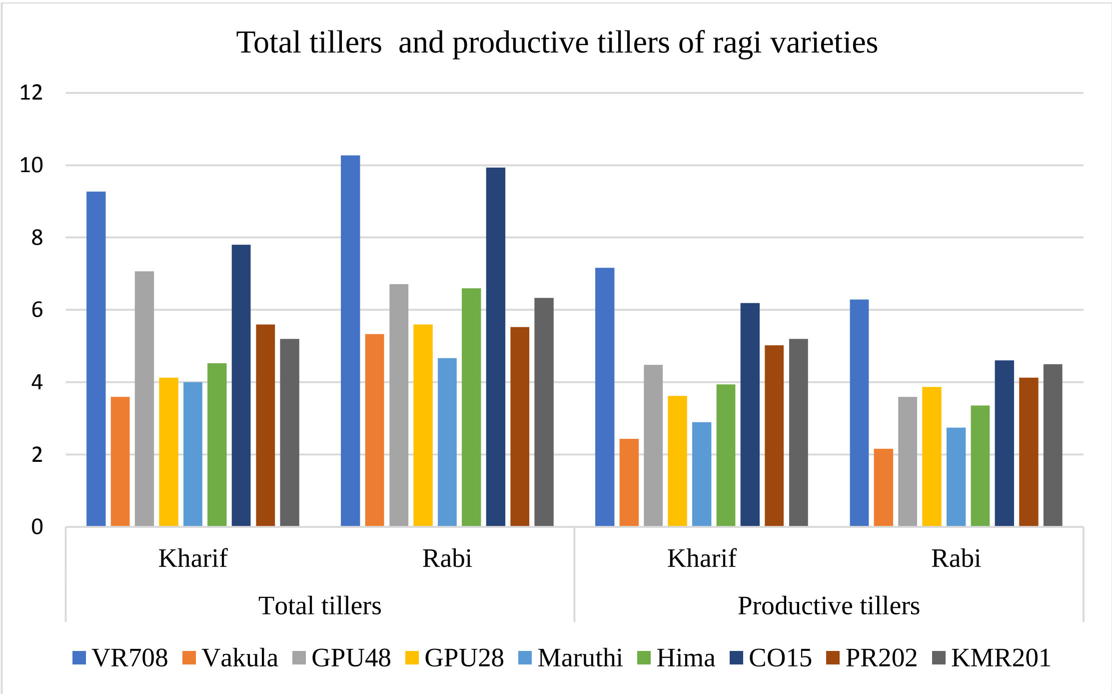


Fig. 7 Total number of basal and productive tillers of ragi varieties during *Kharif* and *Rabi* seasons

5.1.5. Total tillers produced per plant

The number of tillers produced by finger millet is considered as crucial morphological characters which could directly influence on yield (Acharya 1987, Chidambaram and Palanisamy, 1996). The total number of tillers that include unproductive tillers also has a negative relationship with grain yield in finger millet crop (Udayakumar *et al.,* 1990) documented that the total number of tillers per plant which include unproductive tillers are positively correlated to the environment. Tillering in ragi was also influenced by season as all climatic parameters have a direct influence on plant growth. It was reported that tillers contribute 37 per cent to yield and this could be affected and variation could be by biotic and abiotic factors at the tillering stages by Mahadevappa and Ponnaiya (1965).

It was found that unlike in the case of plant height, tillering was more in *Rabi* compared to *Kharif* crop, though the difference was only few tiller/hill. The average value was 5.80 in *Kharif* and 6.80 in *Rabi*. Observations noted were in aligning with Dhagat *et al.* (1973) concerning total tillers produced based on different accession and varieties tested. Mahalakshmi and Bidinger, (1986) documented in their study that dampness stress or waterlogging conditions from active tillering, panicle initiation to grain filling stage could greatly impact on tiller number. Also, this could probably because more photosynthates were diverted for tillering than for plant height. The prevailing high temperature during the maximum temperature 33^{0} C in *Kharif* 31^{0} C in *Rabi*, the minimum temperature was 24^{0} C and 23.4^{0} C in both seasons, respectively might have also favoured the tillering.

Varietal differences were also evident due to the genetic factors associated with the growth and development of plants. The maximum number of basal tillers was observed for the variety VR708 (9.27/hill). The varieties with the lowest tillering potential were Vakula, Hima and Maruti which could produce on an average only around 4 tillers/hill, *i.e.,* lesser than half of the superior variety. The variability in tillering potential in ragi varieties is earlier reported by Aparna *et al.* (2017). A similar observation was observed by her among different varieties tested Sri Chaitanya and

Vakula noted a moderate number of tillers, whereas Hima and PPR1044 noted the lowest number of tiller per plant which was aligned with our study.

In all the varieties (except PR202 where a slight decrease from 5.6 to 5.53 was registered) the tillering increased in *Rabi* season. The performance of varieties in *Rabi* season indicate that VR708 maintained higher tiller number over others in both seasons (10.27 in *Rabi*).

The performance of CO15 was also superior and for this variety the per cent increase in tiller number was 7.80 to 9.93 per cent, showing its adaptability to *Rabi* season. Variety Hima was inferior in both the seasons. However, a sharp increase in tiller number in this variety in *Rabi* compared to *Kharif* (from 4.53 to 6.67 tillers/hill) indicate its better potential in *Rabi* season. Vakula also showed this trend with an increase up to 5.33 tillers/hill from 3.6 tillers/hill

5.2. YIELD AND YIELDING ATTRIBUTES

Quantitative attributed determining yield potentials like productive tillers, 1000 grain weight, grain yield, straw yield and their harvest index. Overall, we could observe slight changes were observed in varieties when observed in both seasons. Productive tillers and 1000 grain weight were more in *Kharif* and *Rabi* had better performance concerning yield and straw yield, were noted in the following study based on the result obtained the possible reasons are listed below.

5.2.1. Number of productive tillers

The productive tillers had said to be aligned with yield and have positive correlation with abiotic parameters documented by various researchers like Gowda (1996), Bedis *et al.* (2006) and Gowda *et al.* (2007). In the study conducted, similar values of productive tiller number were observed. The varieties which had a higher number of total tillers produced a greater number of productive tillers also. Sarala (2007) and Ganapathy *et al.* (2011), reported variability in varietal performance was observed when experimented at different locations. They then conclude the variation could be result due to Genetic X Environment interaction.

Productive tiller is an important yield parameter. Shankar (1982) documented that inheritance of tillers and productive tillers can be governed by additive gene when tested for six generations when tested for quantitative and qualitative characters. The data for *Kharif* and *Rabi* shows that VR708 and CO15 are the potential varieties as they produced more productive tillers on an average.

The wide varietal difference in performance indicates the genetic variability in yield potential of ragi by Nagaraj and Mohankumar, (2009). Not much difference was observed in many varieties in both seasons except for CO15 and GPU48 where significant tiller number drop in *Rabi*. This variation could be due to environmental influence apart of genotypic characteristics. Similar results were documented by Padmaja (2006), Sarala (2007), and Priyadarshini *et al*. (2011).

Though according to Bhaskariah and Mallanna, (1997) dwarf varieties having the combination of productive tillers like VR 708 could yield better grain yield. However, VR 708 and Vakula had less tolerance to floods and waterlogging and could not maintain crop stand and optimum population affecting their performance. The performance of variety Maruthi was inferior in both the seasons 2.93 in *Kharif* and 4.04 in *Rabi*) indicating its poor adaptability to Kerala. Other varieties with lower productive tillers were GPU 48, Hima and Vakula, probably due to poor adaptability of these varieties.

5.2.2. 1000 grain weight

Test weight depends on seed storage reserves and embryo size which differs mostly in each genotype Which could determine germination and plant population. But this is greatly affected by soil and environment conditions. Cordazzo, (2002) based on their works documented that 1000 test weight plays a major role in high test weight enhances germinability, seedling emergence. Fig. 8 represents the 1000 grain weight and its performance in *Kharif* and *Rabi.*

Grain yield showed a positive correlation with 1000 grain test weight reported by Nandini *et al*. (2010), According to her the sunshine, photosynthetic rate, moisture content, aeration and temperature are directly related to 1000 grain yield which could explain the changes observed in case of Hima and CO15 in both the seasons. Similar results were found by Nethra *et al*. (2007) in rice hybrids, and she concluded 1000 grain weight, seed size and seed colour and other seed characters are crucial to identify suitable genotype. Seed weight is reduced Under drought stress could result in cytokine reduction which could be possible to explain a change in KMR201 and GPU28.

Ragi being a small-seeded crop, the 1000 grain weight is only around 2 g. However, within the nine varieties tried in the experiment, the values ranged from 1.53 to 3.53 g in *Kharif* and 1.51 to 3.25 g in *Rabi*. There was not much variation in this parameter. Moisture stress or waterlogging conditions at 47 – 67 days affect the test weight according to Ali and Maqsood (2007).

Seeds were characterised by several researchers into three categories low, medium and high-test weight (John, 2007, Bezaweletawl *et al.* 2006 and Lule *et al.* 2012). The performance of varieties in both the seasons was consistent concerning the test weight and PR 202, GPU48 and CO15 were superior with a value above 3 g were moderate grain weight. The variety with the lowest test weight was Maruti which was considered low 1000 grain weight compared to others studied. This is due to genetic factors as the performance, was similar in both the seasons with a value of 1.5 g. These observations were in line with Aparna *et al.* (2017) where she also had a similar result.

5.2.3 Grain Yield

In any crop grain yield is an important factor in choosing a high yielding variety. It is ideal to choose most ideal and better-performing variety under a certain climate and its impact by weather and adaptability are crucial in determining that variety for the recommendation as indicated by Dhagat *et al*. (1973) and Kempanna *et al.* (1971) after their studies on G X E X Y over several years at different locations.

The grain yield after harvest is represented in Fig. 9 and its influence and change in *Kharif* and *Rabi.* There was a significant difference observed among the varieties from 1.58 t/ha to 6.10 t/ha which was recorded by Gurumurthy, (1982); Ankegowda, (1996); Nagaraj and Mohankumar, (2009); Anon, (2009).

On average there was more yield in *Rabi* than in *Kharif* which could be due to the impact of water stress noted in their studies by Ravikumar, and Seetharam 1990. Also, weed incidence was observed more in *Kharif* influencing in the reduction of yield. The highest grain yield was recorded by KMR201 about 3 t/ha which could be considered high yielding type according to classification given by Roy (1996).

