MORPHO-PHYSIOLOGICAL CHARACTERIZATION OF SUMMER GROUNDNUT (*Arachis hypogaea L.*)

by

Miss. Ghodke Shubhangi Rajendra
(Reg. No. 018/063)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL BOTANY
(PLANT PHYSIOLOGY)

DEPARTMENT OF AGRICULTURAL BOTANY

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. - AHMEDNAGAR
MAHARASHTRA, INDIA.
2021

MORPHO-PHYSIOLOGICAL CHARACTERIZATION OF SUMMER GROUNDNUT (*Arachis hypogaea L.*)

by

Miss. Ghodke Shubhangi Rajendra
(Reg. No. 018/063)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA.

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL BOTANY

(PLANT PHYSIOLOGY)

APPROVED BY

Dr. S.R. More
(Chairman and Research Guide)

Dr. R.S. Wagh
(Committee Member)

Dr. L.B. Mhase
(Committee Member)

Dr. A.A. Kale
Committee Member)

Dr. C.A. Nimbalkar
(Committee Member)

DEPARTMENT OF AGRICULTURAL BOTANY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. - AHMEDNAGAR
MAHARASHTRA, INDIA.
2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institution
for a Degree or
Diploma

Place : MPKV, Rahuri

Date : / /2021 **(Shubhangi R. Ghodke)**

Dr. S. R. More
Associate Professor,
Department of Agricultural Botany
Post Graduate Institute
Mahatma Phule Krishi Vidyapeeth
Rahuri-413 722, Dist. Ahmednagar (M.S)

CERTIFICATE

This is to certify that the thesis entitled, "**MORPHO-PHYSIOLOGICAL CHARACTERIZATION OF SUMMER GROUNDNUT (*Arachis hypogaea L.*)"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **PLANT PHYSIOLOGY,** embodies the results of a piece of *bona fide* research work carried out by **Miss. GHODKE SHUBHANGI RAJENDRA,** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

Place : MPKV, Rahuri (Dr. S.R. More)
Date : Research Guide

Dr. A.S. Jadhav
Head,
Department of Agricultural Botany,
Mahatma Phule Krishi Vidyapeeth,
Rahuri – 413 722, Dist. Ahmednagar,
Maharashtra State, INDIA

CERTIFICATE

This is to certify that the thesis entitled, "**MORPHO-PHYSIOLOGICAL CHARACTERIZATION OF SUMMER GROUNDNUT (*Arachis hypogaea L.*)**" submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **PLANT PHYSIOLOGY,** embodies the results of a piece of *bona fide* research work carried out by **Miss. GHODKE SHUBHANGI RAJENDRA,** under the guidance and supervision of **Dr. S.R. MORE,** Associate Professor, Department of Agricultural Botany, M.P.K.V., Rahuri and that no part of this thesis has been submitted for any other degree or diploma.

Place : MPKV, Rahuri (A.S. Jadhav)

Date :

Dr. P.N. Rasal
Associate Dean,
Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri-413 722, Dist. Ahmednagar,
Maharashtra State, INDIA

CERTIFICATE

This is to certify that the thesis entitled, "**MORPHO-PHYSIOLOGICAL CHARACTERIZATION OF SUMMER GROUNDNUT (*Arachis hypogaea L.*)"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **PLANT PHYSIOLOGY,** embodies the results of a piece of *bona fide* research work carried out by **Miss. GHODKE SHUBHANGI RAJENDRA,** under the guidance and supervision of **Dr. S.R. MORE,** Associate Professor, Department of Agricultural Botany, M.P.K.V., Rahuri and that no part of this thesis has been submitted for any other degree or diploma.

Place : MPKV, Rahuri (P.N. Rasal)

Date : / /2021

ACKNOWLEDGEMENTS

Every successful work indirectly is an output of many person's efforts and even this one is not an exception! Emotions cannot be adequately expressed in words, but are transformed into mere formalities. Nevertheless, formalities have to be completed. This acknowledgment is a sincerely and highly emotional expression of gratitude for all those who made this work a most memorable milestone.

I consider myself to be very fortunate for getting an opportunity to complete the research work under the dynamic and masterly guidance of Dr. S.R. More, Associate Professor of Agril. Botany, Post Graduate Institute, M.P.K.V., Rahuri, the esteemed chairman of my advisory committee. I am deeply indebted to him for their valuable guidance through constructive and rational discussion and constant encouragement, not only throughout this investigation but also during my entire PG programme. I have a great pleasure in recording my heartful feelings to express my deep sense of gratitude and indebtedness for their valuable inspiring and scholastic guidance, supervision, keen and constructive criticism and unfailing interest during the entire course of my research.

It is my privilege to record my sincere guidance and indebtedness to Dr. K. P. Viswanatha, Hon. Vice Chancellor, MPKV., Rahuri, Dr. A L. Pharande, Dean faculty of Agriculture and Director of Instructions, MPKV, Rahuri., Dr. P. N. Rasal, Associate Dean, Post Graduate Institute, M.P.K.V., Rahuri and Dr. A. S. Jadhav, Head Dept. of Agril. Botany, Post Graduate Institute, M.P.K.V., Rahuri for providing necessary facilities, useful suggestions and constant encouragement for the research.

I sincerely express my deep sense of gratitude and cordial thanks to the member of my advisory committee, Dr. R. S. Wagh, Professor of Agril. Botany, Dr. L. B. Mhase, Assistant Professor of Agril. Botany, Dr. A. A. Kale, Associate Professor of Biochemistry and Dr. C. A. Nimbalkar, Associate Professor of Agril. Statistics, for their valuable and helpful suggestions, unremitting encouragement, inspiration, proper guidance and constant help during my research work and in the preparation of this manuscript.

I extend my great sincere thanks to Dr. R. S. Wagh, Professor of Agril Botany, Dr. G. C. Shinde, Professor of Agril. Botany, for their very valuable cooperation and support.

It is incumbent upon me to express my special thanks to Dr. V.L. Amolic, Professor of Agril. Botany, for their timely valuable help of suggestions during the research work. I owe my heartful thanks to Mrs. Kakade madam, Laboratory Assistant of Agril. Botany, M.P.K.V.,Rahuri, Mrs. Ithape madam, all the staff and labours of farm of AICRP Groundnut and Department of Agricultural Botany, Post Graduate Institute, M.P.K.V., Rahuri for their important help and cooperation. I am thankful to all the authers in past and present whose literature has been cited.

I have no words to give thanks to my enthusiastic, cheerful and selfless seniors, Shital Varpe, Sampada Ingulkar, Monika Dure , Pramila Janjire, Pooja Limbhore , Komal Dahiphale, Snehal Badhe, Bhagyashri Totare, Sujata Wayal and Mr. Nitin Thorat without

their support, encouragement and cooperation this work and my PG programme would not have been completed.

One need sincere friend's at all major juncture in life to bear strains and fatigue cheerfully and proverb says that " A friend in need is friend indeed". I have been more than lucky in this respect and could like to record my cardiac sense of gratitude towards my highly energetic friends Shirin Pandit, Supriya Kalambarkar, Akanksha Dhapte, Pallavi Khomane, Renuka Gavade, Komal Mitkal, Vanita Gaikwad, Snehal Ghule, Vinay Sangle, Rushikesh Giri, Suraj Kulkarni, Rahul Mane for their encouragement and kindly co-operation. It is really beyond my capacity to express my feeling for the over whelming affection and kind cooperation that I received from my near and dear friends Mohini Jadhav, Pradnya Pawar, Sayali Shinde, Swati Shinde, Kiran Jadhav and Pankaj Walunj. Even though words will not suit to express my deep sense of gratitude to my beloved unique sweet juniors.

Everything in my life is nothing if I ignore the all time encouragement, evergreen affection and there is nothing to say about love, patience and support of my beloved parents Sau. Savita and Shri. Rajerndra Ghodke who always stood like a light house of illuminating the pathway of my every success and providing me the valuable opportunities and assistance which elevate my morals during the whole educational carrier. I cannot eschew to express special thanks to my beloved brother Vikas, and sister Sonali and also all relatives for their everlasting love, moral support, constant inspiration and encouragement during my life.

I thank to Mahatma Phule Krishi Vidyapeeth, Rahuri, for providing me an opportunity to undertake this post graduation studies.

While travelling on this path of education many hands pushed me fourth, learned hearts put me on the right track enlightened by their knowledge and experience. I ever rest thanks to all of them.

Thank you……..

Place : M.P.K.V., Rahuri (S. R. Ghodke)

Date : / / 2021

CONTENTS

LIST OF TABLES

List of Table contd…

LIST OF FIGURES

List of Figures contd…..

LIST OF PLATES

LIST OFABBREVIATION

Abbreviations		Description
%	:	Per cent
/ or -1	:	Per
µ mol	:	Micro molar
^{0}C	:	Degree Celsius
C.D.	:	Critical difference
cm	:	Centimeter
cm^2	:	Centimeter square
DAS	:	Days after sowing
dm^2	:	Desimeter square
et al.	:	Etalia (and associates)
Etc.	:	Et cetera (and so forth)
Fig.	:	Figures
g	:	Gram
ha	:	Hectare
HI	:	Harvest index
i.e.	:	That is
J	:	Journal
kg	:	Kilogram
LA	:	Leaf area
LAI	:	Leaf area index
M	:	Meter
Max.	:	Maximum
Mg	:	Milligram
Min.	:	Minimum
No.	:	Number
No.	:	Number
NS	:	Non significant
pp	:	Page
S.E.	:	Standard error
Sr. No.	:	Serial number
TDM	:	Total dry matter
viz.	:	Namely (videlicet)

ABSTRACT

MORPHO-PHYSIOLOGICAL CHARACTERIZATION OF SUMMER GROUNDNUT (*Arachis hypogaea L.*)

by

Miss. GHODKE SHUBHANGI RAJENDRA

A candidate for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL BOTANY
(PLANT PHYSIOLOGY)

Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri-413722
2021

Research Guide	**:**	**Dr. S. R. More**
Department	**:**	**Agricultural Botany**
Discipline	**:**	**Plant Physiology**

The present investigation entitled “Morpho-physiological characterization of summer groundnut (*Arachis hypogaea L.*) was carried out at AICRP on Groundnut Improvement Project, M.P.K.V., Rahuri, Dist. Ahmednagar (M.S.) during summer season of 2019.

The field experiment was laid out in randomized block design (RBD) with three replications involving fourteen genotypes. The observations on different plant characters such as plant height, number of branches, number of leaves, leaf area, dry matter content of leaves, stem, roots, pods, photosynthetic rate, transpiration rate, stomatal conductance, stomatal frequency and biochemical analysis i.e. protein, oil and chlorophyll content were recorded. It was observed that, the plant height, number of branches, number of leaves, leaf area, leaf area index were increasing rapidly upto 100 DAS and slowed down thereafter. Dry matter of leaf, stem, root, pods per plant were differed significantly throughout the growth period. Studies on leaf area revealed that, it is good for increasing photosynthetic efficiency of plant.

The genotypes significantly differed in respect of yield per plant. The highest dry pod yield (kg) per plot, dry pod yield (kg) per hectare were recorded by genotypes RHRG-1308 followed by RHRG-1192 and RHRG-1309 due to significant favourable yield characters like number of pods per plant, pod yield (g), kernel yield (kg) per hectare, shelling percentage and harvest index (%). These genotypes also exhibited highest physiological parameters like photosynthetic rate, transpiration rate, stomatal conductance and stomatal frequency.

There were significant differences in the protein and oil content of the groundnut genotypes. The protein content was higher in the genotype RHRG-1192 and it is ranging from 22.20 to 24.89 % in other genotypes. Whereas, oil content was higher in genotype Phule Unnati and it is ranging from 44.93 to 49.69 % in the genotypes that were studied.

Therefore, it can be concluded that, the significant variation in yield could be seen in different genotypes due to their differential behaviour in respect of growth, development, phenology, dry matter production potential and translocation of photosynthates from source to sink. In the high yielding genotypes *viz*, RHRG-1308, RHRG-1192 and RHRG-1309, the photosynthetic rate, number of pods, pod weight, kernel weight and harvest index etc, were observed to be the major yield contributing characters. However, to arrive at definite conclusion more detailed studies are needed.

1. INTRODUCTION

Oilseed crops have been the backbone of several agricultural economies from antiquity and play a prominent role in agricultural industries and trade throughout the world. The self-sufficiency in oilseeds attained in India through "Yellow Revolution" during early 1990's, could not be sustained beyond a short period. These crops varies from 20 per cent for soybean to 40 per cent of sunflower etc. Seed oils are used for industrial as well as edible purposes. Recently, oilseeds attracted more attention due to an increasing demand for their healthy vegetable oils, livestock feeds, pharmaceuticals, biofuels, and other industrial uses.

India is one of the major oilseeds grower and importer of edible oils today. India's vegetable oil economy is world's fourth largest after USA, China and Brazil. The oilseed accounts for 13 per cent of the Gross Cropped Area, 3 per cent of the Gross National Product and 10 per cent value of all agricultural commodities. In India, annual oilseeds are cultivated over 26.67 million hectares of area producing 30.06 million tons annually. Majority of the oilseeds are cultivated under rainfed ecosystem (70 %) .

There are two major sources of vegetable oils i.e. primary and secondary. Primary source of vegetable oil contains 9 oilseeds in the country, which are largely grown under rainfed condition over an area of about 26 million ha. Among these, soybean (34 %), groundnut (27 %), rapeseed and mustard (27 %) contributes to more than 88 per cent of total oilseed production and > 80 per cent of vegetable oil with major share of mustard (35 %), soybean (23 %), and groundnut (25 %). India is producing about 7-8 million tons of vegetable oils from primary sources. In addition to nine oilseeds, 3 million tons of vegetable oil is being harnessed from secondary sources like cottonseed, rice bran, coconut and oil palm.

Groundnut (*Arachis hypogaea* L.*)* is a world prospective oilseed and food crop grown by small and marginal farmers in India as well as in world in diverse agro-climatic environment. It is not only an important oilseed crop of India but also an important agricultural export commodity. In India, though groundnut is cultivated in one or more seasons (*kharif*, rabi and summer) nearly 80 per cent of the annual acreage and production comes from *kharif* crop (June- October). It is widely accepted as an excellent source of nutrition to both human and animals due to it's high protein content. Groundnut is also known by many other local names such as earthnuts, goober peas (US), peanut,

monkey nut (UK), and pig nuts. Despite its name and appearance the Groundnut is not a nut but rather a legume cum oilseed crop of India. It is also referred as the 'King of Oilseeds'. It is useful in improvement in the soil fertility status by fixing the atmospheric nitrogen with the help of *Rhizobium* bacteria.

Groundnut was probably first domesticated and cultivated in the valleys of Paraguay (South America). The term *Arachis* is derived from the Greek word ' arachos' meaning a legume and *hypogaea* meaning below ground referring to the geographic nature of pod formation. It is a member of the subfamily 'papilionaceae' of the family 'leguminaceae'. The chromosome number of groundnut is 2n=40. It is a self pollinated crop. The genus *Arachis* has more than 70 wild species of which only *Arachis hypogaea* L., is a domesticated and commonly cultivated. It is one of the annual herbs and can be grown under tropical and subtropical climatic conditions. It can be grown in wide range of temperature and humid regions but maximum production comes from the semiarid tropics. The temperature range required for groundnut is 20 to 30^0C .

Different cultivars of groundnut are broadly classified into three groups :

1. Virginia (hypogaea) – having bunchy, semi-spreading or spreading growth habit, 2-seeded pod.
2. Spanish (vulgaris) – having bunchy growth habit, pod usually with 2seeds, testa colour tan, red, White or purple.
3. Valencia (fastigiata) – vegetative branches on primaries absent or placed at distal nodes, pod with 2-4 seed, testa colour tan, red, white yellow purple or variegated.

Groundnut plant has a well developed tap root system with numerous laterals, abundant nodules are formed on the main and lateral roots. After fertilization an intercalary meristem at the base of the ovary is activated and the peg or carpophore is produced. The peg enters the soil and enlarges into fruit. The mature fruit (pod) contains one or more seeds (kernels). The seed consists of two cotyledons, a hypocotyl, epicotyls and radical. Dwivedi *et al.* (1986) found epigeal germination behaviour in groundnut where the hypocotyl carries cotyledons to the soil surface and remains their. Seedless fruits or 'pops' may arise due to calcium deficiency in the soil.

Groundnut leaves are tetra foliate, peripinnate with two pairs of opposite subsessile, obovate leaflets with entire ciliate margin. It has been described as natures masterpiece of food values. Its pod consists of about 20-26 per cent shells and 74-80 per cent kernels. It is one of the most nutritious food because of its high proteins and oil

content. It has the highest calorific value among the common proteins food. Kernel contains approximately 50 per cent edible oil, 25 per cent proteins, 15 per cent carbohydrates, 6 per cent moisture, 2 per cent ash, 2 per cent crude fibre (Adsule *et al.,* 1989). Kernels are rich in vit. A, B1, B2, nicotinic acid, E and K (Woodroof, 1983). The oil of groundnut is rich in unsaturated fatty acid (80 %), oleic acid and lenoleic acid containing 38-58 per cent and 16-38 per cent respectively (Nagraj, 1995). Seeds are used for oil extraction, as food and as an ingredient in confectionary products. After oil extraction, the residual cake is processed largely for animal feed and haulms are used as good source of fodder.

Groundnut, a major oilseed crop that ranks 13th position among the food crops and ranks 4th among the oilseed crops of the world. The groundnut seed is value as a desent nut and used as the production of confectionary nut flour, peanut protein and peanut milk. India is the 2nd largest producer of groundnut in the world after China. The major groundnut growing states of India are Gujrat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra. In India there was production of 84.72 lakh tons of groundnut from an area of 53.21 lakh ha. with productivity of 1592 kg/ha. In Maharashtra total area under groundnut cultivation is 2.73 lakh ha with production of 3.58 lakh tons and productivity 1290 kg/ha (Anonymous, 2017).

According to *kharif*-2019 survey of groundnut crop, (IOPEPC, *kharif*-2019 Survey of Groundnut) all India groundnut acreage was 39,31,700 ha. Six states, Gujrat (15,52,200 ha; 39 %), Andhra Pradesh (5,53,383 ha; 14 %), Rajasthan (5,73,889 ha; 15 %), Karnataka (3,70,564 ha; 9 %), Maharashtra (1,87,500 ha; 5 %), Madhya Pradesh (2,21,700 ha; 6 %) jointly accounted for about 88 per cent of the national acreage. In Maharashtra, the highest yield (1370 kg/ha) was estimated in Ahmednagar district followed by Nashik district (1340 kg/ha). The highest production was estimated for Satara which was followed by Nashik. The total production in Maharashtra was estimated at 1,93,875 MT with an average yield of 1034 kg/ha. The maximum yield of groundnut obtained during summer season and this may be due to adequate sunlight, temperature, availability of irrigation and fairly diseases and pest free conditions.

In most of the crop species including groundnut, it seems that in the absence of genetic enhancement in photosynthesis and growth past improvement in yield potential has been derived largely from increase in harvest index (Zhu *et al.,* 2010). Hence, there is need to increase productivity by increasing both total biomass and harvest

index utilizing the genetic variability in physiological traits, especially in groundnut. In addition significant variability in photosynthesis among groundnut cultivars also suggests the need to analyze the genetic potential (Nautiyal *et al.,* 2002).

The yield of groundnut is largely influenced by different internal factors such as synthesis of photoassimilates rate of partitioning of photosynthates between vegetative and reproductive phases and other environmental factors. Though, it leads in area and production in the world, its productivity is low due to various abiotic and biotic stresses.

The pod yield besides physiological traits i.e. transpiration rate, leaf area, stomatal conductance and photosynthetic rate in groundnut are quantitatively inherited complex traits and is highly influenced by environmental factors. The growth analysis techniques help in understanding growth pattern and contribution of various plant parts to economical yield. It also help in yield contributing characters. Thus, growth analysis forms the basis for manipulation of productivity of the crop.

Any morphological character that is associated with higher pod yield or which makes a significant contribution to yielding ability would be useful in the improvement of yield. The studies on the basis of morpho-physiological traits are needed to overcome the yield barriers within the genotypes (Dharanguttikar and Borkar, 2014).

Meteorological parameters play an important role in determination of crop yield because these strongly influence the physiological expression of genetic potential of the crop. Climatic conditions such as temperature and rainfall significantly influence the groundnut production. Warm and moist conditions are very favourable than cool and wet climate, which results in slow germination and seedling emergence. Temperature is a major environmental factor that determines the rate of crop development. It is true that weather parameters strongly influence the crop performance but amongst them the effects of only few parameters are significant. Therefore, it becomes necessary to identify such parameters and quantify their contribution besides developing the relations with growth and yield of the crop (Sundari, 2003).

