EVALUATION OF A COLLECTION OF *INDICA* RICE GENOTYPES UNDER ORGANIC MANAGEMENT ADOPTING FARMER PARTICIPATORY EVALUATION STRATEGY

by

MANJUNATHA, G. A

(2013 - 11 - 176)

THESIS

Submitted in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANT BREEDING AND GENETICS

COLLEGE OF AGRICULTURE

PADANNAKKAD, KASARAGOD – 671314

KERALA, INDIA

2015

DECLARATION

I, hereby declare that this thesis entitled **"EVALUATION OF A COLLECTION OF *INDICA* RICE GENOTYPES UNDER ORGANIC MANAGEMENT ADOPTING FARMER PARTICIPATORY EVALUATION STRATEGY"** is a bonfide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Padannakkad

Date: 01/08/2015

MANJUNATHA, G. A.

(2013-11-176)

CERTIFICATE

Certified that this thesis entitled **"EVALUATION OF A COLLECTION OF *INDICA* RICE GENOTYPES UNDER ORGANIC MANAGEMENT ADOPTING FARMER PARTICIPATORY EVALUATION STRATEGY"** is a record of research work done independently by Mr. Manjunatha, G.A., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Place:Padannakkad

Date: 01/08/2015

Dr. Vanaja, T.

Assistant Professor (Sr. Scale)

Department of Plant Breeding and Genetics

College of Agriculture, Padannakkad

CERTIFICATE

We, the undersigned members of the advisory committee of Mr. Manjunatha, G.A., a candidate for the degree of **Master of Science in Agriculture** with major in Plant Breeding and Genetics, agree that the thesis entitled **"EVALUATION OF A COLLECTION OF *INDICA* RICE GENOTYPES UNDER ORGANIC MANAGEMENT ADOPTING FARMER PARTICIPATORY EVALUATION STRATEGY"** may be submitted by Mr. Manjunatha, G.A. in partial fulfilment of the requirement for the degree.

Dr. Vanaja, T.
Assistant Professor (Sr. Scale)
Department of Plant Breeding and Genetics
College of Agriculture,
Padannakkad-671 314

Dr. Jayaprakash Naik, B.
Professor and Head
Department of Plant Breeding and Genetics
College of Agriculture,
Padannakkad-671 314

Dr. Anil Kumar, A.S.
Professor and Head
Department of Agronomy
College of Agriculture,
Padannakkad-671 314

Dr. Namboodiri Raji Vasudevan
Assistant Professor
Department of Plant Breeding and Genetics
College of Agriculture,
Padannakkad-671 314

1/8/2015
EXTERNAL EXAMINER

Acknowledgement

It's my immense pleasure to express my heartfelt gratitude and deep sense of reverence to ***Dr. Vanaja, T.*** *Assistant Professor (Sr. Scale),Department of Plant Breeding and Genetics and Major Advisor of advisory committee, for her valued guidance, scholarly counsel, sustained support, meticulous care and friendly approach during the entire course of study period.*

With ineffable gratitude, I thank ***Dr. Jayaprakash Naik, B.*** *Professor and Head, Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad and Member of Advisory Committee, for his technical guidance rendered at every stage of work, periodical review of the progress and meticulous personal care.*

I wish to express sincere thanks to ***Dr. Anil Kumar, A. S.*** *Professor and Head, Department of Agronomy , College of Agriculture, Padannakkad and Member of Advisory Committee, for their valuable suggestions andguidance throughout the research work and course of study.*

I wish to express my sincere gratitude to ***Dr. Namboodiri Raji Vasudevan*** *Assistant Professor, Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad and Member of Advisory Committee, for her valuable suggestions andguidance throughout the research work and course of study.*

I wish to express sincere thanks to ***Dr. Sudarshana Rao, G. V.*** *Associate Professor, Department of Plant Physiology, College of Agriculture, Padannakkad for their valuable suggestions andguidance throughout the research work and course of study.*

I thankfully acknowledge ***Dr. M. Govindan****, Associate Dean, College of Agriculture, Padannakkad and* ***Dr. Abdul Kareem****, ADR, RARS, Pilicode for their* *esteemed advice timely help, and valuable suggestions throughout this programme.*

I take this opportunity to express sincere thanks to teachers ***Dr. Meera Manjusha, Dr. P.R. Suresh, Dr. Sujatha, R.*** *who have always given encouragement and highly valuable support.*

I like to express my innermost and sincere thanks to ***Mr. Mukesh*** *(Research Assistant),* ***Dr. Unni, Ms. Aparna, Ms. Siji, Mr. Latheesh, Chandramathi chechi, Mr. Anoop, Ms. Sudhina Sudakaran*** *for their help in implementing my research work.*

I thankfully acknowledge ***Sri. Balakrishnan*** *(Farmer, Mayyil) and members of Arayidam Padasekharam Samithi for their help in implementing my research work.*

Words cannot describe my thanks to my beloved parents ***Sri. S. Amaranarayanaswamy, Rathnamma*** *and my uncle* ***R. M. Gopal,*** *aunty* ***Nagarathna*** *for the unfailing faith, support, and love provided throughout my life. Without their guidance and motivation, I would have never had the courage to overcome the adversities I have faced." I have been highly fortunate and lucky to express my heartfelt respect to my loving brother* ***Mr. Muralidhara, G. A.*** *and sister* ***Sumithra, G. A.*** *who have always been so proud of me. I wish to thank my relatives for their kind blessings.*