When observed each variety separately, VR 708 yields were 850 kg/ha and 1210 kg/ ha in both seasons, Though, more productive tillers were produced, finger length and weight were comparatively low than others cumulatively this could be the reason for low yield and their difference in yield indicate a non-stability in yield. Vakula, having highest finger length and 1000 grain weight among the tested it had less yield due to lesser productive tillers and poor plant performance affected by high rainfall having correlation noted was a high negative correlation (r = -0.9) in *Kharif*. A similar observation was observed Bendale *et al.* (2002) and Anuradha and Suryakumari (2005). Ibrahim *et al.* (1998) noted almost 15 to 20 per cent changes when the same variety was planted at a different location over climate which could explain the change in varieties CO15, GPU48 and PR202

Among different varieties tested GPU28 had most stable yield in both the seasons (2195 kg/ha and 2302 kg/ha respectively) and can be considered better crop for Kerala climatic condition with least changes. Haradari *et al.* (2012) explained that the crop having similar yield could be ideal for suggesting a farmer due to its stability index.

KMR 201 and PR 202 were superior in term of yield and better tiller number and more of ear produced per plant, finger weight, 1000 grain weight all the yield and yield attributing attributes were found to in positive correlation and thus having higher yield. Ravishankar *et al.* (2004) has concluded in his studies that a variety having superior yielding attributes will have better yield and to be in linear relation

CORRELATION OF YIELD AND WEATHER PARAMETERS

Plant yield is a complex and is a polygenically inherited trait. Therefore, direct selection for yield is not much effective. Hence, correlation studies paved a path to find out the association between highly heritable independent character and most economic but dependent character like yield which would help the breeder in obtaining improved yields. Path analysis proposed by Dewey and Lu (1959) facilitates the partitioning of the correlation coefficients into direct and indirect effects of various characters on seed yield. This path analysis would give a better insight into the cause-and-effect relationship between the weather and yield characters.

Relative humidity and rainfall had negative correlation on the yield as earlier whereas sunshine and evaporation had a positive correlation concerning grain yield and a similar observation was followed in both seasons but the extent variation was observed in both seasons. Ramachandran *et al*. (1991) observed that ragi sown in *Kharif* season of 1984-85 revealed that correlation of grain yield with rainfall, temperature, relative humidity, sunshine hours, evaporation and wind speed during the growth period was positively correlated with rainfall and mean daily minimum temperature.

But in this following study, during *Kharif* crop maximum and the minimum temperature had negligible to low negative correlation (0.22, -0.49). Relative humidity was having high negative correlation (-0.71), rainfall (-0.68) was having a moderate correlation concerning grain yield. Sunshine hours (0.5) and evaporation (0.4) were having moderate to low correlation concerning grain yield respectively.

When observed for correlation of weather in *Rabi* concerning grain yield, there was a negligible correlation between sunshine hours (0.26), relative humidity (-0.28) and evaporation (0.133) compared against grain yield. Similar results were given by Anantharaju and Meenaksiganesan (2008)

5.2.4 Straw Yield

Straw yield is an important factor considering a crop for fodder purpose and finger millet is considered alternative feed for livestock due to its beneficial factors which were reported by Basavaraja and Sheriff (1991). It was reported that even among millets ragi tends to have up to 61 per cent of digestible nutrients as reported by Upadhyay *et al*. (2011) The harvested ragi varieties and their influence due to *Kharif* and *Rabi* is depicted in Figure 9.

The average straw yield was highest in *Rabi* with 5347 kg/ha compared to 5503 kg/ha in *Kharif*. There was a 2.8 per cent increase. Though the averages were almost similar, better performance of straw yield was seen in *Kharif* than is *Rabi*. This could be due to more frequent rainfall and moderate temperature providing nominal conditions at critical stages as discussed earlier by Upadhyaya *et al*. (2011) It was visually observed that plants in *Kharif* were taller, greater culm girth and broader leaves were produced than compared to *Rabi,* this could be due to water stress accompanied by higher evaporation rates during *Rabi*. Similar findings were recorded by Moaed-Almeselmani.(2011) in durum wheat.

Vakula and VR708 had a poor straw yield of these, Vakula had inferior tiller number which may be the reason for lesser straw yield. However, VR 708 was superior in terms of tiller number in *Kharif* as well as *Rabi*. In the case of this variety, more straw yield was registered in *Rabi* (4733 kg/ha) compared to *Kharif* (2125 kg/ha) which denotes the poor adaptability of this variety in *Kharif* as indicated by poor vegetative growth.

Among the HYVs tested, higher straw yield in *Kharif* was registered for KMR 201 with 7.2 t/ha and 6.8 t/ha, respectively. However, KMR 201 produced lesser tiller number of 5.20 compared to best performance VR708 which had on an average 9.27 tillers/hill. This may be due to difference in non-branching and prostrate nature of culm. It was observed that erect types were having better yields and also branching types produced more foliage. VR708 could not perform better as when observed in field conditions it had the least population survived after dribbling but could maintain a better population in the nursery which was maintained for gap filling. It could be concluded that the method of planting could also affect the yield indirectly. A better yield was observed in the case of Aparna *et al.* (2017) when VR708 planted using transplanting method.

Hima a white seeded variety also gave better performance under *Kharif* than in *Rabi*. The yields obtained were aligned with observation noted by Dhanalakshmi *et al.* (2013), and Aparna *et al.* (2017) were it performed better with more moisture percentages.

GPU28 and CO15 had identical straw yield and these varieties had comparable tiller number which was reflected in straw yield, 5 to 6 t/ha. In *Rabi*, KMR201 maintained its superiority over other varieties concerning straw yield. Tiller production was also similar in both seasons. The variety Maruti was poor yielder in both the seasons. The yield ranged between 4.5 to 7t/ha reported a straw yield of among different HYV tested, a similar finding was observed by other scientists when a performed experiment with finger millet viz., Kumar and Rai (2005), Anantharaju and Meenaksiganesan (2008), Reddy *et al.* (2009).

5.2.5 Harvest index

Harvest index is an important factor indicating the property of variety to mobilise the photosynthates to produce structures having economic value noted by Wallace *et al.* (1972). Harvest index of different ragi harvest index was depicted in Fig. 10 of both the seasons.

There was a significant difference among the varieties which was also observed by Mohapatra (1989) in his studies. Highest and lowest HI recorded were 0.37 and 0.15 respectively. The varieties with higher straw yield had higher HI also, due to higher grain yield together with straw yield. The variation among seasons was not very high. However, in variety VR 708, a decrease in HI was observed in *Rabi* due to significantly higher straw yield. In all other varieties, HI increased in *Rabi* compared to *Kharif* due to their better grain yield together with straw yield. A similar observation was recorded by Basavaraja and Sheriff (1991).

5.3 QUALITATIVE PARAMETERS OF RAGI VARIETIES

5.3.1 Protein content

Ragi is said to have more protein content among the coarse cereals and millets. The Fig. 11 represent the protein content among the different varieties tested and it was observed that there was a significant difference observed as among the tested Hima being a white seeded variety. Similar findings were found by Shukla (1985b). It recorded the highest protein content more than 8.6 % considerable higher than brown seeded grains varieties.

It was observed that when seen for difference among the brown seeded variety it was non-significant as earlier observed by Solomon *et al.* (2014) However, there was slight difference observed in protein content when observed in both seasons. this could be caused due to abiotic factors as earlier recorded by Baruah *et al.* (2014) in his studies this could explain the extreme difference in protein content Maruthi.

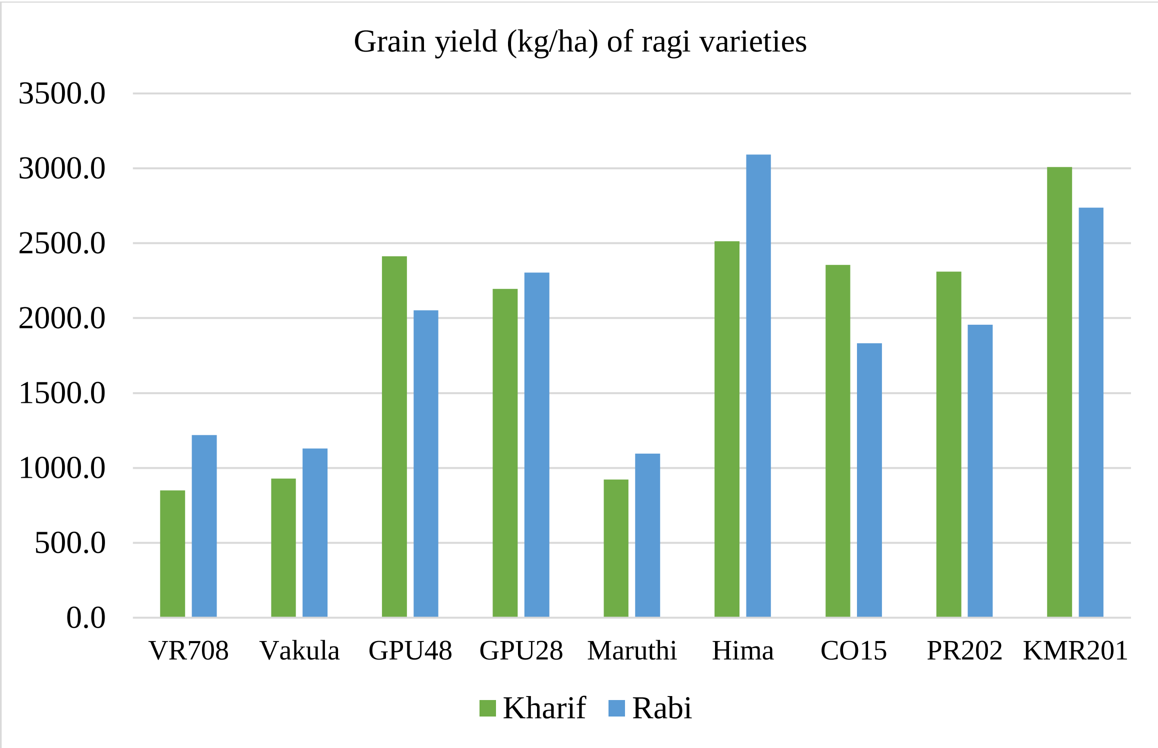
5.3.2 Calcium content and Iron content

Among the cereals and millets, it was reported by Vaidehi (1980) that Ragi grains are a good source of calcium and has the highest Ca content and iron content apart from other minerals such as Zinc, Phosphorus, Copper and Magnesium reported by Samanthray *et al.* (1989) Significant variation in Ca content was noticed among the varieties and is depicted in Fig 12. These changes might be due to their poor genotypic stability as reported earlier by Bhagawat (2018)

The calcium content was as high as 564 mg/100g to as low as 276.28 mg/100g over the seasons. Similar findings were given by Shukla (1985a&b) after experimenting 36 genotypes he concluded calcium content range from 162 to 487 mg/ 100g. Also, the same person found that interaction of micro and macronutrient could result up to calcium content of seed having up to 580 mg/100g seed.