There are two physiological approaches to achieve the target of yield potential. One is physio-genetic, which consists the genotypic difference in physiological traits and another one is the physio-agronomic relates with the management practices. It is ultimately the morpho-physiological variation, which is important for realizing higher

productivity as evident from very high and positive association within their traits (Mathur, 1995).

Availability of assured irrigation supply, adequate sunlight and fairly disease and pest free conditions, summer groundnut gives better returns. Also high prices and increasing demand for edible oil, the summer groundnut is gaining popularity among the farmers, so the research for evolving better varieties suitable for summer cultivation selected. But there are so many different genotypes of groundnut are available, among these genotypes some play significant role in plant height, leaf area per plant and pod yield. For improvement of growth and yield of groundnut it is necessary to gather further information regarding the varietal performance with different genotypes by using physiological parameters. The studies between yield and yield component are of immense help in selecting suitable genotypes. The need for studying the magnitude of interrelationship between different characters was important in many cases particularly for designing reliable and efficient breeding programme.

Considering all these aspects, the present study **"Morpho-physiological characterization of summer groundnut (*Arachis hypogaea L.)*** was planned and conducted at AICRP Groundnut Improvement Project, M.P.K.V., Rahuri. To test whether groundnut cultivars differ in responses of photosynthetic rate, dry matter production and pod yield and whether associations can be detected between various morphological, physiological traits, and yield components to elucidate the variability for higher productivity, the study was undertaken with the following objectives.

1. To study the morphological characters of groundnut genotypes.
2. To study the dry matter accumulation and it's partitioning in groundnut.
3. To study out association of physiological parameters with pod yield.

2. REVIEW OF LITERATURE

Groundnut (*Arachis hypogaea L.*) is an important oilseed crop and food grain legume. However, the literature on the production of physiology of this crop is very rare. Particularly, basis of yield and yield differences between different genotypes of this crop is tenuous. The yield of crop is controlled by the genetic potential and environmental conditions prevailed during its life cycle. In India, productivity of groundnut is lower due to many physiological constraints. There is need to identify suitable genotypes for higher productivity based on morpho-physiological approach. Hence, the literature on attributes like growth variables, dry matter accumulation, yield components and biochemical characters are presented in this chapter.

This chapter deals with the review of research work done by different workers on the aspect of morphological, physiological and yield contributing characters in groundnut under different genotypes. The brief account of literature is classified and presented under different heads to support the findings of the present investigation.

2.1 Growth studies

2.1.1 Plant height (cm)

Mondal (1997) evaluated variability among 30 accessions for plant height and observed high variability in plant height ranging from 33.5 to 50.2 cm.

Mensah and Okpere (2000) conducted field experiment at Edo Stat University, Ekpoma and concluded that the plant height of four cultivars (RMP-91, RMP-12, RMP-12 and Ex-Dakar) decreased under drought conditions imposed on groundnut.

Rahman (2003) studied comparative performance in respect of growth and yield in four groundnut genotypes and reported that high yielding genotypes had shorter plant height than in the low yielding ones. Similar results was also reported by Rahman (2001) after studying the comparative performances of 39 groundnut genotypes.

Jagtap *et al.* (2014) conducted field experiment during summer 2008 at M.P.K.V., Rahuri. He evaluated eighteen groundnut genotypes for physiological analysis of growth and yield variation and concluded that plant height is basically a genetically controlled character and is being influenced by environmental character. In his study he reported that the genotypes SB XI (34.8cm) and JL 24 (34.1cm) for plant height.

Rasheed *et al.* (2015) conducted the field experiment at University of Haripur, Khyber Pakhtunkhwa, Pakistan. Significant variation were noted in different

groundnut genotypes at 5 per cent probability level. Plant height was in the range of 30 to 62 cm. Maximum plant height 62 cm were observed in the genotypes ICGS-07, ICGS-92050, while a minimum plant height 30 cm was taken by genotype PI-161294.

2.1.2 Number of branches per plant

Deshmukh and Dev (1993) in the field experiment conducted at Science College, Nanded (M.S.) during *kharif* season, observed that there was positive correlation between number of branches and pod yield of groundnut.

Rajmane (2001) conducted field experiment at M.P.K.V., Rahuri and observed that number of branches per plant in groundnut increases significantly throughout the growth period.

Rahman (2001) stated that high yielding genotypes had greater number of branches per plant than low yielding ones in groundnut. Similar result was reported by BINA (2002) in groundnut.

John *et al.* (2008) conducted field experiment at Regional Agriculture Research Station, Tirupati. He reported that number of primary branches per plant had significant positive relation with pod yield and pod yield per plant with kernel yield.

2.1.3 Number of leaves per plant

Leaves play very important role in photosynthetic activity, as most of the photosynthetic activity takes place in leaves rather than other plant parts, which further contributes to production of dry matter.

Dhopte *et al.* (1991) in the field experiment conducted at P.D.K.V., Akola showed that the water stress reduced total leaf area (TLA) significantly at all stages of crop growth in groundnut. The groundnut genotypes Girnar-1 has maximum TLA under stress condition. It shows its ability to productive leaf even under stress condition over the groundnut genotype.

Deshpande and Jadhav (1993) observed that greatest pod yield reductions in plants,where leaves from all the branches except the main stem were removed. Removal of leaves from 1-2, 3-4 or 5-7 branches from the bottom gave pod yield of 1526, 2698 and 2512 kg/ha respectively.

Kamshette *et al.* (2015) conducted field experiment in M.P.K.V., Rahuri and reported that, the number of leaves, number of branches per plant and dry matter production and it's distribution in component parts of plant increased progressively with the advancing age of the crop. The rate becomes rapid up to 80 DAS and rather slow after

80 to 100 DAS and 100 DAS to harvest. The number of leaves per plant and leaf area per plant was declined after 100 DAS due to defoliation of leaves and diversion of dry matter towards pod development.

2.1.4 Leaf area per plant (dm^2)

Arjunan *et al.* (1999) in the field experiment conducted at the Regional Research Station, Vrinddhachalam (Madras) stated that, leaf area had the negative direct effect on pod yield in groundnut.

Rajmane (2001) in the field experiment conducted at M.P.K.V., Rahuri observed that, leaf area of all the varieties increased significantly throughout the growth period of the groundnut crop. There was continuous increase in leaf area throughout the growth period. The rate of increase in leaf area was slow up to 60 DAS. Then it increases linearly upto 90DAS and decline thereafter upto harvest.

Shinde *et al.* (2001) observed that, higher plant height and leaf area per plant of groundnut were recorded in polythene mulch treatment compared to treatment without mulch.

Tamilselvi *et al.* (2015) conducted field experiment at Tindivanam (T.N.) on twelve genotypes, and reported that, leaf area per plant was declined after 100DAS due to defoliation of leaves and diversion of dry matter towards pod development.

2.1.5 Leaf area index

Khan (1981) observed that, LAI measures photosynthetic surface area of a crop and it depends on the leaf growth, number of leaf, plant density and leaf senescence.

Hamid *et al.* (1990) observed that percent solar radiation interception and rate of dry matter production increased with leaf area development and approached to maximum at similar leaf area indices.

Umesha (2004) reported that, polythene mulching produced higher leaf area index compared to mulching with groundnut shell and without mulch.

Kathirvelan and Kalaiselvan (2006) in the field experiment conducted at Tamil Nadu Agricultural University, on 4 groundnut varieties reported that, the variety VRI 2 had the highest values of LAI at vegetative stage and DMP at harvest stage though it was on par with CO 3. With regard to plant densities, the closer spacing of 30 x 10 cm significantly had the highest LAI and lowest values were observed with wider spacing of 45 x 15 cm.

Jagtap *et al.* (2014) in the field experiment conducted at M.P.K.V., Rahuri reported that, the LAI of all the genotype increased significantly upto 100DAS and declined thereafter. The genotype TPG-41 (8.870) recorded maximum LAI at 100DAS.

2.2 Phenological studies

2.2.1 Days to initiation of flowering

Bagnall and King (1991) conducted field experiment at Akola and reported that, the time for first flower appearance was little affected by photoperiod but temperature had major and positive effect on time of first flower appearance.

Ransingh (2004) investigated effect of liquid biofertilizers on morphological and physiological parameters of three groundnut genotypes. He observed flowering pattern at 30, 60, 90 DAS. He found that the number of flowers produced at 60 DAS was maximum in JL-24 genotypes as compared to ICGV-86590 and SB-XI. At harvest stage, rate of flower production becomes lower.

Hariprasanna *et al.* (2008) in the field experiment conducted at National Research Centre of Groundnut, Junagadh (Gujrat) observed that, duration of flowering in groundnut has effect on the kernel size and recovery of mature kernels.

2.2.2 Days to physiological maturity

Uddin *et al.* (1999) reported that,days to maturity was positively and significantly related with days to 50 % flowering.

Borkar and Dharanguttikar (2014) conducted field experiment at M.P.K.V., Rahuri and studied 22 groundnut genotypes and reported that, the genotype ICG-8474 (124.70), ICG-8417 (124.80) and SB-XI (124.90) required minimum number of days for physiological maturity. The genotypes, ICG-8525 (130.00), ICG-8420 (129.30) and ICG-8518 (129.20) required maximum days to attend maturity.

Kokkiripati *et al.* (2015) reported that, the genotype required minimum number of days for physiological maturity in ICG- 14127 (108).

Jahangir *et al.* (2016) studied six groundnut genotypes and reported that the all groundnut genotypes significant regarding number of days taken to maturity. The maximum days taken to maturity by the genotype PG-1190 (165.25) and Golden (161.25) were matured earlier than others.

2.3. Dry matter and its partitioning studies

Ghosh *et al.* (1997) in the field experiment conducted at National Research Centre for Groundnut, Junagadh reported that genotypic differences with

respect to total dry matter and their partitioning into different plant parts of groundnut. The genotype M-13 accumulated significantly higher dry matter as compared to other genotypes. Among the different plant parts, the highest percent of dry matter accumulated in pods (kernels + shell) and negligible amount of dry matter partitioning into the roots.

Uguru (1998) in the field experiment studied 12 medium maturing peanut cultivars to determine the average weekly changes in the dry weight of the roots, shoots and pods. Root growth rate appeared to have diminished with the formation of pods. However, dry matter increased significantly in both the shoot and pods until the seeds began to mature. The incremental rate of the pod dry weight was linear with time during pod filling, but declined from 88 days after planting (DAP) when most pods were physiologically inactive due to maturation. Pod yield was positively correlated to the rate of dry matter accumulation, duration of dry matter accumulation and number of leaves, pegs and pods/m^2.

Kumar and Kumar (1999) conducted field experiment at Pantnagar (UP) and observed that in Virginia groundnut cultivar Chitra had significantly higher stem and leaf dry weight at 30, 60, 90 DAS and maturity stage, whereas, Spanish groundnut cultivar SG-84 had higher dry weight of stem and leaf at 90 DAS and maturity stage of groundnut crops.

Azad and Hamid (2000) studied path coefficient analysis in groundnut and observed that biological yield per plant had the maximum positive direct effect on pod yield. Almost all the yield contributing characters had higher positive indirect effect via biological yield per plant.

Jayalakshmi *et al.* (2001) conducted field experiment at Tirupati (A.P.) 56 genotype crosses were evaluated for physiological attributes. Three checks were included in the study, Tirupati-1 an existing popular variety of the tract, ICGV-86031 was identified as a genotype with low temperature and high TDM and TAG-24 was characterized by high HI.

Murthy *et al.* (2002) in the field experiment conducted at Anantpur (A.P.) reported that, for normal sown groundnut crops drought during flowering and pegging resulted in 20 and 16.6 per cent reduction in dry matter accumulation and pod yield, respectively. They also stated that during pod filling, 68.4 per cent dry matter accumulated in the vegetative parts.

Nautiyal *et al.* (2002) conducted field experiment at National Research Centre for Groundnut, Junagadh (Gujrat) and observed that, water deficit at various growth stages influenced partitioning of dry matter, LAI, HI and pod yield.

Laxmi (2003) conducted a field experiment to determine the dry matter distribution and seed yield in 10 lentil cultivars under soil moisture stress and reported that seed yield was mainly dependent on the rate of dry matter partitioning per day of seed filling period and dry matter accumulation.

Patel *et al.* (2005) studied accumulation and partitioning of total dry matter and their relationship with yield of 10 groundnut genotypes and reported that high yielding genotype had a significant and overriding influence on the pattern of dry matter accumulation, partitioning, seed yield and yield attributes. He further reported that, greater seed yield was achieved through the contribution of higher total dry matter. Similar results were also reported by Karanjikar *et al.* (2005) in groundnut.

Idinoba *et al.* (2008) repoted that, the highest dry matter production was reached at about 75 days after sowing. The rate of leaf production between 50 to 70 days after emergence was extremely high but a proportional declined followed after this period.

Jagtap *et al.* (2014) conducted his experiment at M.P.K.V., Rahuri and observed that the overall functioning of the plant ultimately leads to formation and progressive accumulation of dry matter. He studied the dry matter accumulation in roots increased steadily whereas in stem it increased progressively at constant rate with the advancing age of the crop. After flowering, the dry matter is stored in reproductive parts. Therefore, the rate of dry matter accumulation in vegetative parts gets declined and increase in pods with the advancement of crop age.

Monir Hossain *et al.* (2016) conducted the experiment at Crop Botany Field Laboratory of Bangladesh Agriculture University. He studied 4 groundnut genotypes and reported that, the effect of plant spacing on total dry matter per plant was significant at all sampling dates (50, 75 and 100 DAS). At 100 DAS spacing 30 × 20 cm^2 produced the highest total dry matter per plant (11.67 g) while spacing 40 × 20 cm^2 produced lowest total dry matter per plant (7.66 g).

Mane *et al.* (2017) conducted field experiment at Oilseed Research Unit, Dr. P.D.K.V., Akola and evaluated 24 different groundnut genotypes. He concluded that, dry matter is an important criterion to determine the source-sink relationship and depends

upon the net gain in the processes on anabolism and catabolism of plant. The increase in total dry matter could be due to the increase leaf area, LAI and plant height.

2.4 Physiological parameters

The physiological parameters related with rate of photosynthesis, transpiration rate, stomatal conductance and stomatal frequency are some of the vital tools given an important idea about the efficiency index of the plants.

2.4.1 Photosynthetic rate, transpiration rate, stomatal conductance and stomatal frequency

Ghosh and Sengupta (1986) in the field experiment conducted at IARI, New Delhi on groundnut reported that, the differences in photosynthetic rate of the leaves situated on the main shoot and three basal branches almost negligible.

Bhattacharya and Singh (1999) conducted an experiment on chickpea genotypes, whereas normal and late sowing in field rates of photosynthesis, stomatal conductance, leaf temperature, substomatal CO_2 concentration and photosynthetic efficiency were measured during vegetative 50 percent flowering and at an interval of 10 days after flowering till maturity. Through correlation and association the traits under different stage with yield, it was concluded that, although rates of photosynthesis and allied parameter had significant correlation with yield at growth stages but definite association is there between photosynthetic efficiency and yield during 50% flowering and 10 days after under normal and late sowing.

Kalpana *et al.* (2003) conducted a field experiment during *kharif* season of 1999 and 2000 under rainfed condition with cowpea genotypes belonging to different growth habit and found that, the determinate genotype had higher value of photosynthetic rate, transpiration rate, stomatal conductance as compared to indeterminate genotypes. It was also observed that, all these parameters were maximum at flowering stage and declined at pod development stage.

Vijaya Kumar and Vanaja (2004) observed in castor bean that, net photosynthetic rate is positively correlated with light intensity and negatively with vapour pressure deficit.

Jagtap *et al.* (2014) conducted field experiment at M.P.K.V., Rahuri and reported that, the variation in growth, development and yield involves the interaction of external factors with physiological processes of a plant i.e. photosynthesis, respiration, transpiration. Higher rates of photosynthesis may lead to higher yields but this is not

always true. He also observed that, dry matter produced is a result of net photosynthetic process.

2.5 Yield and yield attributes

Dutta (2001) reported that, the number of pods plant^{-1}, the prime yield attribute, is an important criterion for the visual selection of high yielding genotypes. He further recommended that, pods plant^{-1}, plant height and number of productive branches were important for selection of high yielding genotypes. Similar result was also reported by Mondal (1997).

BINA (2002) further observed a wide variation in case of pod plant^{-1} in groundnut. However, most of the researchers reported that seed yield was strongly dependant on pod number plant^{-1}.

Rahman (2003) conducted an experiment on groundnut cultivars *viz.*, Binachinabadam-1, Binachinabadam-2, Binachinabadam-3 and Dhaka-1 and found that 100-pod and seed weight varied significantly among the tested cultivars and 100-pod and seed weight varied significantly among the tested cultivars and 100-pod and seed weight were the highest in Binachinabadam-3.

Sardana *et al.* (2008) conducted field experiment at Punjab Agricultural University, Ludhiana and observed that, for higher pod yield and oil content groundnut should be sown during second week of May 'SG-99' bunch type variety has higher yield potential compared to semi-spreading variety M-522 during *kharif* season.

Jagtap *et al.* (2009) conducted field experiment at College of Agriculture, Akluj, Solapur under M.P.K.V., Rahuri and reported that, the genotype I-10 recorded the significantly lowest dry pod yield per hectare over rest of the genotypes. The higher pod yield of the genotypes *viz.*, T_5, T_1, T_4, T_2, T_7 and T_3 was mainly due to favourable yield contributing characters like per plant number of kernels, kernel yield, dry pod yield, pod yield per net plot and harvest index.

Zaman *et al.* (2011) indicated that pod yield per plant showed highly significant and positive association with nut size, number of nuts per plant, kernel size and days to 50 % flowering.

Jagtap *et al.* (2014) conducted field experiment at M.P.K.V., Rahuri and reported that, the harvest index is the best indicator of photosynthetic translocation efficiency and considered as one of the criteria for selection of high yielding genotypes.

Dharanguttikar and Borkar (2014) conducted field experiment at M.P.K.V., Rahuri and worked on 22 genotypes. He reported that, the highest dry pod yield was recorded by the genotypes ICG-8420, ICG-8473 and ICG-8506 due to significant favourable yield contributing characters like number of pods per plant, pod yield (g) and kernel yield (g) per plant, shelling percentage and harvest index. The genotypes ICG-8029 and ICG-8428 recorded the highest dry pod yield may be due to photosynthetic rate, dry matter accumulation and chlorophyll content.

Rao *et al.* (2014) studied inter-relationships among 50 groundnut genotypes and revealed significant positive correlation of dry pod yield with kernel yield, number of pods per plant, 100-kernel weight and shelling percent would result in rapid improvement of kernel yield in groundnut.

Bhargavi *et al.* (2015) reported that, pod yield per plant had significant positive association with days to maturity, number of mature pods per plant, harvest index, 100-kernel weight, kernel yield per plant, kernel yield per hectare, oil yield per hectare and pod yield per hectare.

Rasheed *et al.* (2015) conducted field experiment at University of Haripur, Khyber Pakhtunkhwa, Pakistan. Highly significant dissimilarity were observed in different groundnut genotypes at 5 per cent probability level. Pod per plant was in the series from 10-47. Maximum pod per plant 47 was observed in the genotype ICGV-93163, while a minimum pod per plant 10 was observed by genotype ICGS-45. The 100 kernel weight was in the range of 43 g to 96 g. Maximum 100 kernel weight 96 g were seemed in the genotype ICGV-86928 tilled by genotype ICGS-57 is 84 g.

Choudhary *et al.* (2016) documented that dry pod yield per plant was positively and significantly correlated with number of pegs per plant, number of mature pods per plant and kernel yield per plant.

Hampannavar *et al.* (2018) observed that, kernel yield per plant, mature pods per plant and haulm yield per plant had significant positive correlation with dry pod yield per plant and also the kernel yield had high direct effect on dry pod yield.

2.6 Biochemical studies

2.6.1 Protein content of kernels (%)

Naik *et al.* (2000) stated that, the protein content was negatively correlated with plant height and days taken to flower appearance and positively correlated with pod

length and seed number and had highly positive association with seed yield and pod number.

Sahoo and Mishra (2003) reported that, bigger kernel should be used for extraction of protein. Hence, rabi groundnut seed should be preferably used for extraction of protein.

2.6.2 Oil content of kernels (%)

Dwivedi *et al.* (1996) in the field experiment reported that, mid season drought had non-significant effect on the content of oil and end season drought significantly reduced total oil content in groundnut.

Deshmukh and Shrikhandkar (1998) conducted field experiment at P.D.K.V., Akola on TG-26, JL-24, TAG-24 and SB-XI groundnut cultivars for oil content and reported that, oil content varied between 50-51 per cent.

Asibuo James Yaw *et al.* (2008) noticed that, virginia cultivars which belong to subspecies *hypogaea* had higher oil content than Spanish and valencia, which belong to subspecies *vulgaris* and *fastigiata* respectively.