The white seeded variety Hima was inferior to others concerning Calcium content of grain (286 g), but it was contrasting to find more calcium content was present in white seeded variety than brown varieties. Variety CO15 had the highest Ca content (539 mg/100g). Whereas, similar findings were recorded by Shashi *et al.* (2007) in the case of GPU28 and PR202.

The difference in iron content among the ragi varieties was observed to be non-significant. similar variation was observed by Solomon *et al.,* (2014) with the non-significant difference among genotypes he studied. There was not much difference in iron content which ranged between 6.3 to 8.8mg/100 g seed Similar findings were observed by Singh and Srivastava (2006) testing 14 varieties and iron content varied from 5.76 to 12.16 mg per 100 g



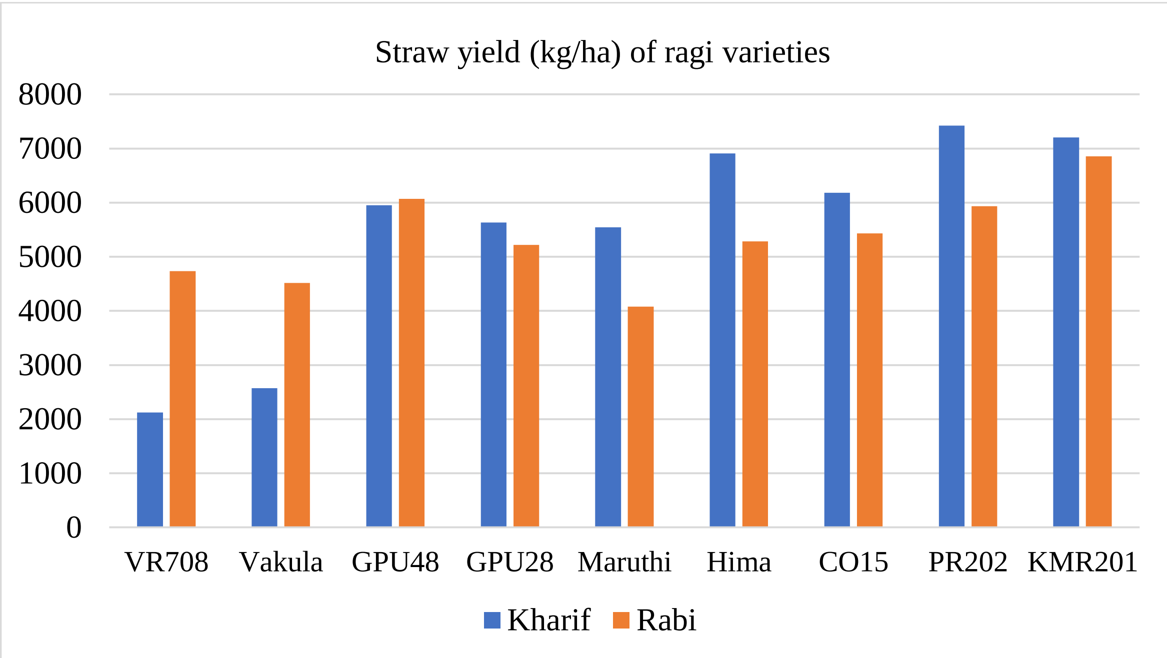


Fig. 9. Grain yield and straw yield (kg/ha) of ragi varieties during *Kharif* and *Rabi* seasons

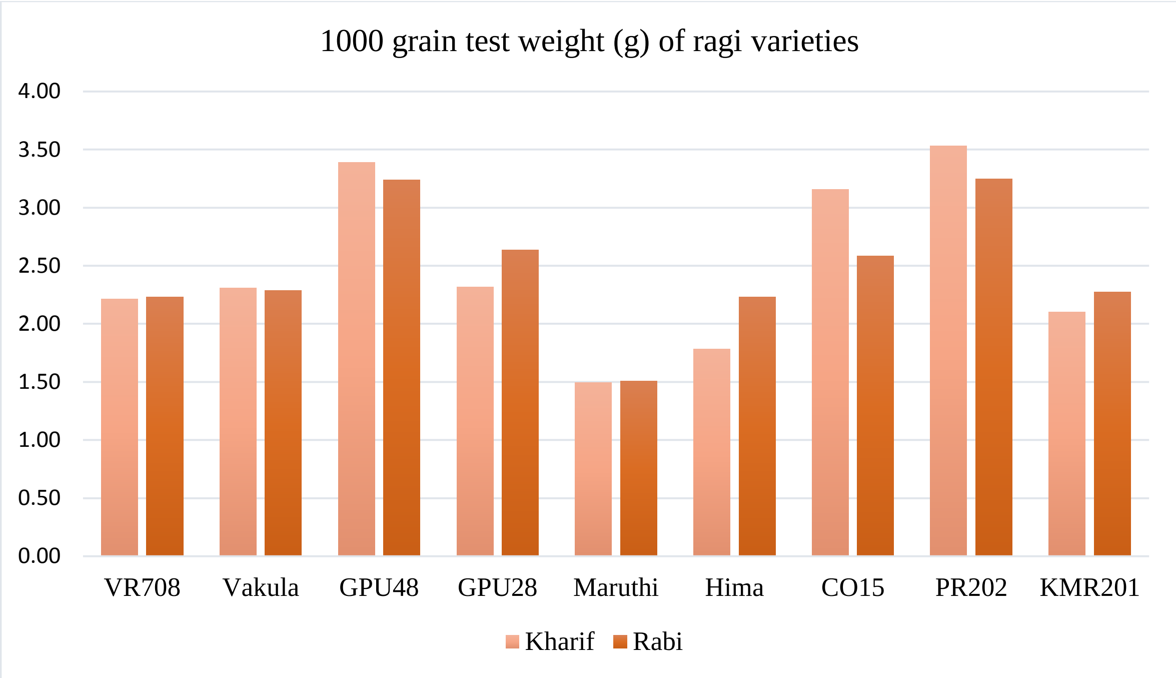


Fig 8 1000 grain weight (g) of ragi varieties during *Kharif* and *Rabi* seasons

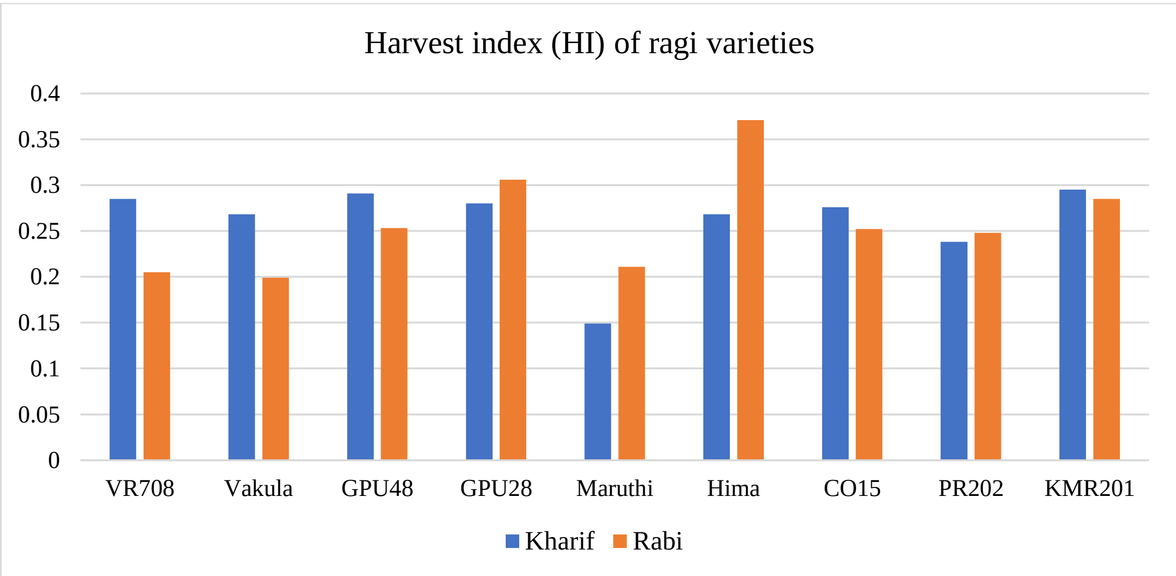


Fig 10. Harvest Index of ragi varieties during *Kharif* and *Rabi*

5.3.3. Crude Fibre content (%)

Millets are rich source of fibre apart of calcium and iron. They possess high antioxidants and dietary fibre content along with vitamin, essential amino acids and minerals (Leder and Monda 1987, Obilana 2003, Ragaee *et al.* 2006) The data analysed and the difference among varieties can be compared using Fig. 13

Ramulu and Rao (1997) reported total dietary fibre, insoluble dietary fibre and soluble dietary fibre to be 12 per cent,11 per cent and 2 per cent respectively which are similar to result obtained in fibre content. The average crude fibre content for *Kharif* was 2.06 and in *Rabi* 2.02 which was aligned with a report given by FAO (1972) which tends to have more fibre content than other common cereals.

The fibre content was significant but had high values as 2.38 per cent variety PR202 and 1.67 per cent in variety which had the least content over the seasons. It can be seen that all other brown varieties had more fibre content in comparison to white variety Hima on an average scale though few varieties like Maruthi had least fibre content. This change in crude fibre content could have differed to an extent if seeds had husk or intact lamella or palea which is peculiar genotypic character differing in Genotype.

Genotypes Vakula, Hima, and Maruthi crude fibre content were in align with the result obtained by Aparna *et al.* (2017). Other varieties were also in range in between 1.89 to 2.14 in *Kharif* and 1.71 to 2.24 in *Rabi*.

High fibre diets contain complex carbohydrates which are slowly digested. The carbohydrate content of finger millet is lower and fibre content is higher than rice (FAO 1972). High fibre levels help to depress digestibility (Spiller and Shiply 1977, Monte *et al*. 1981) and control diabetes by anti-diabetic activity by Chandrasekhar *et al.* (1978)

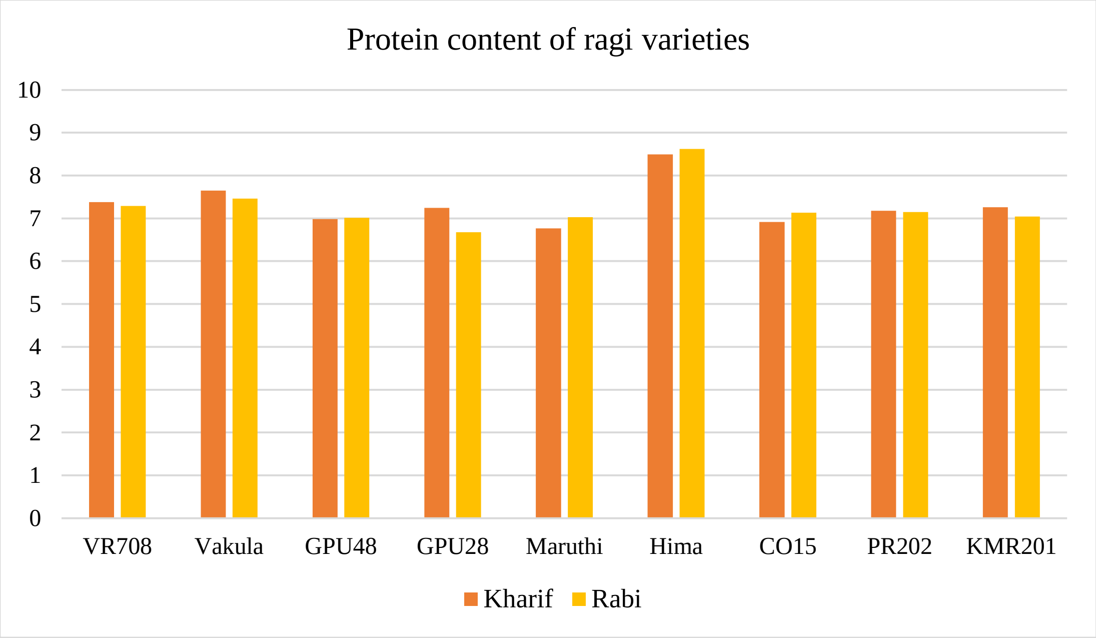


Fig 11. Protein content of ragi varieties during *Kharif* and *Rabi* seasons

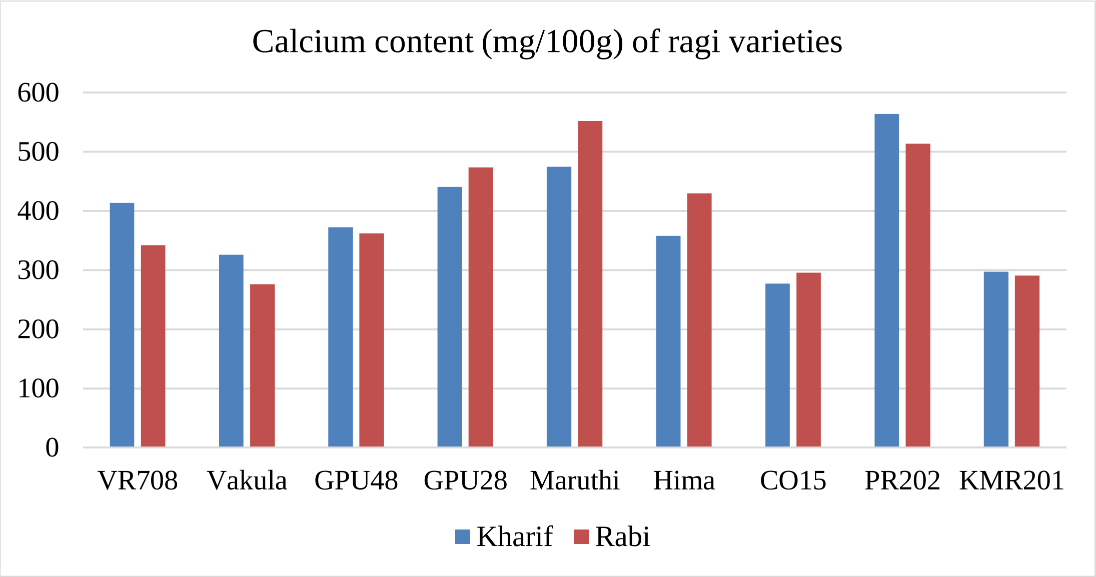


Fig 12. Calcium content of ragi varieties during *Kharif* and *Rabi* seasons

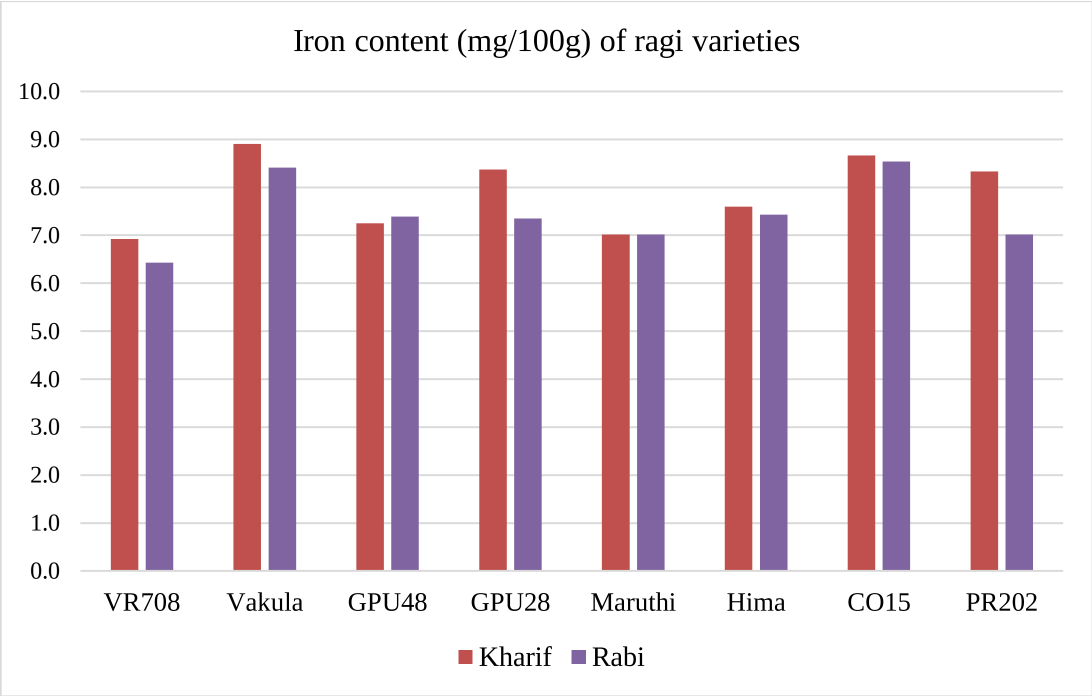


Fig 13. Iron content of ragi varieties during *Kharif* and *Rabi* seasons

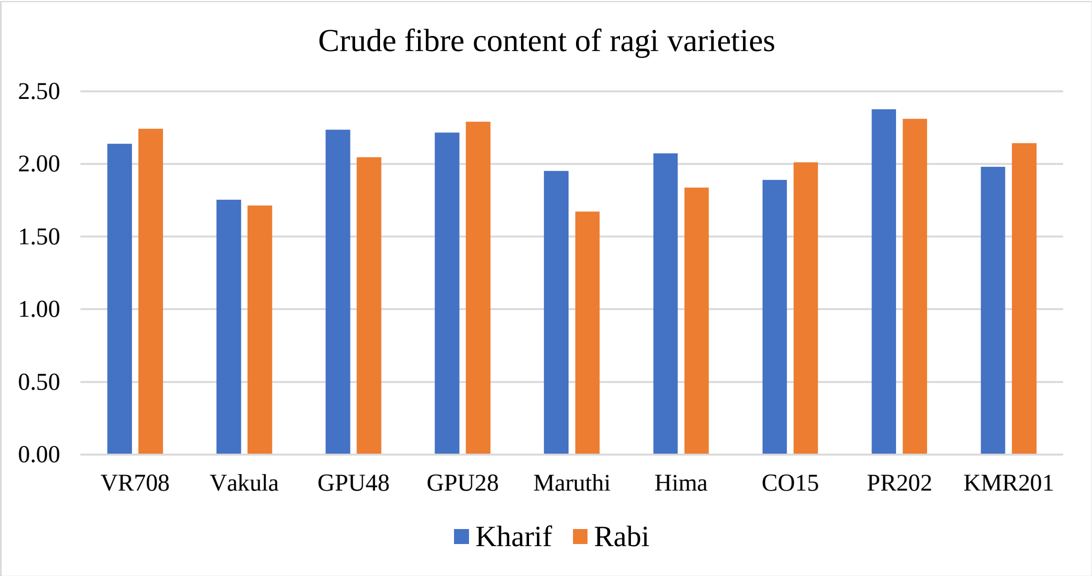


Fig 14. Crude fibre content of ragi varieties during Kharif and Rabi seasons

6.Summary

6. SUMMARY

The present research entitled "Performance of high yielding varieties of finger millet [*Eleusine coracana* (L.) Gaertn]" was conducted at Agronomy farm, College of Agriculture, Vellanikarra, Thrissur, Kerala during the period July 2018 to January2019. The objective was to assess the performance of some prominent high yielding varieties of ragi suitable for *Rabi* and *Kharif* seasons in Kerala. Nine high yielding varieties were collected from different agricultural universities/research stations of South India and their performance under Kerala climatic conditions assessed in *Kharif* and *Rabi* seasons. The varieties included were VR708, Vakula, GPU28, GPU48, Maruthi, Hima, CO15, PR202, and KMR202. The design was Randomised Block Design (RBD) with three replications. Crop was sown at spacing of 25 cm x 15 cm in both the seasons. The salient finding observed from the experiment were summarized below.

Performance of varieties

1. There was significant difference in plant height among the different varieties. PR202 (111.07 cm) and CO15 (100.41 cm) recorded as taller plant than other varieties in *Kharif* and *Rabi* seasons respectively. Vakula and VR708 were dwarf compared to other varieties recording 72.21cm, 72.17 in *Kharif* and *Rabi* respectively.
2. Days to 50 per cent flowering and total crop duration varied significantly with variety. PR202 and Vakula took longer duration of 79 and 81 days for 50 percent flowering in *Kharif* and *Rabi* respectively. VR708 took lesser duration for ear emergence, 56 and 64 days in both seasons.
3. Vakula had longer fingers than other varieties and VR708 had the shortest fingers. Significant difference was observed between the varieties and the finger length ranged from 5.3 cm to 11.8 cm.
4. Higher dry matter accumulation of 68.5 ug/plant & 62.66 g/plant was registered in varieties KMR201 and Hima in *Kharif* and *Rabi* seasons respectively.