Patil *et al.* (2015) reported the genetic variability for yield and its related characters in 49 groundnut. They observed the highest genetic coefficient of variation for secondary branches per plant followed by immature pods, mature pods, pod bearing nodes, pod yield and krenel weight per plant. The highest heritability was observed for 100 kernel weight (98 %), immature pods per plant (97 %), plant height (96 %) oil content (96 %).

2.6.3 Chlorophyll content (a, b and total)

Patil and Patil (1993) conducted the field experiment at Kolhapur with seven groundnut genotypes (ICGS-1, ICGS-5, ICGS-11, ICGS-44, ICGS-76, ICG, FDRS-55 and Girnar-1). These were water stressed at the flowering stage for four days. It was observed that, water stress decreases the total chlorophyll content in groundnut leaves along with yield.

Kathirvelan and Kalaiselvan (2006) conducted the field experiment at Tamil Nadu Agricultural University, on four groundnut varieties and reported that, groundnut varieties had significant influence on total chlorophyll content during both the seasons and the groundnut variety TG-42 has higher values and lowest were observed with VRI 2 groundnut.

Jagtap *et al.* (2014) in the field experiment conducted at M.P.K.V., Rahuri reported that, the higher chlorophyll content is one of the important factor responsible for better yield in groundnut.

Mane *et al.* (2017) conducted field experiment at Dr. P.D.K.V., Akola on 24 different groundnut genotypes for physiological analysis and concluded that, groundnut varieties had significant influence on total chlorophyll content during the season. Chlorophyll content is one of the important factor responsible for better yield. The genotype TAG-24 (1.90 mg/g) and AK-335 (1.77 mg/g) was recorded the higher chlorophyll content.

3. MATERIAL AND METHODS

The present investigation entitled, **Morpho-physiological characterization of summer groundnut (*Arachis hypogaea* L.)** was conducted during summer, 2019. The details of material used and methods adopted during the course of investigation are described in this chapter.

3.1 Description of the study area

The field experiment was conducted during summer, 2019 at farm of AICRP Groundnut, Improvement Project, M.P.K.V., Rahuri. The topography of the field was uniform and leveled. The soil was medium black.

3. 2 Climate

This region is comes under semiarid zone of Ahmednagar district and is characterized by dry climate with an average annual rainfall of about 400 to 600 mm, annual average mazimum and minimum temperature of 30-40^{0}C and 10-20^{0}C respectively.

3.3 Preparation of land

The trial was laid out on medium black soil with uniform fertility and well leveled field. The land was prepared by ploughing, harrowing and brought to the final tilth.

3.4 Experimental details

The experiment was conducted in a randomized block design (RBD) with fourteen different genotypes (including checks) replicated three times with the spacing of 30 cm × 10 cm.

3.5 Seeds and Sowing

The seeds of fourteen groundnut genotypes were supplied by the Groundnut Breeder, M.P.K.V., Rahuri. The sowing was done by dibbling on 18th February, 2019 with the spacing 30×10 cm^2.

3.6 Manures and Fertilizers

Farm yard manure at the rate of 10 cartloads per hectare was uniformly spread in the field and mixed well by harrowing. The fertilizers dose of nitrogen and phosphorous in the form of urea and single super phosphate were applied at the rate of 25 kg ‘N’ and 50 kg P_2O_5 per hectare at the time of sowing.

3.7 Gap filling

Gap filling was done wherever required within a week period after sowing.

3.8 After care

The interculturing operations such as weeding, hoeing were carried out as and when required. The field was kept free from weeds. Irrigation was given after sowing to ensure good germination. Irrigation was given during the critical crop growth stages as per recommendation. Before harvesting, irrigation was given to facilitate easy uprooting of plant.

3.9 Harvesting

Harvesting of the crop was done at physiological maturity. Irrigation was given prior to harvesting to facilitate easy uprooting of plants.

3.10 Weather during experimental period

The data pertaining to various meteorological parameters recorded weekly during experimental period are given in Table 3.1. It is seen from the data that the maximum temperature ranged between 32.4 to 39.7^{0}C with the mean of 36.2^{0}C while, the minimum temperature ranged between 10.3 to 24.4^{0}C with a mean of 18.6^{0}C temperature.

Mean relative humidity at morning ranged between 87 to 93 per cent with average of 90.2 per cent, while, the mean realative humidity at evening ranged between 16 to 57 per cent with an average of 30.2 per cent.

Table 3.1 Meteorological data during *summer,* 2019

Week No.	Date	Temperature		Humidity %		Wind velocity (km/hr)	Sunshine (hrs.)
		Maximum	Minimum	Morning-I	Evening-II		
	Feb.						
8	19-25	33.4	12.3	88.0	22.0	1.0	9.60
9	26-3	34.1	11.0	88.0	23.0	1.8	9.63
	March						
10	4-10	33.7	10.3	87.0	21.0	2.6	9.74
11	11-17	34.8	11.5	87.0	18.0	2.0	9.72
12	18-24	36.4	12.6	88.0	16.0	2.4	8.72
13	25-31	37.5	15.8	89.0	17.0	3.2	8.82
	April						
14	1-7	37.8	19.1	90.0	20.0	2.8	8.92
15	8-14	38.4	20.0	91.0	22.0	2.2	8.88
16	15-21	37.5	21.4	91.0	29.0	2.0	7.98
17	22-28	37.6	15.5	88.0	28.0	5.0	10.02
18	29-5	38.9	20.5	90.0	21.0	6.0	10.23

Table 3.1 contd…..

Week No.	Date	Temperature		Humidity %		Wind velocity (km/hr)	Sunshine (hrs.)
		Maximum	Minimum	Morning-I	Evening-II		
	May						
19	6-12	38.6	20.8	91.0	26.0	6.2	9.46
20	13-19	39.5	18.6	90.0	23.0	6.4	11.21
21	20-26	39.7	20.6	90.0	22.0	7.2	10.24
22	27-2	38.3	20.4	92.0	25.0	10.2	10.42
	June						
23	3-9	36.8	22.5	92.0	38.0	7.4	7.12
24	10-16	35.9	24.4	93.0	39.0	8.3	9.32
25	17-23	34.6	23.1	91.0	40.0	14.2	6.44
26	24-30	34.9	23.4	92.0	46.0	10.7	6.12
	July						
27	1-7	32.4	22.6	93.0	56.0	7.8	3.62
28	8-14	33.6	21.3	92.0	57.0	7.6	3.57
29	15-21	32.6	21.6	92.0	57.0	7.2	3.92
	Mean	**36.2**	**18.6**	**90.2**	**30.2**	**5.6**	**8.3**

3.11 Experimental material

Table 3.2 List of Genotypes of Groundnut

Sl. No.	Genotypes	Pedigree	Source
1.	RHRG-1192	RHRG-6021 X RHRG-6097	AICRP on Groundnut Improvement Project, M.P.K.V., Rahuri
2.	RHRG-1189	RHRG-6021 X Phule unnati	
3.	RHRG-19-1	TAG-24 × Phule Unnati-1	
4.	RHRG-19-2	TAG-24 × Phule Unnati-2	
5.	RHRG-19-3	Phule Unnati × TPG-41	
6.	RHRG-19-4	Phule Unnati × TPG-41	
7.	RHRG-19-5	Phule 6021 × ICGV-00350	
8.	RHRG-19-6	Phule Unnati × SB-XI	
9.	RHRG-19-7	WRGS-15 × RHRG-8808	
10.	RHRG-19-8	ICGS-11 × K-4	
11.	RHRG-1308	Phule unnati X JL-501	
12.	RHRG-1309	Phule unnati X JL-501	
13.	Phule Unnati (LC)		
14.	TPG-41		

3.12 Observations recorded

Five randomly selected plants from each plot were tagged and identified as observational plants. Observations were recorded for all the genotypes in each replication for all characters. The following periodic observations on these plants were recorded at 20 days interval *viz.*, 40, 60, 80, 100 and at harvest. The values of five plants

were averaged and expressed as mean of the respective character for that replication. Observations were recorded as per the details given below.

3.12.1 Growth studies

3.12.1.1 Plant height (cm)

Plant height was measured using a scale as the vertical distance of the main axis from ground level to the apical leaflet. Average plant height was worked out.

3.12.1.2 Number of branches per plant

1. Total number of primary branches originating from the main axis were recorded and average was worked out.
2. Total number of secondary branches originating from the primary branches were recorded and average was worked out.

3.12.1.3 Number of leaves per plant

The number of leaves of five observational plants were counted and average was worked out.

3.12.1.4 Leaf area per plant (dm^2)

Average leaf area of three leaves of selected plants, each sample plant was recorded by using Automatic Leaf Area Meter (Model LIE 3000 A). It measures leaf area in cm^2 which was converted into dm^2. The sample plants used for the dry matter studies were used for measuring leaf area.

3.12.1.5 Leaf area index (LAI)

The leaf area index was calculated from the data of leaf area per plant at 20 days interval starting from 40 days after sowing till harvest according to the following given by Watson (1947).

$$LAI = \frac{\text{Total leaf area of the plant}}{\text{Land area occupied by the plant}}$$

It is expressed in dm^2/plant.

3.12.2 Phenological studies

3.12.2.1 Days to initiation of flowering

The number of days required for appearance of flowering from the date of sowing were recorded.

3.12.2.2 Days of physiological maturity

The number of days required for complete physiological maturity of pod of each variety was recorded.

3.12.3 Dry matter and its partitioning studies

To study the dry matter accumulation and distribution among different component parts of plant, five plants were randomly removed from each variety on 40^{th}, 60^{th}, 80^{th}, 100^{th} DAS and at harvest. These plants were separated into different components *viz.*, leaves, stem and root pegs and pods. These plant parts were dried into hot air oven at 90^0C for first one hour and then at 60^0C till attaining the constant dry weight. The total dry weight per plant was computed by adding per plant dry matter of leaves, stem, reproductive parts (pegs, flowers and pods) and roots. While, dry matter partitioning percentage was computed by comparing the percent of plant parts like leaves, stem, root, pod with total dry matter percent at harvest.

3.12.4 Physiological parameters

3.12.4.1 Photosynthetic rate, transpiration rate and stomatal conductance

The observations for photosynthetic rate, transpiration rate and stomatal conductance were taken with the help of Portable Infrared Gas Analyzer (IRGA) at 50% flowering.

a. Photosynthesis rate (μmol $m^{-2}s^{-1}$)

b. Transpiration rate (mol $m^{-2}s^{-1}$)

c. Stomatal conductance (μmol $m^{-2}s^{-1}$)

Procedure

An intact leaf of plant was kept into the chamber and from 2 to 10 observations of the measurable parameters are logged. The time between observations can be fixed to 20 seconds (seconds on observation upto total 10 observations). During the measurements photosynthetic rate, transpiration rate and stomatal conductance were logged computed and stored in the memory.

Computation and storage

The data on the stomatal conductance and photosynthetic rate for each part of observation were logged also summary statistics were computed on all the variables. Finally transpiration rate an initial value of CO_2 (internal of the leaf) was optionally calculated. After examining the data on the system, the data was concerned and stored in the internal memory and next observations were taken following the same procedure.

3.12.4.2 Stomatal frequency (mm^2/leaf area)

Stomatal frequency was calculated at flowering stages of the crop. For this purpose nail polish was used to make an impression or cast of the leaf surface. First leaf sample from each plot was collected and washed gently with running tap water to remove the dust and debris. A thin layer of clear nail polish was spread on each surface i.e. on upper and lower side of the leaf surface and allowed to dry (it may help to cut the leaf and coat an upper and lower surface at the same time). A strip of clear sticky tape was placed over nail polish and pressed it to make a good connection with the nail polish. Then sticky tape was peeled off, the layer of nail polish came with tape. Tape with leaf impression was placed on a microscope slide and by using razor blade the excess sticky tape was trimmed from the edge of the slide. Same procedure was repeated for other side of the leaf.

The observations on number of stomata per unit area were recorded. For this purpose a circular piece of eyepiece size of a microscope having rectangular cut in the centre was inserted in an eyepiece of the microscope. The length and breadth of rectangular cut at the centre of circular piece was standardized with the help of stage micrometer. The slide prepared for recording stomatal frequency were observed under microscope through the standardized circular paper piece with rectangular hole inside and number of stomata per microscopic area was recorded. The research microscope having search of lense of 10x was used. The half cut stomata covered under the microscopic field were also counted. For the observations two samples from each plot were taken. The observations on stomata were expressed in number of stomata per mm^2.

3.12.5 Yield and yield attributes

3.12.5.1 Number of pods per plant

Total number of pods from five sample plants was counted and then average number of pods per plant was worked out after harvest.

3.12.5.2 Number of mature pods per plant

Number of mature pods were counted and averaged at harvest from five observational plants.

3.12.5.3 Number of immature pods per plant

The number of immature pods were counted and recorded and average was worked out.

3.12.5.4 Number of kernels per pods

The kernels were obtained after deshellling the pods of five randomized plants counted and averaged.

3.12.5.5 Weight of 100 kernels (g) (HKW)

Fully dried seed was taken from each treatment and replications and 100 seed was actually counted. Accurate weight was recorded on electronic balance and reported as 100 seed weight or test weight (g) after harvest.

3.12.5.6 Dry pod yield per plant (g)

Dry pod weight of the five observational plants from each row before deshelling was recorded and averaged.

3.12.5.7 Dry pod yield per plot (g)

Dry pod yield per plot was recorded at harvest and average of three replications were calculated.

3.12.5.8 Dry pod yield per hectare (q)

Dry pod yield per plot was recorded at harvest and multiplied by hectare factor.

3.12.5.9 Dry haulm yield (kg/plot)

Dry haulm yield per plot was recorded at harvest and average of three replications were calculated.

3.12.5.10 Dry haulm yield (kg/ha)

Dry haulm yield per plot was recorded at harvest and multiplied by hectare factor.

3.12.5.11 Kernel yield (kg/ha)

Weight of all kernels obtained from each harvested row was recorded and it is multiplied by hectare factor.

3.12.5.12 Shelling percentage

The shelling percentage from each harvested row was worked out by following formula.

$$\text{Shelling percentage} = \frac{\text{Kernel weight per plant}}{\text{Pod weight per plant}} \times 100$$

3.12.5.13 Harvest index (%)

Harvest index (%) was computed as per the equation given by Donald (1962).

$$\text{Harvest index} = \frac{\text{Economic yield (g) / plant}}{\text{Biological yield (g) / plant}} \times 100$$

3.12.6 Biochemical studies

3.12.6.1 Protein content of kernels (%)

Protein content of kernels was estimated by using NIR Spectrophotometer instrument.

3.12.6.2 Oil content of kernels (%)

Oil content of the kernels was estimated by using NIR Spectrophotometer instrument.

3.12.6.3 Chlorophyll content (a, b and total)

Chlorophyll content of leaves was estimated at 10 days after flowering by Spectrophotometer method describes by Arnon (1949) on fresh weight basis.

Procedure

Leaf samples from each treatment were collected in the morning in polythene bags, cleaned and rinsed in distilled water and blotted with blotting paper. Leaves were then cut into pieces leaving veins and 0.25 g weighed sample was macerated in mortar and pestle with 80 per cent acetone and volume was made to 25 ml with 80 per cent acetone. The optical density of the sample was recorded for a, b and total chlorophyll content on spectrophotometer at 645, 652 and 663 nm wavelength respectively. The chlorophyll a, chlorophyll b and total chlorophyll content of the leaves were calculated by using formulae as suggested by Sadasivam and Manickam (1996).

$$\text{Chlorophyll a (mg/g)} = 12.7\,(D - 663) - 2.69\,(D - 645) \times V \div (1000 \times W)$$

$$\text{Chlorophyll b (mg/g)} = 22.9\,(D - 645) - 4.68\,(D - 663) \times V \div (1000 \times W)$$

$$\text{Total chlorophyll} = \frac{(D - 652) \times 1000}{34.5} \times \frac{V}{1000 \times W}$$

Where,

D = Optical density

V = Final volume of 80 percent acetone chlorophyll extract

W = ` Fresh weight of sample taken in grams

3.13 Statistical analysis

The periodical observations were recorded from time to time. The statistical analysis of data was carried out by the standard method and critical differences were calculated. Whenever, the results were significant critical differences (C.D.) at 5 % of significance was worked out. The data were analysed as per Panse and Sukhatme (1985).

3.13.1 Estimation of mean and range

The arithmetic mean values of each of the characters studied were calculated by dividing the total of the observations by the corresponding number of observations as given below,

$$\bar{X} = \frac{\sum Xi}{N}$$

Where,

$\bar{X}$ = Mean of the character

$\sum Xi$ = Total of the observations

N = Number of observations

The lowest and highest values from mean of each character were regarded as range.

3.13.2 Analysis of variance

Analysis of variance was estimated for the different characters as per the method, suggested by Panse and Sukhatme (1985) for randomized block design.

ANOVA Table

Source	d.f.	Sum of square	M.S.S	Expected M.S.S.	F ratio
Replication	(r – 1)	RSS	M_r	$\sigma^2 e + t\sigma^2 r$	M_r/M_e
Genotype	(t – 1)	TSS	M_t	$\sigma^2 e + r\sigma^2 t$	M_t/M_e
Error	(r - 1) (t – 1)	ESS	M_e	$\sigma^2 e$	-
Total	(rt – 1)	TSS			

Where,

r = Number of replication

t = Number of genotypes

3.13.3 Estimation of standard error and critical difference

Standard error of the mean was calculated as ,

$$\text{SE of mean (SEm)} = \frac{\sigma^2 e}{r}$$

Critical difference between any two mean was calculated as

CD = 't' at error d.f. × SEm × $\sqrt{2}$

3.13.4 Estimation of standard deviation

Standard deviation was calculated by using the formula,

$$\sigma = \frac{\sqrt{d^2}}{N}$$

Where,

d = ($\bar{X}$- X) = deviation between mean and value

N = Number of observations.

4. RESULTS AND DISCUSSION

In the crop science, from an understanding of the causes for the variation in grain yield as well as attempts towards increasing grain yield, a physiological approach is basic. It would be vital to the breeder in tailoring suitable genotypes. Accordingly, the present investigation entitled, "Morpho-physiological Characterization of Summer Groundnut (*Arachis hypogaea* L.)" was conducted at AICRP on Groundnut Improvement Project, M.P.K.V., Rahuri, Dist. Ahmednagar (M.S.) during summer season of 2019.

Various morphological, phenological, physiological and yield contributing characters determine the productivity of the groundnut genotypes. And these observations were recorded at 20 days interval from 40 DAS till the harvest of the crop. The observations recorded during the course of investigation are presented and discussed in this chapter under appropriate headings and sub headings.

4.1 Morphological parameters

4.1.1 Plant height (cm) per plant

The data on mean plant height (cm) as influenced by groundnut genotypes at various growth stages is presented in Table 4.1 and represented in Fig. 4.1. The genotypic differences were statistically significant at all the growth stages which indicates the considerable amount of variation among the genotypes for plant height. The plant height increased with advancement in age of the crop. The generalized trend for plant height (cm) revealed that the increase in plant height was rapid up to 100 DAS and slowed down thereafter.

At 40 DAS, the plant height ranges from 2.00 cm to 4.57 cm and highest plant height was recorded by the genotype RHRG-19-7 (4.57 cm) which was significantly superior over all the genotypes followed by genotypes RHRG-19-3 (3.37 cm) and RHRG-19-6 (3.10 cm). Whereas, the genotype RHRG-19-1 (2.00 cm) recorded the lowest plant height followed by RHRG-19-5 (2.23 cm), RHRG-19-8 (2.30 cm) and RHRG-19-2 (2.47 cm).

At 60 DAS, the genotype RHRG-19-5 (10.30 cm) recorded significantly the highest plant height that was at par with the genotype RHRG-19-3 (10.07 cm). However, the genotype RHRG-19-4 (7.40 cm) was inferior followed by RHRG-1309 (8.13 cm), Phule Unnati (8.17 cm).

At 80 DAS, the genotype RHRG-19-8 (25.20 cm) recorded significantly highest plant height which was at par with the genotypes RHRG-19-7 (25.03 cm), RHRG-19-3 (24.87 cm), RHRG-19-6 (24.57 cm) and RHRG-1189(24.50). While, the genotype RHRG-19-4 (17.50 cm) recorded the lowest plant height among all the genotypes followed by TPG-41 (19.70 cm) and RHRG-19-2 (19.97 cm).