5. Total tillers and productive tillers were more for VR708 followed by CO15 in both seasons. Maruthi and Vakula produced less tillers.
6. Significant difference was observed among the varieties with respect to test weight of grains with Maruthi having least 1000 grain weight of 1.5 g, KMR201 and GPU48 recorded higher value of 3.53g and 3.24g respectively.
7. The highest grain yield of 3008 kg/ha was registered for variety KMR201 in *Kharif* and 3092 kg/ha Hima in *Rabi* season.
8. Higher straw yield of 7432 kg/ha and 6855 kg/ha was observed in varieties PR202 and KMR201.
9. Varieties differed in calcium content and protein content. White seeded variety Hima had higher protein content than others. There was no variation in protein content in both seasons.
10. Iron content and the fibre content of ragi seeds was found to almost similar among the varieties. Iron content ranged from 6.4 (mg/ 100g) to 8.9 (mg/ 100g) and fibre content of the varieties ranged between 1.74% to 2.38%.
11. No significant difference was observed in nitrogen, phosphorus, potassium contents in post-harvest soil. However, in general an increase of nitrogen and phosphorus and a slight decrease in potassium content was observed when compared with nutrient levels prior to planting.

Seasonal influence on varieties

1. Seasonal influence could be observed on plant height as plants had different height in both seasons. *Kharif* crop was taller than *Rabi.*
2. Varieties used for experiment were mostly medium duration except VR708 and Maruthi being short duration varieties. Changes were observed over season. The difference was from 4 days (CO15) to 10 days (Vakula) day for 50 per cent flowering.
3. The finger lengths were almost identical in both seasons indicating minimal to low influence by seasonal change.

4. Seasonal influence was observed on dry matter produced as there was difference in values in most of the varieties. Dry matter production was greater in *Rabi* for most varieties compared to *Kharif* season.
5. There was no seasonal influence impact on tillers number as most of them had almost same tillers in both the seasons. However, variety Vakula and Hima had more tillers in *Rabi* than in *Kharif.*
6. There was no seasonal influence in 1000 grain test weight of grains of different varieties.
7. Quality parameters of grain like calcium, Iron, protein content and fibre content were found to be identical in both kharif and rabi seasons, indicating negligible seasonal influence in determining grain quality.

Based on the findings, it can be concluded that varieties CO15, Hima, KMR201, PR202 GPU28, and GPU 48 can be recommended for cultivation in Kerala in *Kharif* and *Rabi* seasons. Performance VR708, Vakula and Maruthi were inferior among the nine varieties

References

REFERENCES

Acharya, M. N. 1987. Genetic variability and correlation studies of yield contributing characters in (*Panicum miliare* L.). *Andhra Agric. J.* 34: 19-23.

Ali, S.A. and Maqsood, M. 2007. Effects of environmental stress on growth, radiation use efficiency and yield of finger millet (*Eleusine coracana*). *Pakistan J. Bot.* 39(2): 463.

Anantharaju, P. and Meenakshiganesan, N. 2008. Genetic divergence studies in finger millet (*Eleusine coracana* (L.) Gaertn). *Indian J. Agric. Res.* 42(2): 120-123.

Ankegowda, S. J. 1996. Canopy temperature, crop canopy air temperature difference as a screening technique for dehydration postponement under water stress in finger millet (*Eleusine coracana (L.) Gaertn*.). Ph.D. thesis, University of Agricultural Science, Bangalore. 216p

Anon. 2009. Ragi (Finger Millet). Agriculture Marketing and Information Network. Available: www.agmarknet.nic.in [17 March 2020]

Anonymous (2016). *Project Coordinator Review on Pearl Millet Research*. Proceedings of national workshop. All India Coordinated Pearl Millet Improvement Project, Jodhpur. 13p.

Anuradha, N., Patro, T.S.S.K., Divya, M., Rani, Y.S., and Triveni, U. 2017. Genetic variability, heritability and association in advanced breeding lines of finger millet [*Eleusine coracana* (L.) Gaertn]. *Int. J. Curr. Sci.* 5(5): 1042-1044.

Anuradha, T. and Suryakumari, S., 2005. Genetic parameters, correlations and path analysis in finger millet. *Andhra Agri. J*. 52: 575-576.

Aparna, K. and Bhargavi, H. 2017. Identification of drought tolerant and high yielding genotypes in ragi under rainfed conditions. *Agric. Update*. 12(8): 2142-2145.

Asp, N.G., Johansson, C.G., Hallmer, H., and Siljestroem, M. 1983. Rapid enzymic assay of insoluble and soluble dietary fiber. *J. Agric. Food Chem.* 31(3): 476-482.

Aulakh, M.S., Pasricha, N.S. and Bahl, G.S. 2003. Phosphorus fertilizer response in an irrigated soybean-wheat production system on a subtropical, semiarid soil. *Field Crops Res*., 80: 99–109.

Babu, D.V., Reddy, Y.S.K., and Sudhakar, P. 2014. Evaluation of physiological efficiency and yield potential of ragi genotypes under imposed moisture stress conditions. *Bioscan*, 9, pp.1777-1780.

Bandyopadhyay, B.B. 2001. Temperature and precipitation effects on grain yield of finger millet (*Eleusine coracana*) genotypes at high hills of Garhwal Himalayas. *Indian J. Agric. Sci.* 71(3): 205-208

Baruah, D.C., Hiloidhari, M., and Das, D. 2014. Bioenergy potential from crop residue biomass in India. *Renewable Sustain. Energy Rev.* 32, pp. 504-512.

Basavaraja, G.T. and Sheriff, R.A. 1991. Correlation and path-analysis in F2 and F3 populations of finger millet (*Eleusine coracana*). *Indian J. Agric. Sci.* 61(10): 774-775.

Basavarajappa, R. and Sharma, A. 2010. Response of finger millet (*Eleusine coracana* L. Gaertn) genotypes to different doses of NPK fertilizers under shallow red soils. *Karnataka J. Agric. Sci.* 16(2): 127-133.

Bedis, M.R., Ganvirand, B.N. and Patil, P.P. 2006. Genetic variability in finger millet. *J. Maharashtra Agric. Univ*. 31 (3): 369-370.

Bendale, V. W., Bhave, S. G., and Pethe, U. B. 2002. Genetic variability, correlation and path analysis in finger millet (*Eleusine coracana* L. Gaertn.) *J. Soils Crops*, 12: 187-191.

Bezalawetaw, K., Sripichit. P., Wongyai, W., and Hongtrakul, V. 2006. Genetic variation, heritability and path analysis in Ethiopian finger millet (*Eleusine coracana* L. Gaertn) landraces. *Kasetsart J. Nat. Sci*. 40: 322-334.

Bhagat, N.K., Pathidar, G.L., Srivatsava, P.S., and Joshi, R.C. 1972. Correlation and genetic variability study in ragi. *JNKVV Res. J.* 6:121-124.

Bhagwat, S. 2018. Conservation and development in India. *Reimagining wilderness*. (2[nd] Ed.). Taylor and Francis. Abingdon. 520 p

Bhaskariah, K.B and Mallanna, K.N. 1997. Scope and achievements of ragi breeding in India. *Proceedings of the 10[th] symposium*, Bangalore. pp. 83-132

Black, C.A., Evans, D.D. and White, J.L., 1965. *Methods of Soil Analysis: Chemical and Mcrobiological Properties*. Series of Agronomy, American Society of Agronomy Inc., Madison, Wisconsin, USA. 375p

Bray, R.H. and Kurtz, L.T.1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Sci.* 59: 39-45

Chandrasekhar, K. 1978. Photosynthetic efficiency and translocation and their relationship with dry matter production and yield in five genotypes of ragi (*Eleusine coracana* L. Gaertn.). M.Sc. (Ag) thesis, University of Agricultural Science., Bangalore. 364p

Chaudhari, L.B and Acharya, R.C. 1969. Genetic variability and path coefficient analysis of components of yield (*Eleusine coracana*). *Exp. Agric*. 5: 295-300.

Chaudhary, S.K. 1989. Correlation and path analysis in finger millet under mid altitude conditions. *Int. J. Trop. Agric*. 7: 45-49.

Chellamuthu, S., Kothandaraman, G.V., and Duraiswmy, P. 1987. Effect of organic and inorganic forms of nitrogen on the crude protein content of ragi (*Eleusine coracana* L. Gaertn.) crop. *Madras Agric. J.* 74(2): 98-101.

Chidambaram, S. and Palanisamy, S. 1996. Dry matter production and harvest index in little millet (*Panicum sumatrense* Roth Ex. Roem and Schult). *Madras Agric*. J. 83: 15 -17.

Cordazzo, C.V. 2002. Effect of seed mass on germination and growth three dominant species in Southern Brazilian coastal dunes. *Brazilian J. Bio*. 62: 427-435.

Devaliya, S.D., Singh, M., Intawala, C.G., and Bhagora, R.N. 2018. Genetic variability studies in finger millet (*Eleusine coracana* L. Gaertn). *Int. J. Pure and Appl. Biosci.* 6(1):1007-1011.

Dewey, D.R. and Lu, K. 1959. A correlation and path- coefficient analysis of components of crested wheatgrass seed production. *Agron. J.* 51(9):515-518.

Dhagat, N.K., Patida, G.L., Shrivastava, P.S., and Joshi, R.C. 1973. Path analysis and selection indices studies in finger millet. *JNKVV Res. J.* 7(4): 212-215.

Dhamdhere, D.H., Pandey, P. K., and Shrotria, P. K. 2011. Genetic variability, heritability and genetic advance of yield components and mineral nutrients in finger millet (*Eleusine coracana* L. Gaertn). *Pantnagar J.* of *Res*. 9: 46-48.

Dhanalakshmi, T. N., Ramesh, S., Ravishankar, C. R., Upadhyaya, H. D., and Rao, A.M. 2013. Genetic variability for morpho agronomic traits in core germplasm collections of finger millet (*Eleusine coracana* Gaertn. (L.) *Global J. Biol. Agric. Health Sci.* 2(2): 83-85.

Duke, J.A. 1978. *Eleusine coracana* (L.) Gaertn. Poaceae Ragi, Kurakkan, African millet, Finger millet. *Handbook of Energy Crops. [on-line] Available:* http://www.hort.purdue.edu/newcrop/duke_energy/Eleusine_coracana. (Verified 07 March 2020).

FAO. 1972. Food Composition Table for Use in East Asia. Food and Agriculture Organization, Rome. pp. 97-139

FAO. 2005. The state of Food Insecurity in the World. Report on Crop Plants. *Food and Agriculture Organization*. United Nations, Rome, pp. 29-59

Ganapathy, S., Nirmalakumari, A., and Muthiah, A. R. 2011. Genetic variability and interrelationship analysis for economic traits in finger millet germplasm. *World J. Agric. Sci.* 7(2): 185-188.

Gifford, R.M. and Evans, L.T. 1981. Photosynthesis, carbon partitioning, and yield. *Annu. Rev. Plant Physiol.* 32(1): 485-509.

Goitseone M. Jaisil, P., Sanitchon, J., Suriharn, B., and Jothityangkoon, D. 2014. Variations of genotypes, seasons and genotype by season interactions for yield, yield components and agronomic traits in finger millet (*Eleusine conaracana* L. Gaertn). *Plant Knowl. J.* 3(1): 8.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agriculture Research.* John Wiley & Sons. 690p

Govindappa, M., Vishwanath, A.P., Harsha, K.N., Thimmegowda, P. and Jnanesh, A.C. 2009. Response of finger millet (*Eluesine coracana* L.) to organic and inorganic sources of nutrients under rainfed condition. *J. Crop Weed*. 5:291-293.

Gowda, J., Somu, G., Bharathi, S. and Mathur, P.N., 2007. Formation of core set in finger millet (Eleusine coracana (L.) Gaertn.) germplasm using geographical origin and morpho-agronomic characters. *Indian J. Plant Gen. Resour.* 20(1), pp 38-42.

Gowda, M., 1996. Genetic Variability Studies on African Germplasm of Finger Millet (*Eleusine Coracana* Gaertn.) Ph.D. thesis, University of Agriculture Science, Bangalore.

Gupta, R.P. and Dakshinamoorthy, C. 1980. Procedures for physical analysis of soil and collection of agrometeorological data. Indian Agricultural Research Institute, New Delhi, 293p.

Gupta, S.C., Rao, A.S., House, L.R., and Boyle, P.J., 1989. Review of sorghum, pearl millet, and finger millet improvement in SADCC countries. *South Afri. Cent. Coop. in Agric. Res.* 170p.

Gurumurthy, B.R. 1982. Desirable growth characteristics in relation to productivity in fingermillet (*Eleusine coracana* L. Gaertn) M.Sc. (Ag) Thesis, University of Agricultural Sciences, Bangalore.295p

Haradari, C., Gowda, J., and Ugalat, J. 2012. Formation of core set in Indian and African finger millet [*Eleusine coracana* (L.) Gaertn] germplasm accessions. *Indian J. Gen. Plant Breed.* 72(3): 358.

Hemalatha, S. and Chellamuthu, S. 2011. Effect of long-term fertilization on phosphorous fractions under finger millet-maize cropping sequence. *Madras Agric. J.* 98(12):344-346.

Hemalatha, S. and Chellamuthu, S., 2013. Impacts of long-term fertilization on soil Neutral quality under finger millet: maize cropping sequence. *J. Environ. Res. Development*, 7(4A):1571-1576.

Hussain C.M.S., Ghulam, M.S., Muhammad, S., and Usman, S., 2003. Correlation and path coefficient analysis in pearl millet (*Pennisetum americanum* L.). *Pak. J. Biol. Sci.* 6: 597-600.

Ibrahim, M.N.M., Zemmelink, G., and Tamminga, S. 1998. Release of mineral elements from tropical feeds during degradation in the rumen. *Asian-Aust. J. Anim. Sci.* 11(5): 530-537.

Jackson, M. L. 1958. *Soil Chemical Analysis*. Prentice Hall Inc, New Jersey, 498p.

Jackson, W.A., Flesher, D. and Hageman, R.H., 1973. Nutrient uptake by dark-grown corn seedlings: some characteristics of apparent induction. *Plant Physiol.* 51(1): 120-127.

John, K., 2007. Estimates of genetic parameters and character association in finger millet [*Eleusine coracana* (L.) Gaertn]. *Agric. Sci. Dig.* 27(2): 95- 98.

Johnson, H. W., Robinson, H. F., and Comstock, R. E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.* 47: 314-318.

Joshi, N. and M.P. Vaidehi. 1988. Utilization of immature ragi (finger millet). *Curr. Res.* 17(8): 99-101.

Kadam, D.D. 2008. Genetic divergence in finger millet (*Eleusine coracana*). *J. Soil Crops*. 18 (1): 138-142.

Karad, S.R., and Patil, J.V. 2013. Assessment of genetic diversity among finger millet (*Eleusine coracana* L.) genotypes. *Int. J. of Integrative Sci. Innovation and Tech.* 2(4): 37– 43.

Katiyar, S.K. and Bhatia, A.K. 1991. Essential amino acids profile in eight traditional cereal cultivars of Trans-Himalayan region. *J. Food. Sci. Technol.* 28(2): 126-127.

Katiyar, S.K., Bhasin, A.K., and Bhatia, A.K. 1991. Traditionally processed and preserved milk products of Sikkimese Tribes. *Sci Cult.* 57: 10-11.

KAU [Kerala Agricultural University]. 2016. *Package of Practices Recommendations: Crops* (15^{th} Ed.). Kerala Agricultural University, Thrissur, 392 p.

Kempanna, C., Vijayarama, R. and Setty. M.V.N. 1971. The impact of genotype environmental interaction on the determination of the components of variation and other genetic parameters (*Eleusine coracana* L. Gaertn). *Mysore J. Agric. Sci.* 5(3): 295-300.

Kumar, B and Rai. 2005. Genetic divergence in ragi (*Eleusine coracana* L. Geartn.). *J. Res. ANGRAU.* 15: 22-24.

Kumar, B. and Kumar, J. 2009. Evaluation of small millet genotypes against endemic disease in mid-eastern Himalaya. *Indian Phyto Pathology*, 62, 518-521. 5.

Kumar, M.U., Sashidhar, V.R., Gurumurthy, B.R., Prasad, T.G., Kumar, M.U., Seetharam, A. and Sastry, K.K. 1986. Genotypic variation in carbon exchange rate, functional leaf area and productivity in finger millet (*Eleusine coracana* Gaertn.): An approach to identify desirable plant types for higher water use efficiency under rainfed conditions. *Field Crops Res.* 13: 133-146.

Kumar, M.U., Uma, S., and Prasad, T.G. 1995. Genetic variability in recovery growth and synthesis of stress proteins in response to polyethylene glycol and salt stress in finger millet. *An. Bot.* 76(1): 43-49.

Léder, I. 2004. Sorghum and millets: Cultivated plants, primarily as food sources, [Ed. György Füleky], *Encyclopedia of Life Support Systems*, UNESCO, Eolss Publishers, Oxford, UK. Available: http://www.eolss.net/ [26 December 2020]

Leder, I., and Monda, S. 1987. The sorghum and millet and their use in Hongarian. *Elemezesi ipar.* 39 (3): 98-104.

Lindsay, W.L. and Novell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese Litz, [Re edited 2000]. *Botany, Production and CABI.* UK. London, pp.184-185.

Lule, D., Kassahun, T., Masresha, F., and Santie, D.V. 2012. Multivariate analysis for quantitative traits in finger millet (*Eleusine coracana* subsp. Coracana) population collected from Eastern and South-eastern Africa: detection for patterns of genetic diversity. *Int. J. Agric. Res.* 7(6): 303-314.

Mahadevappa M. and Ponnaiya B.W.X. 1965. A discriminant function for selection for yield in Eleusine coracana Gaertn. *Madras Agric. J.* 2(7): 47-5.

Mahalakshmi, V. and Bidinger, F.R., 1986. Water deficit during panicle development in pearl millet: yield compensation by tillers. *J. Agric. Sci.* 106(1): 113-119.

Mahto, R.N., Mahto, J.L. and Ganguli, D.K., 2000. Correlation and path coefficient analysis in ragi (*Eleusine coracana* L. Gaerth.) under rainfed condition. *J. Res. Birsa Agric. Univ.*12(1): 81-83.

Mallanna, K. N., Mallikarjunaradhya, K., Gowda, M.V.C., and Umashankar, R. 1982. Phenotypic stability for yield in finger millet (*Eleusine coracana*) *Indian J. Agric. Sci.*, 52 (3): 1075-1084

Moaed-Almeselmani. 2011. Effect of Drought on Different Physiological Characters and Yield component in different varieties of Syrian Durum wheat. *J. Agric. Sci.* 3: 127-133

Mohapatra, A.K. 1989. Effect of dates of planting, age of seedling and levels of nitrogen on biological yield and harvest index of rice. *Environ. Ecol.* 7(4), pp. 896-898.

Monte, P.R., Campieri, M.G.G.C.F.G., Lanfranchi, G.A., Bazzocchi, G., Franzin, G., Brignola, C., Battocchia, A., Sarti, F., Labo, G. and Dal., 1981. Treatment of ulcerative colitis with high-dose 5-aminosalicylic acid enemas. *The Lancet*. 318(8241): 270-271.

Mostajeran, A. and Rahimi-Eichi, V. 2009.Effect of drought stress on growth and yield of rice (Oryza sativa L.). Cultivars and accumulation of proline and soluble sugars in sheath and blades of their different age leaves. *Am.-Euroasian J. Agric. and Environ. Sci.* 5(2): 264-272.

Nagaraj, A.P and Mohankumar, H.K. 2009. Performance of finger millet (*Eleusine coracana* L. Gaertn) varieties on sowing dates and methods of establishment. *Mysore J. Agric. Sci.* 43(2): 208- 212.

Nagaraja, A., Jagadish, P.S., Ashok, E. G., and Gowda, K. T. 2007. Avoidance of Finger millet blast by ideal sowing time and assessment of varietal performance under rainfed production situations in Karnataka. *J. Mycopath. Res*. 46: 109-111.

Nandini, B., Apoorva, K.B., Prakash, S.S., and Rajesh, N.L. 2010. STCR approach for optimizing integrated plant nutrient supply on growth, yield and economics of Finger millet (*Eleusine coracana* (L.) Garten.). *EJBS*, 4(1): 19-27.

Nath, M. and Sonwal, G.G. 1982. Chemical composition of kotu and maduwa flour. *Indian J. Agric. Chem.* 15 (1):85-89.

Nethra, N., Prasad, S.R., Vishwanath, K., Dhanraj, K.N. and Gowda, R. 2007. Identification of rice hybrids and their parental lines based on seed, seedling characters, chemical tests and gel electrophoresis of total soluble seed proteins. *Seed Sci. Technol.* 35(1): 176-186.