Table 4.1 Plant height (cm) per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Plant height (cm)				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	3.07	9.50	21.90	23.53	23.83
2.	RHRG-1189	2.73	8.47	24.50	27.33	27.57
3.	RHRG-19-1	2.00	9.77	21.67	23.67	23.85
4.	RHRG-19-2	2.47	9.30	19.97	21.63	21.73
5.	RHRG-19-3	3.37	10.07	24.87	29.53	29.68
6.	RHRG-19-4	2.60	7.40	17.50	18.97	19.10
7.	RHRG-19-5	2.23	10.30	22.67	24.27	24.50
8.	RHRG-19-6	3.10	9.80	24.57	27.87	28.03
9.	RHRG-19-7	4.57	8.47	25.03	27.24	27.35
10.	RHRG-19-8	2.30	9.57	25.20	27.73	27.88
11.	RHRG-1308	2.57	9.40	20.37	30.20	30.50
12.	RHRG-1309	2.83	8.13	20.40	24.60	24.87
13.	Phule Unnati	2.60	8.17	20.23	23.00	23.13
14.	TPG-41	2.73	9.67	19.70	22.23	22.40
	Mean	**2.80**	**9.14**	**22.04**	**25.13**	**25.25**
	S.E.±	0.055	0.129	0.373	0.247	0.285
	C.D.at 5%	0.161	0.376	1.086	0.720	0.830

At 100 DAS, the genotype RHRG-1308 (30.20 cm) recorded significantly the highest plant height over rest of the genotypes, which was at par with RHRG-19-3 (29.53 cm). While, the genotype RHRG-19-4 (18.97 cm) exhibited significantly the lowest plant height as compare to rest of all the entries.

At the time of harvest, significantly the highest plant height was showed by the genotype RHRG-1308 (30.50 cm) which was at par with RHRG-19-3 (29.68 cm).

The genotype RHRG-19-4 (19.10 cm) recorded the lowest plant height followed by the genotypes RHRG-19-2 (21.73 cm), TPG-41 (22.40 cm) and Phule Unnati (23.13 cm).

The vegetative phase governs the over all phenotypic expression of the plant and prepares the plant for the further reproductive phase. The root, stem, branches and leaves all these parts constitutes vegetative phase and perform specific functions. Plant height is basically a genetically controlled character and is being influenced by environmental conditions, management practices and genotypes.

The present study concluded that, the plant height increased progressively upto 100 DAS with advancing age of the crop in all the genotypes. The growth rate was rather slow initially but after that the plant enters into grand growth period up to 100 DAS and then rate of growth was rather arrested towards maturity.

The plant height showed considerable amount of variability among the genotypes which were studied. The genotype RHRG-1308 (30.50 cm) and RHRG-19-4 (19.10 cm) has significantly the highest and lowest plant height at harvest stage respectively. Similar results were reported by Mensah and Okpere (2000) and Mane *et al.* (2017) who indicated that groundnut varieties differed significantly for plant height at different growth stages.

4.1.2 Number of primary branches per plants

The data on the number of primary branches per plant at different growth stages is presented in Table 4.2 and graphically presented in Fig. 4.2. The genotypic differences were statistically significant at all the stages of growth. In general, it is found that the number of primary branches per plant to be increased progressively with the advancing age of the crop up to 100 DAS and thereafter an increase was marginal.

At 40 DAS, the genotype RHRG-1189 (4.73) recorded significantly the highest number of primary branches per plant which was at par with TPG-41 (4.63), RHRG-19-7 (4.57) and RHRG-19-6 (4.53). The genotype RHRG-1309 (2.47) recorded the least and followed by RHRG-1308 (3.20), RHRG-19-1 (3.23) and RHRG-19-4 (3.27) genotypes.

At 60 DAS, the genotype RHRG-19-1 (9.10) produced maximum number of primary branches per plant which was followed by genotypes RHRG-19-3 (8.57), RHRG-1189 (8.53). The genotype RHRG-19-4 (6.07) recorded least number of branches per plant followed by RHRG-1308 (5.87).

Table 4.2. Number of primary branches per plant influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Number of primary branches per plant				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	3.47	7.63	10.37	11.17	11.47
2.	RHRG-1189	4.73	8.53	10.23	10.67	10.93
3.	RHRG-19-1	3.23	9.10	10.63	10.97	11.33
4.	RHRG-19-2	4.10	7.40	9.17	9.43	10.67
5.	RHRG-19-3	4.33	8.57	10.40	10.80	11.27
6.	RHRG-19-4	3.27	6.07	8.10	8.17	8.64
7.	RHRG-19-5	4.37	6.50	8.20	9.43	9.63
8.	RHRG-19-6	4.53	8.13	9.03	9.57	10.10
9.	RHRG-19-7	4.57	7.20	8.13	9.00	9.13
10.	RHRG-19-8	4.30	7.20	7.37	9.10	9.13
11.	RHRG-1308	3.20	5.87	7.40	8.40	8.67
12.	RHRG-1309	2.47	6.10	7.43	8.53	8.93
13.	Phule Unnati	4.17	7.23	8.37	8.77	9.40
14.	TPG-41	4.63	7.27	8.50	9.40	9.97
	Mean	**3.95**	**7.13**	**8.80**	**9.53**	**9.95**
	S.E.±	0.077	0.095	0.091	0.088	0.208
	C.D.at 5%	0.224	0.277	0.267	0.258	0.606

At 80 DAS, the genotype RHRG-19-1 (10.63) recorded significantly the highest number of primary branches per plant over rest of the genotypes studied, which was at par with RHRG-19-3 (10.40), RHRG-1192 (10.37). The genotype RHRG-19-8 (7.37) recorded the lowest number of primary branches per plant followed by genotypes RHRG-1308 (7.40) and RHRG-1309 (7.43).

At 100 DAS, the genotype RHRG-1192 (11.17) recorded significantly the highest number of primary branches per plant over all the genotypes however, it was at par with RHRG-19-1 (10.97). The genotype RHRG-19-4 (8.17) recorded the lowest number of primary branches per plant followed by the genotypes RHRG-1308 (8.40) and RHRG-1309 (8.53).

At harvest, maximum number of primary branches per plant was recorded by the genotype RHRG-1192 (11.47) which was at par with genotypes RHRG-19-1 (11.33), RHRG-19-3 (11.27) and RHRG-1189 (10.93). Whereas, the least number of primary branches was recorded by genotype RHRG-19-4 (8.64) which was followed by RHRG-1308 (8.67) and RHRG-1309 (8.93).

One of the way to increase the yield, higher number branches per plant, which helps to increase higher number of pegs which results into pod formation and also increases the fodder yield. In the present study, there was a gradual increase in number of branches per plant up to 100 DAS with the advancing age of crop. The increase was initially rapid thereafter, it remained fairly constant. The genotype RHRG-1192 (11.47) recorded maximum number of branches per plant at harvest and produced higher pod yield. Deshmukh and Dev (1993) obtained significant positive correlation between number of branches per plant with pod yield.

4.1.3 Number of secondary branches per plant

The data on the mean number of secondary branches per plant at different growth stages are presented in Table 4.3 and graphically showed in Fig. 4.3. In general, it was evident that the number of secondary branches per plant to be increased progressively with the advancing age of the crop upto 100 DAS and thereafter an increase was marginal.

At 40 DAS, the genotype RHRG-19-2 (17.03) recorded significantly highest number of secondary branches which was at par with the genotype TPG-41 (17). The genotypes RHRG-19-4 (7.30) recorded least number of secondary branches per plant which was followed by genotypes Phule Unnati (10.27) and RHRG-1309 (11.07).

At 60 DAS, the genotype RHRG-1192 (19.43) recorded significantly the highest number of secondary branches per plant followed by genotypes, RHRG-19-2 (17.87) and TPG-41 (17.73). Whereas, the genotype RHRG-19-4 (10.63) recorded lowest number of secondary braches per plant followed by genotypes RHRG-1309 (12.20) and Phule Unnati (12.47).

At 80 DAS, the genotype RHRG-1192 (21.53) recorded numerically the highest number of secondary branches per plant over rest of the genotypes studied followed by genotypes RHRG-1189 (19.27) and TPG-41 (18.77). The genotype RHRG-19-4 (13.20) recorded lowest number of secondary branches per plant which was followed by RHRG-1309 (13.40) and Phule Unnati (13.43).

At 100 DAS, the genotype RHRG-1192 (22.57) recorded highest number of secondary branches per plant followed by genotypes RHRG-1189 (19.53) and RHRG-19-2 (19.07). The genotypes RHRG-1308 (14.23) recorded lowest number of secondary branches per plant followed by genotypes RHRG-19-4 (14.30) and RHRG-1309 (14.33).

Table 4.3. Number of secondary branches per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Number of secondary branches per plant				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	12.47	19.43	21.53	22.57	22.67
2.	RHRG-1189	16.30	17.53	19.27	19.53	19.67
3.	RHRG-19-1	13.10	14.30	16.13	16.53	17.13
4.	RHRG-19-2	17.03	17.87	18.60	19.07	19.33
5.	RHRG-19-3	15.00	16.73	17.93	18.47	18.70
6.	RHRG-19-4	7.30	10.63	13.20	14.30	14.53
7.	RHRG-19-5	11.90	13.17	15.20	16.07	17.40
8.	RHRG-19-6	15.47	17.57	18.40	19.00	19.53
9.	RHRG-19-7	15.27	15.60	16.80	17.13	17.67
10.	RHRG-19-8	16.30	17.40	18.13	18.50	19.07
11.	RHRG-1308	12.60	13.13	13.53	14.23	14.60
12.	RHRG-1309	11.07	12.20	13.40	14.33	15.13
13.	Phule Unnati	10.27	12.47	13.43	14.67	15.13
14.	TPG-41	17.00	17.73	18.77	18.97	19.33
	Mean	**13.65**	**15.41**	**16.74**	**17.38**	**17.85**
	S.E.±	0.118	0.106	0.079	0.119	0.107
	C.D.at 5%	0.345	0.310	0.230	0.346	0.311

At harvest, maximum number of secondary branches was recorded by genotype RHRG-1192 (22.67) which was followed by genotypes RHRG-1189 (19.67) and RHRG-19-2 (19.33). Whereas, the lowest number of secondary branches were recorded by genotype RHRG-19-4 (14.53) followed by RHRG-1308 (14.60).

As the maximum number of secondary branches gives more pegs and also gives more fodder yield. The highest secondary branches recorded by genotype RHRG-

1192 and that of lowest RHRG-19-4. Similar observations were recorded by Deshmukh and Dev (1993).

4.1.4 Number of leaves per plant

The data on the number of leaves per plant at various stages of growth is presented in Table 4.4 and graphically depicted in Fig. 4.4 which revealed statistically significant differences indicating the wide range of variation among the genotypes. The generalized trend for number of leaves per plant increases progressively with the advancing age of the crop up to 100 DAS and thereafter decreases may be due to senescence.

Table 4.4. Number of leaves per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Number of leaves per plant				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	49.07	129.37	254.40	334.57	316.33
2.	RHRG-1189	61.40	118.00	224.40	289.37	282.67
3.	RHRG-19-1	50.47	130.03	184.73	289.07	281.90
4.	RHRG-19-2	67.57	141.03	180.53	283.33	271.03
5.	RHRG-19-3	59.27	150.10	187.27	286.70	275.47
6.	RHRG-19-4	29.03	151.37	202.10	286.63	277.60
7.	RHRG-19-5	46.60	149.87	201.83	287.93	282.57
8.	RHRG-19-6	50.57	143.57	188.70	245.60	239.97
9.	RHRG-19-7	60.90	149.70	196.53	269.70	266.33
10.	RHRG-19-8	63.77	125.87	217.00	291.47	288.83
11.	RHRG-1308	62.10	170.80	250.20	310.13	307.17
12.	RHRG-1309	44.33	144.60	181.37	257.20	254.47
13.	Phule Unnati	40.50	145.37	246.23	287.40	282.77
14.	TPG-41	46.77	154.97	214.23	290.47	289.93
	Mean	**52.31**	**143.19**	**209.25**	**286.40**	**279.81**
	S.E.±	0.352	2.774	4.724	4.592	4.196
	C.D.at 5%	1.023	8.064	13.731	13.350	12.197

In the present investigation, at 40 DAS, the genotype RHRG-19-2 (67.57) recorded maximum number of leaves per plant which was followed by genotype RHRG-19-8 (63.77). However, minimum number of leaves was recorded by the genotype RHRG-19-4 (29.03), Phule Unnati (40.50), RHRG-1309 (44.33).

At 60 DAS, the genotype RHRG-1308 (170.80) recorded maximum number of leaves per plant followed by genotype TPG-41 (154.97). Whereas, minimum number of leaves was recorded by genotype RHRG-1189 (118.00) followed by genotypes RHRG-19-8 (125.87) and RHRG-1192 (129.37).

At 80 DAS, genotype RHRG-1192 (254.40) had showed significantly the highest number of leaves which was at par with genotypes RHRG-1308 (250.20) and Phule Unnati (246.23). However the genotype RHRG-19-2 (180.53) recorded minimum number of leaves per plant followed by genotypes RHRG-1309 (181.37) and RHRG-19-1 (184.73).

At 100 DAS, the genotype RHRG-1192 (334.57) recorded highest number of leaves per plant followed by genotype RHRG-1308 (310.13). Whereas, the genotype RHRG-19-6 (245.60) recorded least number of leaves per plant followed by genotypes RHRG-1309 (257.20) and RHRG-19-7 (269.70).

At the time of harvest, maximum number of leaves per plant was recorded by the genotype RHRG-1192 (316.33) which was at par with genotype RHRG-1308 (307.47). While least number of leaves showed by the genotype RHRG-19-6 (239.97) followed by genotypes RHRG-1309 (254.47) and RHRG- 19-7 (266.33).

From the physiological point of view, leaf is the most important part of the plant. It is the source from which the plant derives food and energy for their metabolic activities. The primary function of leaves is carbon assimilation. Thus, leaf is the photosynthetic apparatus, depends upon the number of leaves of all the genotypes increased significantly up to 100 DAS and declined thereafter towards maturity due to leaf senescence. The genotype RHRG-1192 (316.33) and RHRG-19-6 (239.97) recorded maximum and minimum number of leaves respectively. Results are in conformity with the findings of Deshpande and Jadhav (1993).

4.1.5 Leaf area per plant (dm^2)

The data on the periodic leaf area (dm^2) per plant at various stages of growth is presented in Table 4.5 and graphically depicted in Fig. 4.5. The generalized trend for leaf area (dm^2) per plant revealed that there was rapid rate of increase in leaf

area up to 100 DAS and slowed down thereafter. The differences among the genotypes were statistically significant at all the stages of growth.

Table 4.5. Leaf area per plant (dm^2) as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Leaf area per plant (dm^2)				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	9.45	12.28	13.69	21.74	20.87
2.	RHRG-1189	8.21	11.54	12.41	21.62	20.78
3.	RHRG-19-1	7.63	10.84	12.11	21.28	20.59
4.	RHRG-19-2	7.33	9.87	12.47	22.77	21.64
5.	RHRG-19-3	8.56	10.55	13.41	22.73	22.04
6.	RHRG-19-4	8.48	10.99	13.89	21.03	20.60
7.	RHRG-19-5	7.61	10.26	11.42	23.36	22.78
8.	RHRG-19-6	7.56	10.92	13.40	21.78	20.37
9.	RHRG-19-7	8.51	11.49	14.08	22.23	21.49
10.	RHRG-19-8	8.35	10.73	12.32	22.34	21.29
11.	RHRG-1308	8.67	11.45	13.92	22.33	21.94
12.	RHRG-1309	7.35	10.35	12.90	22.32	21.97
13.	Phule Unnati	9.55	12.17	15.01	24.71	23.48
14.	TPG-41	8.10	11.87	14.34	24.76	23.05
	Mean	**8.24**	**11.09**	**13.24**	**22.50**	**21.64**
	S.E.±	0.103	0.198	0.091	0.141	0.260
	C.D.at 5%	0.300	0.576	0.266	0.411	0.755

At 40 DAS, the highest leaf area was recorded by genotype Phule Unnati (9.55 dm^2) which was at par with genotype RHRG-1192 (9.45 dm^2). While lowest leaf area per plant was recorded by genotypes RHRG-19-2 (7.33 dm^2) which was followed by RHRG-1309 (7.35 dm^2) and RHRG-19-6 (7.56 dm^2).

At 60 DAS, genotype RHRG-1192 (12.28 dm^2) recorded the highest leaf area which was at par with genotypes Phule Unnati (12.17 dm^2) and TPG-41 (11.87 dm^2). Whereas, lowest leaf area per plant was recorded by genotype RHRG-19-2 (9.87 dm^2) followed by RHRG-19-5 (10.26 dm^2) and RHRG-1309 (10.35 dm^2).

At 80 DAS, Phule Unnati (15.01 dm^2) recorded maximum leaf area per plant which was followed by genotype TPG-41 (14.34 dm^2). While, RHRG-19-5 (11.42 dm^2) recorded minimum leaf area per plant which was followed by genotypes RHRG-19-1 (12.11 dm^2) and RHRG-19-8 (12.32 dm^2).

At 100 DAS, the genotype TPG-41 (24.76 dm^2) attained highest leaf area per plant which was at par with the genotype Phule Unnati (24.71 dm^2). However, the lowest leaf area recorded by genotypes RHRG-19-4 (21.03 dm^2) and it was followed by genotypes RHRG-19-1 (21.28 dm^2) and RHRG-1189 (21.62 dm^2).

At the time of harvest, Phule Unnati (23.48 dm^2) recorded the highest leaf area per plant which was at par with genotypes TPG-41 (23.05 dm^2) and RHRG-19-5 (22.78 dm^2). However, the genotype RHRG-19-6 (20.37 dm^2) recorded lowest leaf area per plant followed by genotypes RHRG-19-1 (20.59 dm^2) and RHRG-19-4 (20.60 dm^2).

Leaf area is important morphological character which had relevance to the performance of the genotype in terms of productivity. Leaf area indicates the maintenance of assimilatory surface area over a period of time, which is pre-requisite for prolonged photosynthetic activity and ultimate productivity in plants. Leaf area per plant depends on number of leaves, rate of expansion, size of leaf area, moisture, nutrients and senescence. Leaf area (dm^2) of all the genotypes increased upto 100DAS and declined thereafter towards maturity due to leaf senescence. The genotype Phule Unnati showed higher leaf area at all growth stages except few entries at few stages.

Generally, more leaf area means more production of photosynthates, more dry matter and finally more yield to be obtained. The present investigation contradicts the findings of Borkar and Dharanguttikar (2014). Even though the genotypes RHRG-1308, RHRG-1192 had less leaf area than Phule Unnati, they produced higher yield.

The reason for this high yield of these genotypes might be better source to sink relationship because the final yield depends on how assimilates are transported and retained in effective sink i.e. pod. The present study showed that, the genotypes with higher leaf area do not necessarily produce higher economic yield. The results are similar to the findings of Borkar and Dharanguttikar (2014) who reported that leaf area had negative effect on pod yield.

4.1.6 Leaf area index (LAI)

The data on mean leaf area index (LAI) are presented in Table 4.6 and graphically depicted in Fig. 4.6. The genotypic differences for LAI were statistically

significant at all the growth stages. LAI increased rapidly up to 100 days and declined thereafter.

At 40 DAS, the genotype Phule Unnati (3.18) recorded significantly higher mean LAI over all the genotypes followed by RHRG-1192 (3.15) which was at par with it, while the genotype RHRG-19-2 (2.44) had significantly lowest mean LAI over rest of the genotypes which was followed by genotypes RHRG-1309 (2.47) and RHRG-19-6 (2.52).

Table 4.6. Leaf area index (LAI) per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Leaf area index (LAI)				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	3.15	4.09	4.56	7.24	6.95
2.	RHRG-1189	2.74	3.84	4.14	7.21	6.93
3.	RHRG-19-1	2.54	3.61	4.03	7.09	6.86
4.	RHRG-19-2	2.44	3.29	4.15	7.59	7.24
5.	RHRG-19-3	2.85	3.52	4.47	7.58	7.34
6.	RHRG-19-4	2.82	3.66	4.63	7.01	6.83
7.	RHRG-19-5	2.53	3.42	3.81	7.79	7.59
8.	RHRG-19-6	2.52	3.64	4.46	7.26	6.79
9.	RHRG-19-7	2.84	3.83	4.69	7.41	7.16
10.	RHRG-19-8	2.78	3.58	4.11	7.45	7.09
11.	RHRG-1308	2.89	3.82	4.64	7.44	7.31
12.	RHRG-1309	2.47	3.45	4.30	7.43	7.32
13.	Phule Unnati	3.18	4.06	5.00	8.23	7.83
14.	TPG-41	2.70	3.95	4.78	8.25	7.68
	Mean	**2.74**	**3.70**	**4.41**	**7.50**	**7.21**
	S.E.±	0.033	0.066	0.030	0.046	0.085
	C.D.at 5%	0.098	0.192	0.087	0.136	0.248

At 60 DAS, the genotype RHRG-1192 (4.09) recorded statistically highest mean LAI over all the genotypes which was at par with the genotypes Phule Unnati

(4.06) and TPG-41 (3.95). While the genotype RHRG-19-2 (3.29) recorded lowest mean LAI followed by genotypes RHRG-19-5 (3.42) and RHRG-1309 (3.45).

At 80 DAS, the genotype Phule Unnati (5.00) recorded highest mean LAI followed by genotypes TPG-41 (4.78) and RHRG-19-7 (4.69). Whereas, RHRG-19-5 (3.81) recorded lowest mean LAI followed by genotypes RHRG-19-1 (4.03) and RHRG-19-8 (4.11).

At 100 DAS, TPG-41 (8.25) genotype recorded significantly highest mean LAI which was at par with genotype Phule Unnati (8.23) and genotype RHRG-19-4 (7.01) recorded lowest mean LAI which was followed by RHRG-19-1 (7.09) and RHRG-1189 (7.21).

At the time of harvest, significantly highest LAI recorded by the genotype Phule Unnati (7.83) followed by genotypes TPG-41 (7.68) and RHRG-19-5 (7.59) which were at par with it. The genotypes RHRG-19-6 (6.79) recorded lowest mean LAI which was followed by genotypes RHRG-19-4 (6.83) and RHRG-19-1 (6.86).

Watson (1947) introduced the concept of leaf area index as one of the most important growth parameter which indicates the assimilatory surface area over per unit ground area gives a fairly good idea of photosynthetic capacity of the plant. In the present investigation, LAI increased progressively with the advancing age of the crop. The rate was rather slow at initial stages and afterwards it becomes rapid upto 100 DAS which was again slowed towards maturity. The genotype Phule Unnati recorded highest LAI, while RHRG-19-6 recorded lowest LAI at harvest stage. The genotype earlier studies made elsewhere also indicated similar results with reference to groundnut reported by Mane *et al.* (2017) and also similar results were reported by Jagtap *et al.* (2014).

4.2 Phenological traits

The data in respect of days required for initiation of flowering and physiological maturity are presented in Table 4.7 and graphically showed in Fig. 4.7. The data revealed that, the genotypic differences were statistically significant for both the characters.

4.2.1 Days to initiation of flowering

The genotype RHRG-19-5 (28.33 days) required least number of days for appearance of flowering over all the genotypes followed by RHRG-19-3 (28.67days).

However, the genotype RHRG-19-7 (30.67 days) required highest number of days for appearance of flowering.

The reproductive phase starts with flowering and ends with maturity. In the present investigation, a wide range of variation was observed at appearance of flowering. It is seen from the data that, the genotype RHRG-19-7 (30.67 days) and RHRG-19-5 (28.33 days) required maximum and minimum days for initiation of flowering respectively. This resulted into maximum dry matter accumulation occurs during the vegetative phase. Similar results recorded by Borkar and Dharanguttikar (2014) in groundnut.

Table 4.7. Days required to initiation of flowering and physiological maturity of groundnut genotypes

Sr. No.	Genotypes	Days to initiation of flowering	Days of physiological maturity
1.	RHRG-1192	29.67	125.67
2.	RHRG-1189	29.33	127.33
3.	RHRG-19-1	29.33	126.33
4.	RHRG-19-2	30.33	128.33
5.	RHRG-19-3	28.67	128.00
6.	RHRG-19-4	29.67	126.00
7.	RHRG-19-5	28.33	124.67
8.	RHRG-19-6	30.00	128.33
9.	RHRG-19-7	30.67	128.67
10.	RHRG-19-8	29.67	127.33
11.	RHRG-1308	30.33	126.67
12.	RHRG-1309	29.67	128.33
13.	Phule Unnati	29.33	128.67
14.	TPG-41	29.67	129.67
	Mean	**29.62**	**127.43**
	S.E.±	0.315	0.375
	C.D.at 5%	0.917	1.091

4.2.2 Days to physiological maturity

In the present investigation, the genotype RHRG-19-5 (124.67 days) required minimum days to attain physiological maturity followed by the genotype RHRG-1192 (125.67 days), while the genotype TPG-41 (129.67 days) required maximum days to attain physiological maturity.

The reproductive phase starts with flowering and ends with maturity. In the present investigation, a wide range of variation was observed at physiological maturity. It is seen from the data that, the days required for physiological maturity ranged between 124.67 to 129.67. The genotype TPG-41 (129.67 days) and RHRG-19-5 (124.67days) required maximum and minimum days for maturity respectively. This resulted into the efficient dry matter partitioning during reproductive phase and it moves towards the development of economic parts of the plant and ultimately increasing the yield. Similar results recorded by Kamshette *et al.* (2015) and Mane *et al.* (2017) in groundnut.

4.3 Dry matter accumulation and its partitioning studies

Data on dry matter accumulation of different component parts of the plant was collected periodically in order to study the dry matter production and its assimilate partitioning in various plant parts *viz.* root, stem, leaves and pods.

4.3.1 Dry matter accumulation in roots (g) per plant

The data on dry matter accumulation in roots (g) per plant is presented in Table 4.8.

The differences as regards to the dry matter accumulation in roots (g) per plant were statistically significant at all the stages of the growth indicating a wide range of variation amongst the genotypes studied. The data revealed that the dry matter of roots increases continuously till the harvest.

At 40 DAS, the genotype RHRG-1192 (0.21 g) accumulated significantly the highest dry matter in roots which was at par with genotype Phule Unnati (0.19 g). Whereas, the genotype TPG-41, RHRG-1309 and RHRG-19-6 (0.14 g) accumulated significantly the lowest dry matter in roots.

At 60 DAS, RHRG-1192 (0.50 g) genotype recorded highest dry matter accumulation in root (g) per plant which was followed by genotype RHRG-1189 (0.38 g). However, genotype RHRG-19-2 (0.27 g) recorded least dry matter accumulation in root per plant followed by geotypes RHRG-19-1 (0.28 g) and RHRG-19-6 (0.29 g).

Table 4.8. Dry matter accumulation in roots (g) per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Dry matter accumulation in roots (g) per plant				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	0.21	0.50	1.38	1.54	1.43
2.	RHRG-1189	0.17	0.38	1.27	1.52	1.32
3.	RHRG-19-1	0.16	0.28	1.27	1.46	1.34
4.	RHRG-19-2	0.18	0.27	1.19	1.39	1.24
5.	RHRG-19-3	0.17	0.31	1.32	1.42	1.30
6.	RHRG-19-4	0.16	0.33	1.26	1.46	1.24
7.	RHRG-19-5	0.17	0.37	1.15	1.39	1.33
8.	RHRG-19-6	0.14	0.29	1.26	1.52	1.27
9.	RHRG-19-7	0.18	0.32	1.32	1.33	1.19
10.	RHRG-19-8	0.15	0.31	1.23	1.29	1.20
11.	RHRG-1308	0.18	0.33	1.27	1.54	1.38
12.	RHRG-1309	0.14	0.35	1.29	1.50	1.38
13.	Phule Unnati	0.19	0.35	1.31	1.54	1.44
14.	TPG-41	0.14	0.37	1.54	1.59	1.45
	Mean	**0.17**	**0.34**	**1.30**	**1.46**	**1.32**
	S.E.±	0.005	0.016	0.026	0.033	0.029
	C.D.at 5%	0.014	0.047	0.075	0.097	0.087

At 80 DAS, the genotype TPG-41 (1.54 g) exhibited significantly maximum dry matter accumulation in root per plant followed by genotype RHRG-1192 (1.38 g) while, genotype RHRG-19-5 (1.15 g) recorded the least dry matter followed by RHRG-19-2 (1.19 g) and RHRG-19-8 (1.23 g) genotypes.

At 100 DAS, significantly highest dry matter in roots (g) per plant was recorded by the genotype TPG-41 (1.59 g) which was at par with the genotypes RHRG-1192 (1.54 g), RHRG-1308 (1.54 g), Phule Unnati (1.54 g), RHRG-1189 (1.52 g), RHRG-19-6 (1.52 g) and RHRG-1309 (1.50 g). Whereas, lowest dry matter accumulation in root was recorded by genotype RHRG-19-8 (1.29 g) followed by genotypes RHRG-19-7 (1.33 g), RHRG-19-2 (1.39 g) and RHRG-19-5 (1.39 g).

At harvest, the genotype TPG-41 (1.45 g) recorded significantly maximum dry matter accumulation in root (g) per plant followed by genotypes Phule Unnati (1.44 g), RHRG-1192 (1.43 g), RHRG-1308 (1.38 g) and RHRG-1309 (1.38 g). Whereas, the minimum dry matter accumulation in root (g) per plant was recorded by genotype RHRG-19-7 (1.19 g) and followed by RHRG-19-8 (1.20 g).

Dry matter is an important criterion to determine the source sink relationship and depends upon the net gain in the processes on anabolism and catabolism of plant. The pattern of the dry matter production and its distribution into component plant parts has been of phenomenal interest to the research workers engaged in yield analysis. This method has been accepted as one of the standard method of yield analysis. The data on dry matter collected at different time intervals would give the picture in quantitative terms as regards to accumulation and partitioning of the total dry matter among the plant parts throughout the growth period of the crop. In view of this it was envisaged to know the pattern of dry matter accumulation and its distribution in component parts of plant.

The overall functioning of the plant ultimately leads to formation and progressive accumulation of dry matter. All the physiological processes results into a net balance and accumulation of dry matter and hence, the biological productivity of plant is judged from their actual ability to produce and accumulate dry matter.

In the present investigation it is clearly indicates that, the dry matter accumulation in roots increased steadily upto 80 DAS with the advancing age of the crop. The genotype TPG-41 and RHRG-19-7 recorded maximum and minimum dry matter of roots per plant. Ghosh *et al.* (1997) stated that, there was negligible amount of dry matter partitioning into the roots.

4.3.2 Dry matter accumulation in stem (g) per plant

The data on mean dry matter of stem (g) per plant is presented in Table 4.9. The genotypic differences are statistically significant at all the growth stages.

At 40 DAS, RHRG-1192 (2.23 g) genotype recorded highest dry matter accumulation in stem (g) per plant which was followed by genotype RHRG-19-7 (1.93 g) and RHRG-19-4 (1.90 g). However, genotype RHRG-19-6 (1.07 g) recorded least dry matter accumulation in stem per plant followed by geotypes RHRG-19-1 (1.18 g) and RHRG-1309 (1.21 g).

At 60 DAS, the genotype RHRG-1192 (4.02 g) accumulated significantly the highest dry matter in stem which was at par with genotype RHRG-19-4 (3.89 g). Whereas, the genotype RHRG-1309 (2.35 g), RHRG-1308 (2.71 g) and RHRG-19-8 (2.82 g) accumulated significantly the lowest dry matter in stem.

Table 4.9. Dry matter accumulation in stem (g) per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Dry matter accumulation in stem (g) per plant				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	2.23	4.02	8.24	10.62	9.47
2.	RHRG-1189	1.27	3.40	7.57	9.74	8.64
3.	RHRG-19-1	1.18	3.31	7.77	9.46	9.06
4.	RHRG-19-2	1.36	3.85	7.82	9.60	9.12
5.	RHRG-19-3	1.80	3.75	8.00	9.43	8.94
6.	RHRG-19-4	1.90	3.89	8.80	9.23	8.63
7.	RHRG-19-5	1.33	3.66	7.45	9.50	8.65
8.	RHRG-19-6	1.07	3.67	7.62	9.74	8.46
9.	RHRG-19-7	1.93	3.82	7.88	9.87	9.13
10.	RHRG-19-8	1.65	2.82	8.02	9.26	8.28
11.	RHRG-1308	1.52	2.71	7.61	9.65	9.10
12.	RHRG-1309	1.21	2.35	7.47	9.35	8.32
13.	Phule Unnati	1.70	3.85	8.10	10.70	9.56
14.	TPG-41	1.83	3.61	7.33	9.34	8.36
	Mean	**1.57**	**3.48**	**7.83**	**9.68**	**8.84**
	S.E.±	0.057	0.043	0.070	0.085	0.096
	C.D.at 5%	0.168	0.127	0.203	0.248	0.281

At 80 DAS, the genotype RHRG-19-4 (8.80 g) recorded significantly maximum dry matter accumulation in stem (g) per plant followed by genotypes RHRG-1192 (8.24 g) and Phule Unnati (8.10 g). Whereas, the minimum dry matter accumulation in stem (g) per plant was recorded by genotype TPG-41 (7.33 g) and followed by RHRG-19-5 (7.45 g), RHRG-1309 (7.47 g) and RHRG-1189 (7.57 g).

At 100 DAS, significantly highest dry matter in stem (g) per plant was recorded by the genotype Phule Unnati (10.70 g) which was at par with the genotypes RHRG-1192 (10.62 g). Whereas, lowest dry matter accumulation in stem was recorded by genotype RHRG-19-4 (9.23 g) followed by genotypes RHRG-19-8 (9.26 g), TPG-41 (9.34 g) and RHRG-1309 (9.35 g).

At the time of harvest, the genotype Phule Unnati (9.56 g) accumulated significantly the highest dry matter in stem which was at par with genotype RHRG-1192 (9.47 g). Whereas, the genotype RHRG-19-8 (8.28 g) accumulated lowest dry matter (g) in stem followed by RHRG-1309 (8.32 g), TPG-41 (8.36 g) and RHRG-19-6 (8.46 g) genotypes.

In spite of roots, the rate of dry matter accumulation in stem was higher. In the present investigation, dry matter accumulation in stem increased progressively at constant rate with the advancing age of the crop and after 100 DAS it is declined. The genotypes Phule Unnati and RHRG-1192 exhibited highest while, genotype RHRG-19-8 exhibited lowest dry matter accumulation in stem. Similar results also shown by Borkar and Dharanguttikar (2014).

4.3.3 Dry matter accumulation in leaves (g) per plant

The data pertaining to the leaf dry matter content per plant at various stages of the growth are presented in Table 4.10. The genotypic differences for dry matter accumulation in leaves were statistically significant at all growth stages showing considerable amount of variation among the genotypes.

In the present investigation, at 40 DAS, the genotype TPG-41 (3.20 g) accumulated significantly the highest dry matter accumulation in leaves which was at par with genotype RHRG-1192 (3.15 g), RHRG-19-7 (3.01 g), Phule Unnati (2.84 g), RHRG-19-6 (2.82 g) and RHRG-1189 (2.80 g). Whereas, the genotype RHRG-19-4 (1.74 g), RHRG-1308 (1.80 g) and RHRG-19-5 (2.04 g) accumulated significantly the lowest dry matter accumulation in leaves.

At 60 DAS, RHRG-19-6 (5.75 g) genotype recorded highest dry matter accumulation in leaves (g) per plant which was followed by genotype RHRG-19-4 (5.60 g) which was at par with it. However, genotype Phule Unnati (4.43 g) recorded least dry matter accumulation in leaves per plant followed by geotypes RHRG-19-2 (4.54 g) and RHRG-19-1 (4.55 g).

Table 4.10. Dry matter accumulation in leaves (g) per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Dry matter accumulation in leaves (g) per plant				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	3.15	5.17	13.46	13.78	13.06
2.	RHRG-1189	2.80	4.79	11.12	12.49	12.22
3.	RHRG-19-1	2.47	4.55	10.42	12.09	11.82
4.	RHRG-19-2	2.28	4.54	11.55	12.51	11.74
5.	RHRG-19-3	2.49	5.23	11.21	13.31	11.67
6.	RHRG-19-4	1.74	5.60	11.36	12.96	11.84
7.	RHRG-19-5	2.04	5.16	11.06	12.54	11.78
8.	RHRG-19-6	2.82	5.75	12.80	13.30	12.87
9.	RHRG-19-7	3.01	4.96	10.98	11.81	11.10
10.	RHRG-19-8	2.72	4.86	10.96	12.13	11.39
11.	RHRG-1308	1.80	4.84	10.91	11.66	11.34
12.	RHRG-1309	2.21	4.75	10.81	11.37	10.46
13.	Phule Unnati	2.84	4.43	13.27	13.91	11.99
14.	TPG-41	3.20	5.10	12.57	13.43	11.60
	Mean	**2.54**	**4.98**	**11.61**	**12.67**	**11.78**
	S.E.±	0.152	0.136	0.142	0.082	0.230
	C.D.at 5%	0.442	0.396	0.415	0.238	0.669

At 80 DAS, the genotype RHRG-1192 (13.46 g) exhibited significantly maximum dry matter accumulation in leaves per plant which was at par with genotype Phule Unnati (13.27 g) while, genotype RHRG-19-1 (10.42 g) recorded the least dry matter followed by RHRG-1309 (10.81 g) and RHRG-1308 (10.91 g) genotypes.

At 100 DAS, significantly highest dry matter in leaves (g) per plant was recorded by the genotype Phule Unnati (13.91 g) which was at par with the genotype RHRG-1192 (13.78 g). Whereas, lowest dry matter accumulation in leaves was recorded by genotype RHRG-1309 (11.37 g) followed by genotypes RHRG-1308 (11.66 g), RHRG-19-7 (11.81 g) and RHRG-19-1 (12.09 g).

At harvest, the genotype RHRG-1192 (13.06 g) recorded significantly maximum dry matter accumulation in leaves (g) per plant followed by genotype RHRG-19-6 (12.87 g) which was at par with it. Whereas, the minimum dry matter accumulation in leaves (g) per plant was recorded by genotype RHRG-1309 (10.46 g) and followed by RHRG-19-7 (11.10 g), RHRG-1308 (11.34 g) and RHRG-19-8 (11.39 g).

The rate of dry matter accumulation in leaves was low at initial stages which were rapid in between grand growth period and steadily up to 100 DAS. The genotypes RHRG-1192 and RHRG-1309 recorded highest and lowest dry matter accumulation in leaves respectively. The above were in agreement with the results of Kumar and Kumar (1999).

4.3.4 Dry matter accumulation in pods (g) per plant

The data pertaining to the dry matter in pods (g) per plant at various stages is presented in Table 4.11. The data revealed that, there was continuous and progressive increase in dry matter of pods (g) per plant till the harvest. The genotypic differences regarding to the dry matter accumulation in pods (g) per plant are statistically significant at all stages of growth.

In the present investigation, at 80 DAS, the genotype RHRG-1192 (7.04 g) recorded significantly maximum dry matter accumulation in pods (g) per plant followed by genotypes RHRG-19-1 (6.39 g) and Phule Unnati (6.37 g). Whereas, the minimum dry matter accumulation in pods (g) per plant was recorded by genotype RHRG-19-3 (5.38 g), RHRG-1309 (5.38 g) followed by RHRG-1308 (5.51 g).

At 100 DAS, significantly highest dry matter accumulation in pods (g) per plant was recorded by the genotype RHRG-1192 (12.02 g) followed by genotypes Phule Unnati (11.52 g), TPG-41 (11.26 g). Whereas, lowest dry matter accumulation in pods was recorded by genotype RHRG-19-4 (9.60 g) followed by genotypes RHRG-19-2 (9.70 g), RHRG-19-1 (9.74 g) and RHRG-19-7 (9.78 g).

At the time of harvest, the genotype RHRG-1192 (17.24 g) accumulated significantly the highest dry matter accumulation in pods which was followed by genotype RHRG-19-5 (16.77 g), Phule Unnati (16.54 g). Whereas, the genotype RHRG-19-7 (14.08 g), RHRG-19-1 (14.30 g), TPG-41 (14.37 g) and RHRG-19-2 (14.62 g) accumulated significantly the lowest dry matter in pods.

Table 4.11. Dry matter accumulation in pods (g) per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Dry matter accumulation in pods (g) per plant		
		80 DAS	**100 DAS**	**At harvest**
1.	RHRG-1192	7.04	12.02	17.24
2.	RHRG-1189	5.55	10.41	15.47
3.	RHRG-19-1	5.57	9.74	14.30
4.	RHRG-19-2	6.39	9.70	14.62
5.	RHRG-19-3	5.38	10.64	16.51
6.	RHRG-19-4	5.90	9.60	15.25
7.	RHRG-19-5	5.80	10.12	16.77
8.	RHRG-19-6	5.66	10.51	16.16
9.	RHRG-19-7	6.23	9.78	14.08
10.	RHRG-19-8	5.62	10.65	15.30
11.	RHRG-1308	5.51	9.87	16.30
12.	RHRG-1309	5.38	10.45	15.10
13.	Phule Unnati	6.37	11.52	16.54
14.	TPG-41	6.15	11.26	14.37
	Mean	**5.90**	**10.45**	**15.57**
	S.E.±	0.041	0.066	0.091
	C.D.at 5%	0.120	0.192	0.264

After the flowering dry matter was shared in reproductive parts. The total dry matter accumulation in vegetative parts get declined and increased in reproductive parts. The total dry matter accumulation increased in the pods with advancement of the crop growth stage. The genotype RHRG-1192 recorded highest whereas RHRG-19-7 recorded lowest dry matter of pods per plant at harvest. These findings are similar with Murthy *et al.* (2002).