Nishit, D. 2013. Study of genetic divergence for grain yield and yield components in finger millet *(Eleusine coracana (L.)* Gaertn*.)* M.Sc. (Ag) thesis, Acharya N.G. Ranga Agriculture University, Rajendranagar, Hyderabad. 244p

Obilana, A. B. 2003. Overview: importance of millets in Africa. Available: http://www.afripro.org.uk/papers/Paper02Obilana._[17 march 2020]

Padmaja, G., 2006. Character association and selection indices in finger millet [*Eleusine coracana* (L.) Gaertn] Ph. D. thesis, Acharya N.G. Ranga Agriculture University, Rajendranagar, Hyderabad. 314p

Pandey, P.K., and Kumar, G.S. 2005. Finger Millet: A Flair for Human Nutrition in Uttaranchal. *Indian Farmers Digest*. 38(9): 28-30.

Patnaik, M.C., Misra, R.C., and Das, S. 2009. AMMI model analysis of stability and adaptability of late duration finger millet (*Eleusine coracana*) genotypes. *World Appl. Sci. J.* 6(12): 1650-1654.

Piper, C.S. 1942. Soil and Plant Analysis. (Asian Reprint, 1996). Hans Publications, Bombay, 368p.

Priyadharshini, C., Nirmalakumari, A., Jhon, J. A., and Raveendran, M. 2011. Genetic variability and trait relationships in finger millet hybrids. *Madras Agric.* J., 98 (1- 3):18-21.

Prusti, A.M., Mahapatra, B.K., and Baisaikh, B. 1998. Genotype environmental interaction and stability of performance of some strives of ragi. *Environ. Ecol.* 16: 909-912.

Ragaee, S., Abdel-Aal, E. S. M. and Noaman, M., 2006. Antioxidant activity and nutrient composition of selected cereals for food use. *Food Chem.* 98(1): 32-38.

Ramachandran, V.S., Parvathappa, H.C., Kantharaju, M.L. and Murali, N.M., 1991. Yield response of ragi to components of climatic water balance in different fertilizations. *Indian J. Soil Conserv*. 19p.

Ramakrishnan, K. and Bhuvaneswari, G. 2014. Effect of inoculation of am fungi and beneficial microorganisms on growth and nutrient uptake of *Eleusine coracana* (L.) Gaertn. (Finger millet). *Int. Letters Natural Sci.* 8(2).

Ramasamy, P., Subbaraman, N., Venakatachalam, R., and Soundarpandian, G. 1996. Contribution of weather variables to G × E interaction in finger millet genotypes. *Int. Sorghum and Millets Newsl.* 37: 79-8.

Ramulu, P. and Rao, P.U., 1997. Effect of processing on dietary fiber content of cereals and pulses. *Plant Foods Human Nutri*. 50(3): 249-257.

Rao, S. A., Prabhu, U.H., Sampath, S.R., and Oosting, S.J., 1993. Variation in chemical composition and digestibility of finger millet (*Eleusine coracana*) straw. pp. 297-307.

Ravikumar, P., Avadhani, K.K., Shariff, R.A. and Murthy, K.N.K. (2000). Variability and correlation studies in Zimbabwe lines in ragi. *Environ. and Ecol.* 18:371-374.

Ravikumar, R.L. and Seetharam, A., 1990. Inheritance of plant pigmentation in finger millet. *Crop Improv.* 17(2): 141-143.

Ravindran, G. 1991. Studies on millets, proximate composition, mineral composition, phytate and oxalate contents. *Food Chem*. 39 (1): 99-107.

Ravishankar, C.R., Ramappa, H.K., Prakash, P., and Geethadevi, T. 2004. Performance of promising finger millet (*Eleusine coracana* Gaertn.) lines for higher grain, straw yield and reaction to blast diseases. *Environ. Ecol.* 22: 693-695.

Reddy, C.V., Reddy, P.V.R.M., Munirathnam, P., and Gowda, J. 2013. Studies of genetic variability in yield and yield attributing traits of finger millet [*Eleusine coracana* (L.) Gaertn]. *Indian J. Agric. Res.* 47(6): 549-552.

Reddy, V.C and Patil, V.S. 1982. Growth analysis studies in finger millet in relation to moisture stress. *Mysore J. Agric. Sci.* 16: 238-243.

Reddy, V.G., Upadhyaya, H.D., Gowda, C.L.L., and Singh, S. 2009. Characterization of eastern African finger millet germplasm for qualitative and quantitative characters at ICRISAT. *J. SAT Agric. Res*. 7(9): 744-751

Roy, D.K. 1996. Response of finger millet varieties to levels of nitrogen under rainfed red and laterite zone of West Bengal. *Environ. Ecol.* 14: 367-370.

Roy, D.K., Maitra, S., Saren, A.K., Chakraborty, A. and Chakraborty, P. K. 1996. Response of finger millet varieties to levels of nitrogen under rainfed red and laterite zone of West Bengal, *Environ. Ecol.* 14 (2):367-370.

Sahu, S. and Pradhan, K. 2012. Genetic divergence in finger millet (*Eleusine coracana* L. Gaertn). *Environ. Ecol*. 30(2): 291-294.

Samanthray, G.T., Misra, P.K., and Patnaik K.K. 1989. Mineral composition of ragi. *Indian J. Nutr. Diet.* 26: 113-116.

Sarala, N. 2007. Phenotypic stability analysis in finger millet *[Eleusine coracana (L.) Gaertn*] Ph. D. Thesis, Acharya N.G. Ranga Agriculture University, Rajendranagar, Hyderabad. 182p.

Seetharam, A., Ardhya, K.M., Sheshidar, V.R., Mahishi D.M., and Gowda, B.T.S. 1984. Protein content in white and brown seeded finger millet genotypes. *Sabro J.*16(1): 65-67.

Shankar, T.1982. Genetics of yield and yield components in finger millet *(Eleusine coracana* Gaertn) following generation mean analysis, Ph.D. (Ag) thesis, University of Agricultural Sciences, GKVK, Bangalore, 58p.

Shanthakumar, G., and Gowda, B.T.S. 1997. Character association and path analysis of grain yield and its components in a segregating population of finger millet. *Karnataka J. Agri. Sci*. 10: 708-712.

Shashi, B.K., Sharan, S., Hittalamani, S., Shankar, A.G., Nagarathna, T.K., 2007. Micronutrient composition, antinutritional factors and bioaccessibility of iron in different finger millet (*Eleusine coracana*) genotypes. *Karnataka J. of Agric. Sci.* 20: 583.

Shukla, S. S., Gupta, O. P., Sawarkar, N. J., and Sharma, Y. K. (1985a). Study of macro and micro mineral nutrient content of some cultivates of ragi (*Eleusine coracana* Gaertn.). *Indian J. Nutri. Diet.* 22(8): 249-252.

Shukla, S.S., Gupta, O.P., and Tomar, A. K. (1985b). Proximate composition and grain characteristics of some varieties of ragi. *Crop Improv.* 12(2): 165-167.

Singh, D., Verma, N.S., and S.M. Tyagi. 1983. Proximate composition of milled fraction of ragi (*Eleusine coracana*) varieties. *Bull Gra. Technol.* 21 (2): 119-126.

Singh, P. and Srivastava, S. 2006. Neutral composition of sixteen new varieties of finger millet. *J. Community Mobilization Sustain. Dev*. 1(2): 81-84.

Solomon, I.S., Oliver, N., Richard, O., and Jane, A. 2014. Variation of nutritional and anti-nutritional contents in finger millet (*Eleusine coracana* L. Gaertn) genotypes, IOSR. *J. of Agric. Vet. Sci.* 7(11): 6-12.

Sonnad, S. K.B., and Kumar, G.S. 2008. Stability of seed and straw yield of white finger millet (*Eleusine coracana*) genotypes. *Indian J. of Agric. Sci.* 78: 706-707.

Spiller, G. A. and Shipley, E. A. 1977. Perspectives in dietary fibre in human nutrition. *Worm Rev. Nutr. Diet*. 27: 105p.

Srilakshmi, P. 2013. Character association and selection indices in finger millet [*Eleusine coracana* (L.) Gaertn]. M. Sc (Ag.) thesis. Acharya N.G. Ranga Agriculture University, Rajendranagar, Hyderabad. 210p

Srinivasarao, C., Vineela, C., Wani, S.P., Padmaja, B. and Vittal, K.P.R. 2008. Microbial properties of soils as affected by cropping and nutrient management practices in several long-term manurial experiments in the semi-arid tropics of India. *App. Soil Eco.* 40(1):165-173.

Subbiah, B.V. and Asija, G.L., 1956. A raped processor of determination of available nitrogen in nitrogen in soil. *Curr. Sci.* 25: 259-260.

Subramanian, K.S. and Kumaraswamy, K. 1989. Effect of continuous cropping and fertilization on chemical properties of soil. *J. Indian Society Soil Sci.* 37(1):171-173.

Sundaram, K. M., Gopalakrishnan. S., and Ratnam, N.N. 1986. Genotypic environment interaction in ragi (*Eleusine coracana* Gaertn.). *Madras Agric. J.* 73(10): 558-560.

Suryanarayana, L., Sekhar. D., and Rao N.V. 2014. Genetic variability and divergence studies in finger millet [*Eleusine coracana* (L.) Gaertn]. *Int. J. Curr. Microbiol. Appl. Sci.* 3(4): 931-936

Swarup, V. and Chaugale, D.S. 1962. A preliminary study on resistance to stem borer, Chilo zonellus (Swinhoe) infestation on sorghum [*Sorghum vulgare* Pers.] *Curr. Sci.* 31:163-164.

Tahsin, K. and Auti, S.G. 2017. Screening of higher mineral containing finger millet landraces from Maharashtra. *Int. J. Food Sci. Nutr.* 2(3):21-25.

Tewari, L., Johri, B.N. and Tandon, S.M. 1993. Host genotype dependency and growth enhancing ability of VA-mycorrhizal fungi for Eleusine coracana (finger millet). *World J. Microbiol. Biotechnol.* 9(2):191-195.

Tiwari, R. K., Baniya, B. K., Chaudhary, P., Shrestha, S. K., and Tiwari, P.R. 2005. Planting materials seed systems of finger millet, rice and taro in Jumla, Kaski and Bara districts of Nepal. *Nepal Agric. Res. J.* 6:10-22.

Udayakumar, M., Shankar, A.G., and Prasad, T.G. 1990. Genetic variability for net photosynthesis in finger millet (*Eleusine coracana* L. Gaertn) genotypes an approach to identify high CER types. *J. Agron. Crop Sci.* 165(4): 240-252.