4.3.5 Total dry matter (g) per plant

The roots, stem, leaves and pods dry weights were added together for total dry matter (g) per plant. The data is presented in Table 4.12 and graphically depicted in Fig. 4.8. The genotypic differences for mean total dry matter (g) per plant are statistically significant at all the crop growth stages.

Table 4.12. Total dry matter accumulation (g) per plant as influenced by groundnut genotypes at various growth stages

Sr. No.	Genotypes	Total dry matter accumulation per plant (g)				
		40 DAS	60 DAS	80 DAS	100 DAS	At harvest
1.	RHRG-1192	5.59	9.69	30.12	37.96	42.20
2.	RHRG-1189	4.24	8.57	25.51	34.16	37.65
3.	RHRG-19-1	3.81	8.14	25.03	32.75	36.52
4.	RHRG-19-2	3.82	8.66	26.95	33.20	36.72
5.	RHRG-19-3	4.46	9.29	25.90	34.80	38.42
6.	RHRG-19-4	3.80	9.82	27.32	33.25	36.96
7.	RHRG-19-5	3.54	9.19	25.46	33.55	38.53
8.	RHRG-19-6	4.03	9.71	27.34	35.07	38.76
9.	RHRG-19-7	5.11	9.10	26.41	32.79	35.50
10.	RHRG-19-8	4.52	7.99	25.83	33.33	36.16
11.	RHRG-1308	3.50	7.88	25.30	32.72	38.12
12.	RHRG-1309	3.56	7.45	24.95	32.67	35.26
13.	Phule Unnati	4.73	8.63	29.05	37.67	39.53
14.	TPG-41	5.17	9.08	27.59	35.62	35.78
	Mean	**4.28**	**8.80**	**26.64**	**34.25**	**37.58**
	S.E.±	0.146	0.449	0.777	1.135	1.033
	C.D.at 5%	0.426	1.305	2.245	3.300	2.986

In present investigation, at 40 DAS, RHRG-1192 (5.59 g) genotype recorded highest total dry matter (g) per plant which was at par with genotype TPG-41 (5.17 g). However, genotype RHRG-1308 (3.50 g) recorded least total dry matter (g) accumulation per plant followed by geotypes RHRG-19-5 (3.54 g) and RHRG-1309 (3.56 g).

At 60 DAS, the genotype RHRG-19-4 (9.82 g) accumulated significantly the highest total dry matter (g) which was at par with genotype RHRG-19-6 (9.71 g), RHRG-1192 (9.69 g), RHRG-19-3 (9.29 g), RHRG-19-5 (9.19 g), RHRG-19-7 (9.10 g), TPG-41 (9.08 g), RHRG-19-2 (8.66 g), Phule Unnati (8.63 g) and RHRG-1189 (8.57 g). Whereas, the genotype RHRG-1309 (7.45 g), RHRG-1308 (7.88 g) and RHRG-19-8 (7.99 g) accumulated significantly the lowest total dry in plants.

At 80 DAS, the genotype RHRG-1192 (30.12 g) recorded significantly maximum total dry matter (g) accumulation in plant which was at par with genotype Phule Unnati (29.05 g). Whereas, the minimum total dry matter content (g) per plant was recorded by genotype RHRG-1309 (24.95 g) and followed by RHRG-19-1 (25.03 g), RHRG-1308 (25.30 g).

At 100 DAS, significantly highest total dry matter (g) per plant was recorded by the genotype RHRG-1192 (37.96 g) which was at par with the genotypes Phule Unnati (37.67 g), TPG-41 (35.62 g), RHRG-19-6 (35.07 g), RHRG-19-3 (34.80 g). Whereas, lowest total dry matter accumulation (g) per plant was recorded by genotype RHRG-1309 (32.67 g) followed by genotypes RHRG-1308 (32.72 g) and RHRG-19-1 (32.75 g).

At the time of harvest, the genotype RHRG-1192 (42.20 g) accumulated significantly the highest total dry matter (g) which was at par with genotype Phule Unnati (39.53 g). Whereas, the genotype RHRG-1309 (35.26 g), RHRG-19-7 (35.50 g), and TPG-41 (35.77 g) accumulated significantly the lowest total dry matter content.

The total dry matter of plant was contributed mainly by dry matter content of stem and leaves, up to 60-80 DAS. Thereafter, increase in total dry matter of plant was due to the increase in the dry matter of pods. The genotype RHRG-1192 and genotype RHRG-1309 recorded highest and lowest total dry matter at harvesting respectively. The genotypic differences with respect to total dry matter content was also reported by Tamilselvi *et al.* (2015). Total dry matter of plant increased progressively with the advancing age of the crop. Similar results were reported by Kamshette *et al.* (2015) and also Mane *et al.* (2017).

Table 4.13. Mean root, stem, leaf, pod and total dry matter (g) per plant as influenced by various groundnut genotypes at harvest stage

Sr. No.	Genotypes	Mean total dry matter (g) per plant at harvest				
		Root	Stem	Leaves	Pod	Total
1.	RHRG-1192	1.43	9.47	13.06	17.24	42.20
2.	RHRG-1189	1.32	8.64	12.22	15.47	37.65
3.	RHRG-19-1	1.34	9.06	11.82	14.30	36.52
4.	RHRG-19-2	1.24	9.12	11.74	14.62	36.72
5.	RHRG-19-3	1.30	8.94	11.67	16.51	38.42
6.	RHRG-19-4	1.24	8.63	11.84	15.25	36.96
7.	RHRG-19-5	1.33	8.65	11.78	16.77	38.53
8.	RHRG-19-6	1.27	8.46	12.87	16.16	38.76
9.	RHRG-19-7	1.19	9.13	11.10	14.08	35.50
10.	RHRG-19-8	1.20	8.28	11.39	15.30	36.16
11.	RHRG-1308	1.38	9.10	11.34	16.30	38.12
12.	RHRG-1309	1.38	8.32	10.46	15.10	35.26
13.	Phule Unnati	1.44	9.56	11.99	16.54	39.53
14.	TPG-41	1.45	8.36	11.60	14.37	35.78
	Mean	**1.32**	**8.84**	**11.78**	**15.57**	**37.58**
	S.E.±	0.029	0.096	0.230	0.091	1.033
	C.D.at 5%	0.087	0.281	0.669	0.264	2.986

4.3.6 Dry matter partitioning percentage

The data on dry matter partitioning (%)is presented in Table 4.14 and graphically showed in Fig. 4.9. The genotypic differences in roots, leaves and pods partitioning are statistically significant. The dry matter partitioning percentage was higher in the pods followed by leaves and stem.

4.3.6.1 Root dry matter partitioning percentage

The mean root dry matter partitioning percentage varied from 3.20 to 3.91. Significantly, the highest root dry matter partitioning was recorded by genotype RHRG-1309 (3.91) which was at par with genotypes RHRG-19-1 (3.69), Phule Unnati (3.64), RHRG-1308 (3.62) and RHRG-1192 (3.58). The genotype TPG-41 (3.20) recorded

significantly lowest root dry matter partitioning followed by genotypes RHRG-19-6 (3.28) and RHRG-19-8 (3.31).

Table 4.14. Dry matter partitioning (%) as influenced by groundnut genotypes at harvest stage

Sr. No.	Genotypes	Per cent partitioning of dry matter				
		Root	Stem	Leaves	Pod	Total
1.	RHRG-1192	3.58	23.50	30.99	41.93	100
2.	RHRG-1189	3.50	22.94	32.48	41.08	100
3.	RHRG-19-1	3.69	24.80	32.36	39.15	100
4.	RHRG-19-2	3.39	24.83	31.97	39.81	100
5.	RHRG-19-3	3.40	23.26	30.37	42.97	100
6.	RHRG-19-4	3.35	23.34	32.03	41.28	100
7.	RHRG-19-5	3.45	22.45	30.57	43.53	100
8.	RHRG-19-6	3.28	21.83	33.20	41.69	100
9.	RHRG-19-7	3.36	25.71	31.26	39.67	100
10.	RHRG-19-8	3.31	22.89	31.49	41.31	100
11.	RHRG-1308	3.62	23.87	29.74	42.77	100
12.	RHRG-1309	3.91	23.59	29.67	42.83	100
13.	Phule Unnati	3.64	24.19	30.33	41.84	100
14.	TPG-41	3.20	23.38	32.42	40.18	100
	Mean	**3.54**	**23.61**	**31.34**	**41.51**	**100**
	S.E.±	0.114	1.350	1.068	0.296	-
	C.D.at 5%	0.331	3.924	3.104	0.863	-

4.3.6.2 Stem dry matter partitioning percentage

The mean stem dry matter partitioning varied from 21.83 to 25.71. The genotype RHRG-19-7 (25.71) recorded highest stem dry matter partitioning percentage which was at par with the genotypes RHRG-19-2 (24.83), RHRG-19-1 (24.80) and Phule Unnati (24.19). However, lowest stem dry matter partitioning percentage recorded by genotype RHRG-19-6 (21.83).

4.3.6.3 Leaf dry matter partitioning percentage

The mean leaf dry matter partitioning percentage varied from 29.67 to 33.20. The genotype RHRG-19-6 (33.20) recorded significantly highest leaf dry matter

partitioning percentage which was at par with the genotypes RHRG-1189 (32.48), TPG-41 (32.42), RHRG-19-1 (32.36), RHRG-19-4 (32.03), RHRG-19-2 (31.97), RHRG-19-8 (31.49), RHRG-19-7 (31.26), RHRG-1192 (30.99), RHRG-19-5 (30.57), RHRG-19-3 (30.37) and Phule Unnati (30.33). Whereas, least leaf dry matter partitioning percentage recorded by genotype RHRG-1309 (29.67) followed by RHRG-1308 (29.74).

4.3.6.4 Pod dry matter partitioning percentage

The mean pod dry matter partitioning percentage varied from 39.15 to 43.53. The highest pod dry matter partitioning percentage recorded by genotype RHRG-19-5 (43.53) which was at par with the genotypes RHRG-19-3 (42.97), RHRG-1309 (42.83) and RHRG-1308 (42.77). However, the lowest dry matter exhibited by genotype RHRG-19-1 (39.15) followed by RHRG-19-7 (39.67) and RHRG-19-2 (39.81).

Dry matter production and its partitioning is one of the yield contributing trait of dry matter production and its distribution in different plants parts would give a better understanding of groundnut genotype in relation to its grain yield potential. The proportion of dry matter production diverted to pods (15.57 g/plant) was greater than the roots (1.32 g/plant), stem(8.84 g/plant) and leaves (11.78 g/plant).

The groundnut genotypes RHRG-1192 accumulated higher dry matter (42.20 g/plant) and translocated 30.99 per cent for leaf development and 41.93 per cent for pod development with harvest index 36 per cent indicating its poor translocation of assimilates from source to sink reflecting in the higher biomass. The genotype RHRG-1309 with relatively lowest dry matter (35.26 g/plant) and translocated 29.67 per cent for leaf development and 42.83 per cent for pod development with harvest index 38.41 per cent. It is thus concluded that, the high harvest index and thus the grain yield was mainly due to active translocation of assimilates from source to sink.

The genotype RHRG-1308 translocated maximum percentage i.e. 42.77 per cent for pod development, while 29.74 per cent for leaf development, 23.87 per cent for stem development and 3.62 per cent for root development with highest dry pod yield (20.54 g/plant) which shows active translocation of assimilates from source to sink.

4.4 Physiological parameters

4.4.1 Photosynthetic rate, transpiration rate and stomatal conductance

The data regarding photosynthetic rate, transpiration rate and stomatal conductance at 50 % flowering stage influenced by groundnut genotypes are presented in Table 4.15 which are statistically significant.

The genotype RHRG-1308 (26.89 µ mol CO_2 $m^{-2}s^{-1}$) recorded maximum photosynthetic rate which was followed by genotypes RHRG-1309 (25.70 µ mol CO_2 $m^{-2}s^{-1}$) and RHRG-19-4 (25.69 µ mol CO_2 $m^{-2}s^{-1}$). The genotype RHRG-19-2 (24.33 µ mol CO_2 $m^{-2}s^{-1}$) recorded minimum photosynthetic rate followed by RHRG-19-8 (24.55 µ mol CO_2 $m^{-2}s^{-1}$) and TPG-41 (24.65 µ mol CO_2 $m^{-2}s^{-1}$).

Table 4.15 Rate of photosynthesis, transpiration and stomatal conductance as influenced by groundnut genotypes at 50 % flowering stage

Sr. No.	Genotypes	Photosynthesis rate ($\mu molm^{-2}s^{-1}$)	Transpiration Rate ($mmolm^{-2}s^{-1}$)	Stomatal Conductance ($mmolm^{-2}s^{-1}$)
1.	RHRG-1192	25.26	1.91	0.28
2.	RHRG-1189	25.57	2.30	0.26
3.	RHRG-19-1	25.62	2.49	0.26
4.	RHRG-19-2	24.33	1.82	0.28
5.	RHRG-19-3	24.97	2.68	0.27
6.	RHRG-19-4	25.69	2.35	0.31
7.	RHRG-19-5	25.35	1.95	0.35
8.	RHRG-19-6	25.08	2.18	0.24
9.	RHRG-19-7	25.61	2.77	0.31
10.	RHRG-19-8	24.55	1.73	0.25
11.	RHRG-1308	26.89	3.52	0.37
12.	RHRG-1309	25.70	2.43	0.23
13.	Phule Unnati	24.88	3.24	0.33
14.	TPG-41	24.65	2.12	0.26
	Mean	**25.30**	**2.39**	**0.29**
	S.E.±	0.155	0.029	0.007
	C.D.at 5%	0.452	0.086	0.020

The genotype RHRG-1308 (3.52 m mol CO_2 $m^{-2}s^{-1}$) recorded highest transpiration rate which was at par with the Phule Unnati (3.24 m mol CO_2 $m^{-2}s^{-1}$). However, genotype RHRG-19-8 (1.73 m mol CO_2 $m^{-2}s^{-1}$) recorded the least transpiration rate which was followed by genotypes RHRG-19-2 (1.82 m mol CO_2 $m^{-2}s^{-1}$) and RHRG-1192 (1.91 m mol CO_2 $m^{-2}s^{-1}$).

The genotype RHRG-1308 (0.37 m mol CO_2 $m^{-2}s^{-1}$) recorded highest stomatal conductance which was at par with the genotype RHRG-19-5 (0.35 m mol CO_2 $m^{-2}s^{-1}$). However, genotype RHRG-1309 (0.23 m mol CO_2 $m^{-2}s^{-1}$) and RHRG-19-6 (0.24 m mol CO_2 $m^{-2}s^{-1}$) recorded the least stomatal conductance which was followed by genotype RHRG-19-8 (0.25 m mol CO_2 $m^{-2}s^{-1}$).

The data regarding photosynthetic rate revealed that, the genotype RHRG-1308 had maximum photosynthetic rate and also produced maximum grain yield whereas, genotype RHRG-19-2 had minimum photosynthetic rate.

In case of transpiration rate, the data revealed that, the genotype RHRG-1308 had showed maximum transpiration rate than other groundnut genotypes. In contrast, the genotype RHRG-19-8 had minimum transpiration rate.

The data regarding stomatal conductance revealed that, the genotype RHRG-1308 exhibited highest and RHRG-19-6 recorded lowest stomatal conductance. Stomatal conductance is necessary to have higher plant conductance so as to achieve higher photosynthesis which would lead to higher biological yield. Stomatal conductance was observed high due to which there was high transpiration rate and CO_2 exchange rate. The similar results were obtained by Kalpana *et al.* (2003).

4.4.2 Stomatal frequency (mm^2/leaf area)

The data on mean stomatal frequency are presented in Table 4.16 and graphically depicted in Fig. 4.12. The genotypic differences as regards to stomatal frequency of plant were statistically significant in both abaxial and adaxial side of leaf.

On abaxial side of the leaves the genotype RHRG-1308 (18.23) recorded the maximum stomatal frequency followed by Phule Unnati (18.00) which was at par with it. Whereas, the minimum stomatal frequency recorded by genotype RHRG-19-3 (15.57) followed by RHRG-19-1 (15.90) and TPG-41 (16.00).

Stomatal frequency revealed that, the genotypes RHRG-1308 had maximum stomatal frequency on abaxial side whereas, the genotype RHRG-19-3 recorded lowest stomatal frequency. The genotype Phule Unnati recorded highest

stomatal frequency on adaxial side whereas, the genotype RHRG-19-7 recorded lowest stomatal frequency. The results regarding stomatal frequency are similar with the findings of Borkar and Dharanguttikar (2014).

On adaxial side of the leaves, the genotype Phule Unnati (11.83) recorded the highest stomatal frequency followed by genotypes RHRG-1308 (11.33) and TPG-41 (11.30). However, RHRG-19-7 (8.47) recorded lowest stomatal frequency followed by genotypes RHRG-19-5 (8.73) and RHRG-19-6 (9.37).

Table 4.16. Genotypic differences in stomatal frequency (mm^2/leaf area) by groundnut at 50 % flowering stage

Sr. No.	Genotypes	Stomatal frequency (mm^2/leaf area)	
		Abaxial	Adaxial
1.	RHRG-1192	16.33	10.50
2.	RHRG-1189	17.20	10.33
3.	RHRG-19-1	15.90	10.80
4.	RHRG-19-2	16.40	10.50
5.	RHRG-19-3	15.57	9.43
6.	RHRG-19-4	17.03	10.60
7.	RHRG-19-5	16.53	8.73
8.	RHRG-19-6	16.33	9.37
9.	RHRG-19-7	17.70	8.47
10.	RHRG-19-8	16.30	10.43
11.	RHRG-1308	18.23	11.33
12.	RHRG-1309	16.43	10.70
13.	Phule Unnati	18.00	11.83
14.	TPG-41	16.00	11.30
	Mean	16.71	10.31
	S.E.±	0.129	0.119
	C.D.at 5%	0.376	0.346

4.5 Yield and yield attributes

The data on yield and yield contributing characters are presented in Table 4.17. The genotypic differences are statistically significant for all the traits showing the wide range of variation for yield and yield attributes amongst the genotype.

4.5.1 Number of pods per plant

The genotypic differences in respect of number of pods per plant were statistically significant. The genotype RHRG-1308 (37.83) recorded significantly highest number of pods per plant followed by genotypes RHRG-1192 (32.73) and RHRG-19-1 (30.43). Whereas, lowest number of pods per plant recorded by genotype RHRG-19-6 (19.78) followed by RHRG-19-4 (20.19), RHRG-19-7 (22.30) and RHRG-19-8 (23.19).

The generative growth constitutes the growth and development of reproductive parts. From yield point of view, this phase assumes significance as the sink lies in the reproductive part. The number of pods per plant is one of the important yield contributing character.

The number pods per plant is genetically controlled phenomenon. In the present study, the number of pods per plant in different genotypes ranged from 23.19 to 37.83. It was seen that, the genotype RHRG-1308 produced significantly highest number of pods per plant and that of lowest by RHRG-19-6. Similar results reported by Jagtap *et al.* (2009).

4.5.2 Number of mature pods per plant

The genotype RHRG-1308 (29.78) recorded significantly highest number of mature pods per plant followed by genotypes RHRG-1192 (27.43) and RHRG-19-2 (27.08). However, lowest number of mature pods per plant recorded by genotype RHRG-19-8 (15.91) followed by RHRG-19-6 (18.45), RHRG-19-4 (18.47) and RHRG-19-7 (19.92).

In the present investigation, the number of mature pods per plant varied significantly in all genotypes. Whereas, the maximum and minimum mature pods recorded by genotypes RHRG-1308 and RHRG-19-8 respectively. These results are similar with the Jagtap *et al.* (2009).

4.5.3 Number of immature pods per plant

The genotype RHRG-1189 (6), RHRG-19-1 (6), RHRG-19-8 (6) and RHRG-1309 (6) recorded maximum number of immature pods per plant. Whereas,

minimum number of immature pods per plant recorded by genotype RHRG-19-5 (2.67) followed by RHRG-19-4 (3.33), TPG-41 (3) and RHRG-1308 (4).

In the present investigation, the number of immature pods per plant varied significantly in all genotypes. Whereas, the minimum immature pods recorded by genotypes RHRG-19-5. These results are similar with the Jagtap *et al.* (2009).

Table 4.17. Yield and yield contributing characters as influenced by groundnut genotypes

Sr. No.	Genotypes	Number of pods per plant	Number of mature pods per plant	Number of immature pods per plant	Number of kernels per pods	Weight of 100 kernels (g) (HKW)	Dry pod yield (g/plant)
1.	RHRG-1192	32.73	27.43	5.33	2	41.46	20.12
2.	RHRG-1189	28.37	23.55	6.00	2	33.67	16.12
3.	RHRG-19-1	30.43	20.59	6.00	2	25.06	13.29
4.	RHRG-19-2	26.70	27.08	5.00	2	31.81	16.96
5.	RHRG-19-3	27.25	24.23	4.00	2	37.91	15.89
6.	RHRG-19-4	20.19	18.47	3.33	2	33.80	12.66
7.	RHRG-19-5	29.26	26.06	2.67	2	33.79	18.01
8.	RHRG-19-6	19.78	18.45	4.00	2	38.20	17.44
9.	RHRG-19-7	22.30	19.92	4.00	2	26.65	16.34
10.	RHRG-19-8	23.19	15.91	6.00	2	34.25	18.50
11.	RHRG-1308	37.83	29.78	4.00	2	45.61	20.54
12.	RHRG-1309	25.83	20.43	6.00	2	29.71	14.56
13.	Phule Unnati	26.04	21.56	5.33	2	37.23	18.67
14.	TPG-41	25.93	22.82	3.00	2	32.32	17.44
	Mean	26.85	22.59	4.62	2	34.39	16.90
	S.E.±	1.090	0.731	0.690	NS	0.840	1.290
	C.D.at 5%	3.168	2.125	2.007	NS	2.441	3.750

Table 4.17 Contd….

Sr. No.	Genotypes	Dry pod yield (kg/plot)	Dry pod yield (kg/ha)	Dry haulm yield (kg/plot)	Dry haulm yield (kg/ha)	Harvest index (%)	Kernel yield (kg/ha)	Shelling percentage
1.	RHRG-1192	1.91	4413.33	3.39	7837.67	36.00	3072.35	69.63
2.	RHRG-1189	1.60	3696.00	3.22	7442.67	33.19	2474.00	66.95
3.	RHRG-19-1	1.43	3307.00	3.01	6959.67	32.23	2260.05	68.37
4.	RHRG-19-2	1.20	2788.33	3.03	7007.00	28.41	1935.40	69.41
5.	RHRG-19-3	1.59	3680.67	2.80	6490.67	36.20	2541.68	69.06
6.	RHRG-19-4	1.34	3106.67	2.87	6649.67	31.82	2094.29	67.34
7.	RHRG-19-5	1.48	3434.00	2.86	6631.33	34.06	2339.44	68.20
8.	RHRG-19-6	1.24	2876.67	3.15	7288.00	28.24	1957.02	67.99
9.	RHRG-19-7	1.61	3720.33	2.91	6742.67	35.53	2533.84	68.11
10.	RHRG-19-8	1.29	2996.67	2.85	6601.67	31.21	2022.48	67.44
11.	RHRG-1308	1.93	4473.67	3.03	7002.33	38.97	2955.40	66.03
12.	RHRG-1309	1.80	4173.00	2.88	6656.67	38.41	2763.08	66.25
13.	Phule Unnati	1.62	3751.33	3.19	7378.00	33.70	2572.46	68.56
14.	TPG-41	1.40	3245.67	2.94	6801.67	32.17	2198.71	67.62
	Mean	**1.53**	**3547.38**	**3.01**	**6963.55**	**33.58**	**2408.58**	**67.93**
	S.E.±	0.084	196.368	0.066	153.352	1.450	137.574	0.594
	C.D.at 5%	0.246	570.835	0.192	445.790	4.217	399.923	1.727

4.5.4 Number of kernels per pod

All the groundnut genotypes had showed 2 kernels per pod. There was no range of variation among genotypes.

The number of kernels per pod is also one of the important character. In the present investigation, all the genotypes recorded same number of kernels per pod indicating that there was no range of variation. These results are similar with the results of Kamshette *et al.* (2015).

4.5.5 100 kernels weight (HKW) (g)

The genotypic difference in respect of 100 kernel weight were statistically significant. The genotype RHRG-1308 (45.61 g) recorded significantly highest 100 kernels weight (g) than all the rest of genotypes. However, the genotype RHRG-19-1 (25.06 g) recorded lowest 100 kernel weight followed by genotypes RHRG-19-7 (26.65 g) and RHRG-1309 (29.71 g).

The 100 kernel weight i.e. test weight is the most dominating yield contributing character. In the present study, the genotype RHRG-1308 exhibited its superiority in respect of 100 kernel weight and RHRG-19-1 having lowest test weight. Significant variation among the genotypes for 100 kernel weight were also reported by Jahangir *et al.* (2016).

4.5.6 Dry pod yield (g) per plant

The data revealed that, the genotype RHRG-1308 (20.54 g) recorded significantly highest dry pod yield (g) per plant followed by genotypes RHRG-1192 (20.12 g), Phule Unnati (18.67 g), RHRG-19-8 (18.50 g), RHRG-19-5 (18.01 g), RHRG-19-6 (17.44 g) and TPG-41 (17.44 g) which were at par with it. Whereas, genotype RHRG-19-4 (12.66 g) recorded least dry pod yield (g) per plant followed by RHRG-19-1 (13.29 g) and RHRG-1309 (14.56 g).

The dry pod yield (g/plant) for groundnut genotypes were statistically significant, indicating considerable amount of genetic variation in yield potential. The highest dry pod yield (g) per plant was recorded by genotype RHRG-1308 while, lowest recorded by genotype RHRG-19-5. Similar type of results were also reported by Jagtap *et al.* (2014), Borkar and Dharanguttikar (2014).

4.5.7 Dry pod yield (kg) per plot

The performance of genotypes in respect of dry pod yield (kg) per plot was statistically significant. The genotype RHRG-1308 (1.93 kg) produced significantly highest dry pod yield (kg) per plot over all the genotypes followed by RHRG-1192 (1.91 kg) and RHRG-1309 (1.80 kg) which were at par with it. Genotype RHRG-19-2 (1.20 kg) produced lowest dry pod yield (kg) per plot followed by RHRG-19-6 (1.24 kg), RHRG-19-8 (1.29 kg) and RHRG-19-4 (1.34 kg).

As regards to the dry pod yield (kg) per plot showed wide range of variation amongst the genotypes studied. It is observed that, the genotype RHRG-1308 had highest value of dry pod yield (kg) per plot while, the genotype RHRG-19-2 had lowest value of dry pod yield (kg) per plot. The similar results were reported by Kamshette *et al.* (2015) and Borkar and Dharanguttikar(2014).

4.5.8 Dry pod yield (kg) per hectare

The genotype RHRG-1308 (4473.67 kg) produced significantly highest dry pod yield (kg) per hectare over all the genotypes followed by RHRG-1192 (4413.33 kg) and RHRG-1309 (4173 kg) which were at par with it. However, genotype RHRG-19-

2 (2788.33 kg) produced lowest dry pod yield (kg) per hectare followed by RHRG-19-6 (2876.67 kg), RHRG-19-8 (2996.67 kg) and RHRG-19-4 (3106.67 kg).

The results of dry pod yield (kg) per hectare were statistically significant. The highest dry pod yield (kg) per hectare recorded by genotype RHRG-1308 and lowest recorded by genotype RHRG-19-2. Similar results also showed by Borkar and Dharanguttikar (2014).

4.5.9 Dry haulm yield (kg) per plot

The data revealed, that the performance of different genotypes in repect of dry haulm yield (kg) per plot was statistically significant. The genotype RHRG-1192 (3.39 kg) recorded significantly highest dry haulm yield (kg) per plot followed by genotypes RHRG-1189 (3.22 kg) and Phule Unnati (3.19 kg) which were at par with it. While, least dry haulm yield (kg) per plot was recorded by genotype RHRG-19-3 (2.80 kg) and it is followed by RHRG-19-8 (2.85 kg), RHRG-19-5 (2.86 kg) and RHRG-19-4 (2.87 kg).

The dry haulm yield (kg) per plot showed wide range of variation among genotypes studied. It is observed that, RHRG-1192 recorded maximum and RHRG-19-8 recorded minimum dry haulm yield (kg) per plot.

4.5.10 Dry haulm yield (kg) per hectare

The genotype RHRG-1192 (7837.67 kg) recorded significantly highest dry haulm yield (kg) per hectare followed by genotypes RHRG-1189 (7442.67 kg) which were at par with it. While, least dry haulm yield (kg) per hectare was recorded by genotype RHRG-19-3 (6490.67 kg) and it is followed by RHRG-19-8 (6601.67 kg), RHRG-19-5 (6631.33 kg) and RHRG-19-4 (6649.67 kg).

The dry haulm yield (kg) per hectare showed wide range of variation among genotypes studied. It is observed that, RHRG-1192 recorded maximum and RHRG-19-8 recorded minimum dry haulm yield (kg) per hectare.

4.5.11 Harvest index (%)

The performance of different genotypes in respect of harvest index were statistically significant. The genotype RHRG-1308 (38.97 %) recorded significantly highest harvest index over rest of the genotypes followed by RHRG-1309 (38.41 %), RHRG-19-3 (36.20 %) and RHRG-1192 (36 %) which were at par with it. Whereas, the genotype RHRG-19-6 (28.24 %) recorded lowest harvest index followed by RHRG-19-2 (28.41 %) and RHRG-19-8 (31.21 %).

The harvest index is the best indicator of photosynthetic translocation efficiency of the genotype. The genotype RHRG-1308 maintained highest harvest index indicating the better translocation efficiency. The harvest index is considered as one of the criteria for selection of high yielding genotypes. These results are in accordance with Borkar and Dharanguttikar (2014).

4.5.12 Kernel yield (kg) per hectare

The data revealed that, the genotype RHRG-1192 (3072.35 kg) recorded highest kernel yield (kg) per hectare which were at par with the genotypes RHRG-1308 (2955.40 kg) and RHRG-1309 (2763.08 kg). Whereas, lowest kernel yield recorded by genotype RHRG-19-2 (1935.40 kg) followed by RHRG-19-6 (1957.02 kg) and RHRG-19-8 (2022.48 kg).

In the present investigation the kernel yield (kg) per hectare were statistically significant. The genotypes RHRG-1192 and RHRG-19-2 recorded highest and lowest kernel yield respectively.

4.5.13 Shelling percentage

The genotypic difference in respect of shelling percentage were statistically significant. The genotype RHRG-1192 (69.63 %) recorded highest shelling percentage followed by genotypes RHRG-19-2 (69.41 %), RHRG-19-3 (69.06 %) and RHRG-19-1 (68.37 %). While lowest shelling percentage recorded by genotype RHRG-1308 (66.03 %) followed by RHRG-1309 (66.25 %).

As regards to the shelling percentage the genotype RHRG-192 recorded highest whereas, RHRG-1308 recorded lowest shelling percentage. The results were similar with the findings of Jagtap *et al.* (2014)Borkar and Dharanguttikar (2014).

Thus, on the basis of foregoing discussion broadly it can be inferred that, the pod number, number of kernels per pod, 100 kernel weight, dry pod yield (g) per plant, harvest index were observed to be the most dominating yield contributing characters in high yielding genotype. However, to arrive at a definite conclusion further confirmative studies are required to be undertaken.

Present investigation reveals that, there is positive correlation association of number of mature pods per plant, 100 kernel weight, dry pod yield (g) per plant, dry matter yield (kg) per plot, dry matter yield (kg) per hectare, kernel yield (kg) per hectare and harvest index.

4.6 Biochemical studies

4.6.1 Protein content (%)

The genotype RHRG-19-2 (25.60 %) recorded significantly highest protein content over all the genotypes except RHRG-19-1 (24.51 %), RHRG-1192 (24.89 %) and RHRG-19-7 (24.73 %) genotypes on which it was at par. The lowest protein content recorded by genotype RHRG-1189 (22.20 %) followed by RHRG-1309 (22.60 %) and RHRG-19-3 (22.70 %).

Protein content of the genotypic differed significantly ranging from 22.20 to 24.89 per cent. The genotype RHRG-1192 recorded the highest protein content while, the genotype RHRG-1189 recorded the lowest protein content. These findings are in accordance with the results of Borkar and Dharanguttikar (2014).

Table 4.18. Protein and oil content as influenced by groundnut genotypes

Sr. No.	Genotypes	Protein content (%)	Oil content (%)
1.	RHRG-1192	24.89	48.07
2.	RHRG-1189	22.20	45.31
3.	RHRG-19-1	24.51	48.51
4.	RHRG-19-2	25.60	48.68
5.	RHRG-19-3	22.70	48.60
6.	RHRG-19-4	24.09	48.21
7.	RHRG-19-5	23.67	47.68
8.	RHRG-19-6	24.22	47.28
9.	RHRG-19-7	24.73	46.29
10.	RHRG-19-8	24.39	44.93
11.	RHRG-1308	23.83	46.40
12.	RHRG-1309	22.60	48.77
13.	Phule Unnati	23.30	49.69
14.	TPG-41	23.46	49.47
	Mean	**23.87**	**47.71**
	S.E.±	0.134	0.163
	C.D.at 5%	0.392	0.476

4.6.2 Oil content (%)

The genotype Phule Unnati (49.69 %) recorded significantly the highest value for oil content than all the genotypes except TPG-41 (49.47 %) on which it was at par. However, the lowest oil content recorded by genotype RHRG-19-8 (44.93 %) followed by RHRG-1189 (45.31 %) and RHRG-19-7 (46.29 %).

There were significant differences in oil content of the genotype ranging from 44.93 to 49.69 per cent. The genotype Phule Unnati recorded highest oil content however, the genotype RHRG-19-8 recorded lowest oil content. These findings are in accordance with the results of Borkar and Dharanguttikar (2014).

4.6.3 Chlorophyll content (mg/g)

4.6.3.1 Chlorophyll - a

The genotype RHRG-1192 (0.73 mg/g) recorded significantly highest chlorophyll-a content which was followed by genotypes TPG-41 (0.63 mg/g) and Phule Unnati (0.62 mg/g). The lowest chlorophyll-a content recorded by genotype RHRG-19-1 (0.36 mg/g) which was followed by RHRG-1308 (0.41 mg/g).

The chlorophyll content in leaves considered as an important index for judging the rate of photosynthesis. The higher chlorophyll content is one of the important factor responsible for better yield. In the present investigation, the chlorophyll-a, highest in genotype RHRG1192. Similar results shown by Dharanguttikar and Borkar (2014).

4.6.3.2 Chlorophyll-b

From the recorded data it was seen that, genotype RHRG-1309 (0.55 mg/g) has maximum chlorophyll-b content and it was followed by genotypes RHRG-19-5 (0.48 mg/g) and TPG-41 (0.47 mg/g). And minimum chlorophyll content recorded by genotype RHRG-19-1 (0.23 mg/g) followed by RHRG-19-2 (0.31 mg/g).

The chlorophyll-b content recorded highest in genotype RHRG-1309 while lowest recorded by RHRG-19-5. These results are similar with the Borkar and Dharanguttikar (2014).

4.6.3.3 Total chlorophyll

The data on total chlorophyll content revealed that, the highest total chlorophyll content recorded by the genotype RHRG-1192 (1.43 mg/g) which was at par with RHRG-19-5 (1.36 mg/g). Whereas, lowest chlorophyll content recorded by genotype RHRG-19-1 (0.71 mg/g) followed by RHRG-19-8 (0.82 mg/g) and RHRG-19-2 (0.85 mg/g).

Table 4.19. Chlorophyll content (a, b and total) as influenced by groundnut genotypes

Sr. No.	Genotypes	Chlorophyll content (mg/g)		
		Chlorophyll - a	Chlorophyll – b	Total chlorophyll
1.	RHRG-1192	0.73	0.46	1.43
2.	RHRG-1189	0.54	0.38	1.12
3.	RHRG-19-1	0.36	0.23	0.71
4.	RHRG-19-2	0.43	0.31	0.85
5.	RHRG-19-3	0.46	0.33	1.03
6.	RHRG-19-4	0.53	0.46	1.25
7.	RHRG-19-5	0.46	0.48	1.36
8.	RHRG-19-6	0.50	0.41	1.03
9.	RHRG-19-7	0.49	0.39	0.95
10.	RHRG-19-8	0.43	0.33	0.82
11.	RHRG-1308	0.41	0.40	1.15
12.	RHRG-1309	0.51	0.55	1.14
13.	Phule Unnati	0.62	0.42	1.14
14.	TPG-41	0.63	0.47	1.25
	Mean	**0.51**	**0.40**	**1.09**
	S.E.±	0.013	0.018	0.050
	C.D.at 5%	0.040	0.053	0.148

Total chlorophyll content has seasonal influence in which light and temperature profound effect on synthesis and accumulation of these pigments. The highest and lowest total chlorophyll content recorded by genotypes RHRG-1192 and RHRG-19-1 respectively. Similar results reported by Kamshette *et al.* (2015)**.**

5. SUMMARY AND CONCLUSION

The present investigation entitled, “Morpho-physiological characterization of summer groundnut (*Arachis hypogaea* L.)” was conducted at AICRP on Groundnut Improvement Project, M.P.K.V., Rahuri, during summer season of 2019 to study the efficiency of physiological parameters of summer groundnut genotypes, dry matter accumulation and it’s partitioning and to study the association of physiological parameters with pod yield of the fourteen genotypes which were selected for studies. The experiment was conducted in randomized block design with three replications on medium black soil. Various morphological, physiological and yield attributing characters along with dry matter production and partitioning were collected periodically at an interval of 20 days starting from 40 DAS up to harvest. The data were statistically analyzed. Also, the per cent of kernel protein content (%) and oil content (%) were determined.

The results obtained in the present investigation are summerized as below.

1. The growth observations *viz.*, plant height revealed that the genotypes RHRG-1308 and RHRG-19-3 were superior to other genotypes which recorded the highest plant height at harvest stage. The genotype RHRG-19-4 and RHRG-19-2 recorded lowest plant height at harvest stage.
2. The number of branches i.e. primary and secondary per plant were highest in the genotype RGRG-1192, while the lowest in the genotype RHRG-19-4 at harvest stage.
3. The genotype RHRG-1192 and RHRG-1308 recorded the highest number of leaves per plant, while the genotype RHRG-19-6 recorded the lowest number of leaves per plant at harvest stage.
4. The highest leaf area per plant was recorded in the genotype Phule Unnati, while the lowest leaf area per plant was recorded in the genotype RHRG-19-6 at harvest stage.
5. The highest leaf area index at harvest stage recorded in the genotype Phule Unnati, whereas the lowest leaf area index recorded in genotype RHRG-19-6 at harvest stage.

6. The genotype RHRG-19-5 required least number of days for appearance of flowering, while the genotype RHRG-19-7 required maximum number of days to flowering.
7. The genotype RHRG-19-5 required minimum number of days for physiological maturity, whereas genotype TPG-41 required more number of days to maturity.
8. The highest root dry matter (g) per plant was recorded by the genotype TPG-41, RHRG-1308, while the genotype RHRG-19-7 and RHEG-19-8 recorded lowest root dry matter (g) per plant at harvest stage.
9. The highest stem dry matter (g) per plant was recorded by the genotypes Phule Unnati and RHRG-1192. However, the lowest stem dry matter (g) per plant was recorded by genotype RHRG-19-8 at harvest stage.
10. The genotype RHRG-1192 recorded the highest leaf dry matter (g) per plant at harvest, while the lowest leaf dry matter (g) per plant at harvest stage was recorded by the genotype RHRG-1309.
11. Highest dry matter accumulation in pod (g) per plant at harvest was recorded by the genotype RHRG-1192, while lowest dry matter accumulation in pod (g) per plant at harvest was recorded by genotype RHRG-19-7.
12. Total dry matter (g) per plant at harvest was recorded highest by genotype RHRG-1192 followed by genotype Phule Unnati. Whereas, lowest recorded by genotype RHRG-1309 at harvest stage.
13. The genotype RHRG-1309 recorded highest root dry matter partitioning at harvest stage. However, genotype TPG-41 recorded lowest root dry matter partitioning at harvest.
14. The genotype RHRG-19-7 recorded highest stem dry matter partitioning at harvest stage. Whereas, genotype RHRG-19-6 recorded lowest stem dry matter partitioning at harvest.
15. The genotype RHRG-19-6 recorded the highest, while RHRG-1309 recorded the lowest leaf dry matter partitioning at harvest.
16. The genotype RHRG-19-5, RHRG-19-3 and RHRG-1308 recorded the highest pod dry matter partitioning, whereas RHRG-19-1 recorded the lowest pod dry matter partitioning at harvest.
17. Physiological characters which recorded at 50 % flowering stage showed that, maximum photosynthetic rate was showed by the genotype RHRG-1308 followed

by genotype RHRG-1309, while minimum by the genotype RHRG-19-2 followed by RHRG-19-8.