Ulaganathan, V. and Nirmalakumari, A. 2013. Phenotypic selection of elite genotypes based ongenetic analysis in finger millet [*Eleusine coracana* (L.) Gaertn] germplasm. *Plant Arch.* 13(2): 1003-1008.

Upadhyay, S.R., Bishwokarma, S.B., Ghimire, J., Chaudhari, I.B., Subedi, G.P., Karki, L.S. and Shah, P. 1997. Finger millet varietal investigation report for terai/inner terai and foot-hills of Nepal. *National Summer Crops Workshop.* Parwanipur. pp. 22-24.

Upadhyaya, H. D., Ramesh, S., Sharma, S., Singh, S. K., Varshney, S. K., Sarma, N. D. R. K., Ravishankar, C.R., Narasimhudu, Y., Reddy, V. G., Sahrawat, K. L., Dhanalakshmi, T. N., Mgonja, M. A., Parzies, H. K., Gowda, C. L. L., and Singh, S. 2011. Genetic diversity for grain nutrients contents in a core collection of finger millet (*Eleusine coracana* (L.) Gaertn.) germplasm. *Field Crops Res*. 121(1): 42-52.

Utta, D., Pragya, M., Pradesh, V.E., and Singh, T.K. 2015. Chemical composition of finger millet of food and nutritional security. *Int. J. Food Sci. Microbiol*. 3(6): 92-98.

Vadivoo, A.S., Joseph, R., Ganesham, N.M., and Joseph. 1988. Variability and diversity for protein and calcium content relation to grain colour. *Plant Food Human Nutr.* 52(4): 353-364.

Vaidehi, M.P. (1980). Ragi-nutrition and alternate uses. Proceeding of State Level Training Class on Ragi. University of Agriculture Sciences Bangalore. pp: 46-51.

Venkanna, B.B., Ramana, T., and Radhakrishnan, T.M. 1987. Chemical composition and protein content in hybrid varieties of finger millet. *Ind. J. Agric. Sci.* 57(7): 520-522.

Venkat, D.B., Reddy, Y.S.K., and Sudhakar, P. 2014. Evaluation of physiological efficiency and yield potential of ragi genotypes under imposed moisture stress conditions. *Bioscan.* 9:1777-1780.

Wallace, A.T., Burton, G.W., and Rachie, K.O. 1972. Chemical composition and nutritive value of pearl millet (*Pennisetum typhoides* (Burm.) Stapf and EC Hubbard) grain. *Crop Sci.* 12(2);187-188.

Watanabe, F.S. and Olsen, S.R. 1965. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. *Soil Sci. Soc. Am. J.*, 29(6); 677-678.

Wet, J. M.J. 2006. *Eleusine coracana* (L.) Gaertn. in Brink. *Plant Resour. Trop. Africa*. Wageningen. 1475p

Appendix

APPENDIX

Week no.		Max. °C	Min. °C	Mean RH%	SS hrs	Total rain (mm)	Rainy Days	Evp. (mm)
25	25 june -01 july	29.1	22.6	91	1.0	169.7	5	2.1
26	02 july -08 july	30.1	22.6	87	2.6	93.0	6	2.4
27	09 july- 15 july	31.8	23.0	81	5.7	65.5	2	3.2
28	16 july- 22 july	28.4	22.1	93	0.3	304.2	7	2.5
29	23 july-29 july	28.3	21.8	93	0.0	254.1	6	1.9
30	30 july- 05 aug	29.5	23.0	87	0.9	110.5	5	2.5
31	06 aug- 12aug	30.0	23.2	87	1.5	103.6	6	2.5
32	13 aug-19aug	29.1	22.3	90	0.6	208.6	7	2.0
33	20 aug-26aug	27.2	21.7	93	0.0	629.0	7	1.5
34	27 aug - 02 sept	30.4	22.1	82	5.7	12.9	3	3.0
35	03 sept-09sept	30.1	22.6	83	2.9	32.6	2	2.7
36	10 sept to16 sept	31.4	22.2	76	8.9	0.5	0	3.5
37	17 sept-23 sept	32.2	22.2	74	9.1	0.0	0	3.8
38	24 sept-30 sept	32.0	22.6	75	6.5	0.9	0	3.1
39	01 oct -7 oct	33.6	22.6	77	5.7	27.6	1	3.1
40	08 oct to 14 oct	33.1	22.2	77	4.5	141.0	5	3.0
41	15 oct -21oct	32.8	24.0	83	5.3	65.7	2	2.9
42	22 oct-28 oct	31.8	23.2	82	4.5	146.5	4	2.8
43	20 oct - 4 nov	33.2	22.7	65	7.3	39.8	2	3.5
44	05 nov - 11 nov	32.8	23.4	70	6.2	1.0	0	3.3
45	12 nov to 18 nov	33.6	23.0	64	7.3	0.0	0	3.6
46	19 nov-25 nov	32.8	23.4	72	6.8	4.1	1	2.6
47	26 nov-o2 dec	33.0	23.3	72	7.7	61.5	4	3.6
48	03 dec to 09 dec	31.8	23.3	61	7.7	0.0	0	4.2
49	10 dec to 16 dec	32.8	23.4	61	7.8	0.0	0	4.0
50	17 dec to 23 dec	33.2	21.8	65	6.3	0.0	0	3.1
51	24 dec to 30 dec	33.1	21.6	64	6.5	0.0	0	3.0
52	31dec to jan 6	33.2	22.9	62	6.8	0.0	0	3.6
1	7 jan to 13 jan	31.6	19.2	48	9.5	0.0	0	5.3
2	14 jan to 20 jan	33.1	19.3	53	9.2	0.0	0	4.6
3	21 jan to 27 jan	33.2	21.1	49	7.7	0.0	0	5.5
4	28jan to 3 feb	33.4	21.0	63	6.8	0.0	0	3.3

PERFORMANCE OF HIGH YIELDING VARIETIES
OF
FINGER MILLET
[*Eleusine coracana* (l.) Gaertn]

By
KISHORE NEERUGANTI (2017-11-134)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture (Agronomy)

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA

2021

ABSTRACT

An experiment entitled "Performance of high yielding varieties of finger millet (*Eleusine coracana* (L.) Gaertn)" was undertaken during the period from July 2018 to January2019 at the Agronomy Farm, College of Agriculture, Vellanikkara, Thrissur.The objective of the experiment was to evaluate the performance of some prominent high yielding varieties of ragi suitable for *Kharif* and *Rabi* seasons in central Kerala. Randomized block design was adopted with nine varieties and three replications in both seasons. The plot size was 5 m x 4 m and the seeds were line sown at a spacing of 25 cm x 15 cm.

The high yielding varieties included were VR 708 (Champavathi), Vakula, Hima, Maruthi and PR 202 (Godavari) (released from Andhra Pradesh), GPU 48, GPU 28 and KMR 201 (released from Karnataka) and Co15 (released from Tamil Nadu). All the management practices were done as per Package of Practices Recommendations of KAU. Observations on growth parameters were taken at 30 DAS, flowering and at harvest. Quality parameters of grain (crude protein, crude fibre, Ca and Fe), yield and yield attributes were also recorded.

Varietal differences were significant with respect to plant height. In *Kharif*, when plant height was recorded at harvesting, GPU 28 (109.71 cm) and PR 202 (111.07 cm) were superior to all other varieties with statistically comparable values. The shorter varieties were GPU 48 (77.75 cm) and VR 708 (78.39 cm). At this stage in *Rabi*, CO15 had the tallest plants (100.41 cm). However, PR 202 also had statistically comparable plant height (98.65 cm). VR 708, Maruthi and GPU 48 were statistically on par and were inferior to other varieties with plant height in the range 72.17cm to 73.99cm.

The varieties differed significantly with respect to total number of tillers in both the seasons. In general, *Rabi* crop had a greater number of basal tillers than the *Kharif* crop. The average number of basal tillers was 5.80 in *Kharif* and 6.80 in *Rabi*. In *Kharif*, variety VR 708 (9.27) was statistically superior with respect to basal tillers produced than other varieties. Variety Vakula produced only 3.6 tillers per plant. In

*Rab*i, the greater number of tillers were produced by VR 708 (10.27) and CO15 (9.93). Total number of tillers showed an increase in most of the varieties, and in Hima and Vakula, a sharp increase in tiller number during *Rabi* was registered compared to *Kharif.*

Seasonal differences were not pronounced in many varieties with respect to days to flowering but variation to the extent of up to 11 days was noticed in variety GPU 28. On an average, the days to 50 per cent flowering was 69 in *Kharif* and 72 in *Rabi* season. In *Kharif* season, PR 202 took the longest period for 50 percent flowering (79 days).

The calcium content in ragi grain showed wide variability among varieties ranging from 326mg/100g to 564 mg/100g over the seasons and Fe content was in a narrow range of 6.25 – 8.91 mg/100g. There was no significant difference in fibre content of various varieties.

More productive tillers were produced by CO15 and the minimum number of productive tillers were produced by Maruthi. Wide variations in finger length was observed among varieties and the values ranged from 5.30cm to 11.87 cm in *Kharif* and 6.23 to 11.97 cm in *Rabi* season. Vakula had the highest value in both seasons and was significantly superior to all others. The test weight ranged from 1.53 to 3.53 g in *Kharif* and from 1.51 to 3.25 g in *Rabi* among the varieties. Variety PR 202 had the highest 1000 grain weight of 3.53g.

The average straw yield was 3592 kg/ha in *Kharif* whereas a higher value of 4010 kg/ha was realized in *Rabi.* The highest straw yield was for KMR 201(5100 kg/ha & 5141 kg/ha in *Kharif* and *Rabi*)) which was on par with GPU 48 (4578 kg/ha) in *Kharif.* The straw yields were low in Maruthi (3059.7 kg/ha), Vakula (3388.8 kg/ha) and VR 708 (3550 kg/ha) in both seasons.

Among the nine varieties tried, six varieties - GPU 48, GPU 28, Hima, CO15 , PR 202 (Godavari) and KMR 201 performed better in *Kharif* as well as in *Rabi* season. The variety KMR 201 was found to be superior in terms of yield in both the seasons (3008.3 and 2737 kg/ha, respectively), whereas the white seeded variety Hima was found to be ideal for *Rabi* season due to its superior yield of 3092 kg/ha . Variety CO15 showed more adaptability to *Kharif* with grain yield of 2355 kg/ha and the performance was poor in *Rabi* (1833.33 kg/ha). Three varieties VR 708, Vakula and Maruthi are not ideal varieties for Kerala especially for *Kharif* season