18. Highest transpiration rate at 50% flowering stage recorded by the genotype RHRG-1308 followed by genotype Phule Unnati, while the genotype RHRG-19-8 had showed lowest transpiration rate followed by RHRG-19-2.
19. Stomatal conductance was reported to be highest by the genotype RHRG-1308 and lowest by genotype RHRG-1309.
20. At 50 % flowering stomatal frequency was reported on adaxial side highest by genotype RHRG-1308 followed by genotype Phule Unnati and lowest by genotype RHRG-19-3. While, stomatal frequency on abaxial side of leaves is reported to be highest by genotype Phule Unnati and lowest by genotype RHRG-19-7.
21. Yield contributing characters like number of pods per plant revealed that, the genotype RHRG-1308 is superior over other genotypes.
22. 100 kernel weight observation revealed that, the genotype RHRG-1308 shows highest weight.
23. Characters like dry pod yield (g) per plant, dry pod yield (kg) per plot and dry pod yield (kg) per hectare revealed that, the genotype RHRG-1308 showed better performance.
24. The characters like dry haulm yield (kg) per plot and dry haulm yield (kg) per hectare revealed that, the genotype RHRG-1192 showed maximum haulm yield than other genotypes.
25. The genotype RHRG-1192 and RHEG-1308 showed highest kernel yield (kg) per hectare than other genotypes. However, lowest kernel yield recorded by genotype RHRG-19-2.
26. The highest shelling percentage recorded by genotype RHRG-1192, while lowest shelling percentage was recoreded by genotype RHRG-1308.
27. The highest harvest index recorded by genotype RHRG-1308 followed by RHRG-1192, while lowest harvest index recorded by genotype RHRG-19-6.
28. In case of chemical studies like protein and oil content the superior varieties are RHRG-19-2 and Phule Unnati respectively. While in case of chlorophyll-a, The genotype RHRG-1192 recoded highest. Genotype RHRG-1309 is superior in chlorophyll-b content over other genotypes and total chlorophyll content was

highest in RHRG-1192. Other better performing genotypes in respect of chlorophyll content are RHRG-19-5, Phule Unnati, RHRG-1308.

29. Traits like photosynthetic rate, Transpiration rate, number of mature pods, dry pod yield (g) per plant, dry pod yield (kg) per plot, dry pod yield (kg) per hectare and weight of 100 kernel showed positive correlation with dry pod yield.

Conclusions

1. The genotype RHRG-1308 recorded highest dry pod yield per plot and dry pod yield per hectare due to the highest values of number of pods per plant, 100 kernel weight, dry pod yield (g) per plant.
2. The genotype RHRG-1308 showed highest harvest index. It might be due to better translocation efficiency from source to sink.
3. The genotypes RHRG-19-6 and RHRG-19-2 with lowest harvest index indicated poor translocation of assimilates from source to sink. Therefore, this genotype could be utilized in breeding programme for the high biological yield point of view.
4. The physiological processes like photosynthesis rate, transpiration rate and stomatal conductance were found at highest rate in genotype RHRG-1308 which resulted in highest yielding and it is followed by genotype RHRG-1192.
5. The genotype RHRG-1192 recorded highest protein content whereas, highest oil content showed by genotype Phule Unnati. Genotype RHRG-1192, RHRG-1309 and RHRG-1192 recorded highest chlorophyll-a, chlorophyll-b and total chlorophyll content respectively which may be further useful for crop improvement.
6. From the result obtained in the present investigation, it was concluded that, the genotypes RHRG-1192, RHRG-1308 and RHRG-1309 showed better performances in all parameters and these may be utilised for yield heterosis in further breeding programme.
7. From the above results it was concluded in the present study that, the morphological characters *viz.*, plant height (cm), number of branches, number of leaves and leaf area (dm^2) are mainly responsible for growth in groundnut. Whereas, the physiological processes like photosynthesis, stomatal conductance, transpiration rate, stomatal frequency etc. were found at highest rate in some genotypes which showed positive correlation with dry pod yield per plant.

8. Total number of pods, mature pods per plant, dry pod yield (g) per plant, dry pod yield (kg) per plot, 100 kernel weight and harvest index are main yield contributing characters in groundnut and showed positive effect on dry pod yield per plant. Suggesting that the direct selection of genotypes based on these characters, these traits could be considered for further breeding programme to achieve high dry pod yield per plant and helps in selecting high yielding genotypes in groundnut.

6. LITERATURE CITED

Adsule, R.N., Kadam, S.S. and Salunke, D.K. 1989. Peanut in handbook of world food legumes. (Ed. Salunke, D. K. and Kadam S. S.). CRC Press, FL, USA. pp: 193-215.

Anonymous, 2017. Annual groundnut workshop, Dharwad 2016.

Arjunan, A., Manoharan, V. and Senthil, N. 1999. Path analysis of characters. Contributing to drought resistance in groundnut. *Madras Agric. J.* **86**(1-3) : 36-39.

Aronon, D.I. 1949. Copper enzymes in isolated chloroplast. Polyphenol oxidase in Beta vulgaries. *Pl. Physiol.* **24** : 1-15.

Asibuo, James Yaw, Akromah, Richard, Safo- Kantanka, Osel, Adu- Dapaah, Hans Kofi, Ohemeng-Dapaah, Seth and Agyeman, Adelaide. 2008. Chemical composition of groundnut, *Arachis hypogaea* L. landraces, *African Journal of Biotechnology.* **7**(13): 2203-2208.

Azad, M.A.K. and Hamid, M.A. 2000. Genetic variability, character association and path analysis in groundnut. *Thai J. Agric. Sci.* **33** : 153-157.

Bagnall, D.J. and King, R.W. 1991. Response of peanut (*Arachis hypogaea* L.) to temperature, photoperiod and irradiance (i) Effect of flowering. *Field Crop Res.* **26**(3-4) : 263-293.

Bhargavi, G., Rao, S.V., Babu, D.R and Rao, N.K.L. 2015. Character association and path coefficient analysis of pod yield and yield components in Spanish bunch groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding.* **6**(3) : 764-770.

Bhattacharya, A. and Singh, D.N. 1999. Physiological studies in chickpea genotypes photosynthesis and allied parameters under normal and late sowing. *Indian J. Pulses Res.* **12**(2) : 211-220.

BINA (Bangladesh Institute of Nuclear Agriculture) 2002. Evaluation of M_5 generation of 30 groundnut mutants. Annual report of 2001-2002. Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh.p. 36-37.

Borkar, V.H. and Dharanguttikar, V.M. 2014. Evaluation of groundnut (*Arachis hypogaea* L.) genotypes for physiological traits. *International J. of Scientific and Research Pub.* **4**(1) : 1-8.

Choudhary, M., Sharma, S.P., Dashora, A. and Maloo, S.R. 2016. Assessment of genetic variability, correlation and path analysis for yield and its components in groundnut (*Arachis hypogaea* L.). *Environment and Ecology.* **34**(2A) : 792-796.

Deshmukh, D.D. and Dev, D.V. 1993. Association of physiological traits with productivity and regression analysis in groundnut (*Arachis hypogaea* L.). *Ann. Pl. Physiol.* **7**(1): 123-125.

Deshmukh, S.N. and Shrikhandar, N.S. 1998. Performance of groundnut variety TG-261 Vidarbha. *P.K.V. Res. J.* **22**(22) : 200-233.

Deshpande, R.S. and Jadhav, B.B. 1993. Effect of defoliation on growth and yield of peanut. *Ann. Pl. Physiol.* **7**(2) : 230-233.

Dharanguttikar, V.M. and Borkar, R.V. 2014. Physiological analysis of Groundnut *(Arachis hypogaea* L.) Genotypes. *International J. Scientific and Research Pub.* **4**(1) : 1-9.

Dhopte, D.R., Ramteke, S.D. and Thote, S.G. 1991. Water use and drought tolerance efficiency of peanut genotypes in relation to canopy growth under field conditions. *Ann. Pl. Physiol.* **5**(2): 202-212.

Dutta, R.K. 2001. Assessment of the advanced mutant lines/varieties of BINA with emphasis on physiological criteria. Report on ARMP Project # 112, BARC,Farmgate, Dhaka 1215. p. 52-53.

Dwivedi, R.S., Saha, N.M. and Joshi, Y. C. 1986. A comparative study of solar energy conserving efficiency of groundnut (*Arachis hypogaea* L.), Wheat (*Triticum astivum* L.) and Cynodon dactylon press oleaginaeux. **40** : 79-93.

Dwivedi, S.L., Nigam, S.N., Rao, R.C.N., Singh, U. and Rao, K.V.S. 1996. Effect of drought on oil, fatty acids and protein contents of groundnut (*Arachis hypogaea* L.) seeds. *Field Crop Res.* **48**(2-3) : 125-133.

Ghosh, B.K. and Sengupta, U.K. 1986. Effect of source manipulation on photosynthetic activity in groundnut (*Arachis hypogaea* L.). *Indian J. Plant Physiol.* **4** : 351-356.

Ghosh, P.K., Mathur, R.K., Ravindra, V. and Gor, H.K. 1997. Dry matter accumulation, nitrogen uptake and their partitioning pattern in Virginia groundnut (*Arachis hypogaea* L.). *Indian J. Pl. Pysiol.* **2**(3) : 234-236.

Hamid, M.A., Agata, W. and Kawamitsu, Y. 1990. Photosynthesis, transpiration and water use efficiency in four cultivars of mungbean. *Photosynthetica.* **24** : 96 -101.

Hampannavar, M.R., Khan, H., Temburne, B.V., Janila, P. and Amaregouda, A. 2018. Genetic variability, and correlation and path analysis studies for yield and yield attributes in groundnut (*Arachis hypogaea* L.). *Journal of Pharmacognosy and Phytochemistry.* **7**(1): 870-874.

Hariprasanna, K., Chunilal, S.T. and Radhakrishnan, T. 2008. Relationship between flowering duration and physical quantity as well as pod yield in groundnut (*Arachis hypogaea* L.). *Indian J. Agric. Sci.* **78**(2) : 180-182.

Idinoba, M.E., Idinoba, P.A., Gbadegesin, A. and Jagtap, S.S. 2008. Growth and evaporation of groundnut (*Arachis hypogaea* L.) in transitional humid zone. *African J. Agri. Res.* **3**(5) : 384-388.

IOPEPC, (2019). Kharif Survey Of Groundnut.

Jagtap, D.T., Jadhav, D.J., Kanase, R.V. and Nalawade, R.G. 2009. Physological basis of yield variation in groundnut genotyped in *kharif* season. *International Journal of Agricultural Sciences.* **5**(1) : 120-122.

Jagtap, P.B., Mate, S.N., Deshmukh, D.V. and Amolic, V.L. 2014. Physiological analysis of growth and yield variation in summer groundnut (*Arachis hypogaea* L.). *J. Agric. Res. Technol.,* **39**(2) : 183-189.

Jahangir Ahmed, M. Saleem Lodhi, Abdul Razaq Reki, Muhmmad Saeed and Farooq. A. Marri. 2016. Performance evolution of different groundnut genotypes under climatic condition of Quetta Life Sci. *Int. J.*, **10** (1) : 21-24.

Jayalakshmi, V., Reddy, P.V., Ashalatha, M. and Vasanthi, R.P. 2001. Evaluation of progenies of groundnut for physiological traits for which confer water use efficiency. *Agric. Sci. Digest.* **21**(3) : 170-172.

John, K., Vasanthi, R.P., Venkateswarlu, D., Muralikrushna, T. and Harinath, N.P. 2008. Genetic analysis and regression studies for yield and yield attributes in 2 segregating population crosses. Legume Research. **31**(1) : 26-30.

Kalpana, M., Chetti, M.B. and Ratnam, B.P. 2003. Phenological changes in photosynthetic rate, transpiration rate and stomatal conductance and their relationship with seed yield in cowpea (*Vigna unguiculata* L.). *Indian J. Plant Physio.* **8**(2) : 160-164.

Kamshette, R.R., Bhagde, M.S. and Pawal, S.N. 2015. Evaluation of summer groundnut genotypes for dry matter production and its partitioning studies (*Arachis hypogaea* L.). *Trends in Biosciences*. **8**(2) : 321-327.

Karanjikar, P.N., Jadhav, G.S., Wakle, P.K. and Pawar, S.B. 2005. Effect of sowing dates and genotypes on dry matter partitioning in groundnut during post monsoon season. *J. Maharashtra Agric. Univ.* **30** : 83-84.

Kathirvelan, P. and Kalaiselvan, P. 2006. Growth Characters, Physiological Parameters, Yield Attributes and Yield as influenced by the Confectionary Groundnut Varieties and Plant Population. *Research Journal of Agriculture and Bilogical Sciences,* **2**(6): 287-291.

Khan, M.A.H. 1981. The effects of CO_2 enrichment on the pattern of growth and development in rice and mustard. Ph.D Dissrt., Royal Vet. Agril. Univ., Copenhagen. p. 104.

Kokkiripati Chaitanya, R., Rai Prashant Kumar, Markar Shailesh, Veraja Pragada and Vivekananda, T. 2015. Study on the performance of groundnut (*Arachis hypogaea* L.) genotypes for seed yield and quality traits. Annals *of West University of Timisoara, ser. Biology*. **2** : 139-144.

Kumar, S. and Kumar, A. 1999. Dry matter partitioning in different plant parts of Spanish and Virginia groundnut cultivars in mid-western plains of U.P.J. *Oilseed Res.* **16**(2) : 354-357.

Laxmi, V. 2003. Dry matter accumulation pattern and seed yield of different genotypes of lentil. *Farm Sci. J.* **12**(2) : 110-112.

Mane, V.A., Ladole, M.Y., Shinde, A.A. and Bhuyar, A.R. 2017. Physiological analysis of growth and yield variation in groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding*. **8**(4) : 1258-1264.

Mathur, R. 1995. Genetic variability and correlation studies in segregating generations of cowpea. *Madras Agric. J.*, **82** : 150-152.

Mensah, J.K. and Okpere, V.E. 2000. Screening of four groundnut cultivars from Nigeria for drought resistant. *Legume Res.,* **23**(1) : 37-41.

Mondal, M.M.A. 1997. A study of flowering pattern in groundnut. M.Sc. Thesis, Dept. Crop Bot., Bangladesh Agric.Univ., Mymensingh.

Monnir Hossain, K.M., Md. Nesar Uddin, Md. Masudul Karim, Md. Ashrafuzzaman, 2016. Morpho-physiological attributes and yield of four groundnut genotypes as influenced by different plant spacing. *International Journal of Natural and Social Sciences*, **3**(4) : 35-42.

Murthy, S.K.K., Padmalatha, Y. and Rao, A.Y. 2002. Impact of drought on dry matter production and yield of groundnut (*Arachis hypogaea* L.) during *kharif* season. *J. Agrometerology.* **4**(2) : 195-197.

Nagraj, G. 1995. Quality and Utility of Oilseeds, Directorate of Oilseeds Research (ICAR) Hydrabad.

Naik, K.S.S, Reddy, P.N. and Reddy, C.D.R. 2000. Variability studies in F_2 populations of some subspecies crosses in groundnut. National Seminar on Oilseed and Oil Research and Development Needs in the Millennium. pp. 2-4.

Nautiyal, P.C., Ravindra, V. and Joshi, Y.C. 2002. Dry matter partitioning and water use efficiency under water deficit during various growth stages in groundnut. *Indian J. Pl. Physiol.* **7**(2) : 135-139.

Panse, V.C. and Sukhatme, P.V. 1985. Statistical methods for Agriculture Workers. ICAR, New Delhi, 4th Edition.

Patel, D.P., Munda, G.C. and Islam, M. 2005. Dry matter partitioning and yield performances of HPS groundnut. *Crop Res.* (Hisar). **30** : 156-161.

Patil, N.A. and Patil, T.M. 1993. Physiological responses of groundnut genotypes to water stress. *Legume Res.* **16**(1) : 23-30.

Patil, S., Shivanna, S., Irappa, B.M. and Shweta, R.V. 2015. Genetic variability and character association studies for yield and yield attributing components in groundnut. (*Arachis hypogaea* L.). *International Journal of Recent Scientific Research.* **6**(6) : 4568-4570.

Rahman, M. T. 2001. Study on the flowering pattern, reproductive efficiency and yield of groundnut mutants. M.Sc. Thesis, Dept. Crop Bot., Bangladesh Agric. Univ., Mymensingh, Bangladesh.

Rahman, M.A. 2003. A study of some imopratant growth and yield attributes in four groundnut genotypes. M.Sc. Thesis, Dept. Crop Bot., Bangladesh Agric. Univ., Mymensingh.

Rajmane, V.S. 2001. Crop physiological studies in *kharif* groundnut (*Arachis hypogaea* L.) . M.Sc. (Agri.) thesis submitted to M.P.K.V., Rahuri (M. S.).

Ransingh, S.K. 2004. Studies on effect of morphological and biochemical parameters influencing yield of groundnut (*Arachis hypogaea* L.) varieties during *kharif* season. Ph.D. (Agri) thesis submitted to M.P.K.V., Rahuri (M. S.).

Rao, P.K. and Shukla, A.S. 2014. Evaluation of groundnut genotypes for yield and quality traits. *Annals of Plant and Soil Research.* **16**(1) : 41-44.

Rasheed, B., Rasheed, H. and Khan, A. 2015. Screening and selection of high yielding groundnut genotypes for commercial cultivation. *J. Agri. Sci. and Res.* (JASR), **2**(1) : 85-90.

Sadasivam, S. and Manickam, A. 1996. Biochemical methods. IInd Edn. New Age International Publishers. pp. 184-191.

Sahoo, N. C. and Mishra, R. K. 2003. Nutritional components and physiological properties of groundnut seeds as effected by growing season. *Indian Plant Physio.* (Special Issue). pp. 110-113.

Sardana, V., Kandhola, S.S. and Sheoran, P. 2008. Influence of sowing dates on the productivity of semi spreading and bunch type varieties of groundnut (*Arachis hypogaea* L.) . *Indian J. Agri. Sci.* **78**(4) : 372-374.

Shinde, S.H., Kaushik, S.S., Bhilare, R.L. and Thokale, J.G. 2001. Effect of plastic mulch and fertilizers with foliar spray of nitrofoska on growth and yield of groundnut. *J. Oilssed Res.* **18**(2) : 281-282.

Sundari, A. 2003. Weather parameter influence the optimum time of sowing of soybean. *Crop Res.* **26**(3) : 405-408.

Tamilselvi, C.V., Radhakishnan and Vaidyanathan, R. 2015. Identification of physiological traits related to higher translocation efficiency in groundnut genotypes (*Arachis hypogaea* L.). *Int. J. of multidisciplinary Res. and Review.* **1**(1) : 12-15.

Uddin, M.K., Shamsuddin, A.K.M. and Ghosh, A.K. 1999. Performance of groundnut (*Arachis hypogaea L.)* genotypes and relationship between their yield and yield contributing characters. *Bangladesh J. Agril. Sci.* **26**(1) : 123-128.

Uguru, M.I. 1998. The Pattern of Dry Matter Distribution During Podding and its Effect on Pod Yield in Medium Maturing Peanut Cultivars. *Peanut Science.* **25** : 1-4.

Umesha, N.C. 2004. Effect of planting methods and mulching on growth and yield of groundnut under rainfed condition. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Vijaya Kumar, P. and Vanaja, M. 2004. Effect of weather parameters on photosynthesis in four castorbean genotypes. *Ind. J. Plant Physiol.* **9**(4): 442-446.

Watson, D.J. 1947. Comparative physiological studies on the growth of field crops. *Ann. Bot.* **11**(41) : 141-146.

Woodroof, J.G. 1983. Peanuts production, Processing products 3rd edition Avi Publishing Company Inc. Westport, Connecticut.

Zaman, M.A., Tuhina-Khatun, M., Ullah, M.Z., Moniruzzamn, M. and Alam, K. H. 2011. Genetic variability and path analysis of groundnut (*Arachis hypogaea* L.). *The Agriculturist*. **9**(1&2): 29-36.

Zhu, Xin-Guang, Long Stephen, P. and Ort Donald, R. 2010. Improving photosynthetic efficiency for greater yield. *Ann. Rev. Plant Biol.* **61** : 235-261.

7. VITAE

Miss. GHODKE SHUBHANGI RAJENDRA

A candidate for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL BOTANY (PLANT PHYSIOLOGY)

2021

Title of thesis		**:**	"Morpho-physiological characterization of summer groundnut (*Arachis hypogaea L.*)"
Department		**:**	Agricultural Botany
Major field		**:**	Plant Physiology
Biographical information		**:**	
Personal	**Date of Birth**	**:**	25th January, 1996.
	Place of Birth	**:**	Arvi, Beed.
	Father's Name	**:**	Mr. Rajendra Vikram Ghodke.
	Mother's Name	**:**	Mrs. Savita Rajendra Ghodke.
Educational	**Bachelor Degree Obtained**	**:**	Received B.Sc. (Agriculture) degree from College of Agriculture, Baramati.
	Class	**:**	I st class with distinction
	Name of the University	**:**	Mahatma Phule Krishi Vidyapeeth, Rahuri.
Address		**:**	At post- Tisgaon Taluka – Pathardi Dist.- Ahmednagar, Pin – 414106.
	Email - id	**:**	ghodkeshubhangi25@gmail.com
	Contact No.	**:**	+917558693953 / +919139082285