I have been highly fortunate and lucky to express my heartfelt thanks tomy friend ***Jayashree, M.*** *(DFRL, Mysore) who have always given encouragement and support with love and care.*

I would like convey my innermost respect to ***Mr. Umesh, Dr. Nagaraj, Dr. Ramkumar, Dr. Jayaramaiah, Dr. Manjunath, Dr. Bairappanavar*** *(Agricultural College Hassan), who have always given encouragement and support. Their personal involvement at times of need was highly valuable.*

Everything went well with the presence of my best friends, Chethana, S, Shruthi, C, Suchithra, Shruthi lakshmi, Madhuri, Pramod, and juniors, Arun Kumar Singh, Yusuf Abbas, Saravana kumar, Aloka, Sowmya, Harikrishna and seniors, Sivakumar (Phd, GKVK), Jeevan, Suresh, Manu, Gowrish, Ramesh, Sainath, Ramana, Jayanth. I thank for their everlasting support during my study period. I feel happy to thank all my lovely batchmates, Shahid, Shruthi, Amida, Farsana, Neethu.

I sincerely acknowledge the Kerala Agricultural University for financial support in the form of KAU Junior Research Fellowship during my studies.

Thanks to the God, the Almighty, for his showers of blessings throughout my research work to complete the research successfully.

Manjunatha, G. A.

CONTENTS

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES CONTINUED

LIST OF PLATES

INTRODUCTION

1. INTRODUCTION

Rice is the staple food for millions of people in Asia with 90% of the world's rice being grown and consumed in this continent. Among the rice growing countries, India stands first in area (44.8 m ha) and second in production (91.0 MT) next to China. With the release of short/mid duration high yielding varieties of rice in the early seventies, the production of rice has increased from 20.6 MT in 1996 to 89.5 MT in 2000 (FAI, 2000). Most of the growth in rice production during this period is attributed to release of high yielding varieties. Use of higher doses of fertilizers and insufficient use of organics have created deficiencies of secondary and micronutrients. The soils are showing signs of fatigue, as judged by decline in the yields of rice as well as a lower response to applied chemical fertilizers (Yadav *et al.*, 1998). Farmers have to use more and more fertilizers year after year to obtain the same yield level as of previous years. Excessive use of chemical fertilizers and pesticides also pollutes our air and water (Singh *et al.*, 1995). The concerns for sustainable soil productivity and ecological stability in relation to the use of chemical fertilizers have become an important issue. To overcome these problems, organic farming presents a valid alternative approach (Stockdale *et al.*, 2001).

Organic farming is gaining much importance in the world with more than 100 countries already practicing it with global area under organic production accounting more than 31 million hectare (Yadav, 2007) with this, Asian region constitute 4.1 million hectare which includes China, India and Russia. In India organic production is practiced in 2775 hectare with annual organic rice production of is 3500 tonnes (Deshpande *et al.*, 2010).Rice has immense potential under organic farming as it is a staple food for about 60% of population in India.

The trade in world organic market has now touched 26 billion US$ and is expected to increase to 102 billion US$ by 2020 (Bueren *et al.*, 2011). According to APEDA (2011), about 9,76,646 MT of different organic products worth 498 crore rupees are being exported from India. But it is estimated that more than 95%

of organic production is based on crop varieties that were bred for the conventional high-input sector. Recent studies have shown that such varieties lack important traits required under organic and low-input production conditions. This is primarily due to selection in conventional breeding programmes being carried out in the background of high inorganic fertilizer and crop protection inputs (Bueren *et al.*, 2011).

One of the constraints identified for promoting organic rice cultivation in India is lack of sufficient FYM and also efficient production and protection technologies that can be easily adopted by the farmers for cultivating rice organically. Further, varieties with inherent potential to perform well even under low input management and best suited to organic farming systems have to be identified to evolve profitable and productive organic farming package (Jagadeeshwar *et al.*, 2012).

The greatest advantage of breeding within organic systems is that it enables for selection of ideotype traits like weed tolerance, nutrient use efficiency, robust plant architecture, quality of produce and field resistance against pests and diseases as well as interactions among these traits. As per the draft standards for Organic Plant Breeding (OPB) by International Federation of Organic Agriculture Movements(IFOAM), in the short middle and long run, organic market segment can utilize the best available in the pool of existing conventional varieties to be for organic cultivation. However in the long term, breeders can influence further improvement of such varieties by integrating organic traits in varieties (Bueren, 2002, 2003).

The present era is aiming at evergreen revolution focusing on organic farming for health as well as environment protection. Organic farmers need crop varieties that are adapted to the challenges of organic systems, such as varieties that can better access to organic sources, competition with weeds and resistance to pests (Bueren & Osman, 2002). Currently, plant varieties that have been bred specifically for organic systems are meager. To increase organic farmers' success, we must increase the number of varieties bred for organic systems adopting the concepts and strategies of organic plant breeding (Halewood *et al*., 2007). This can be best achieved by Participatory Plant Breeding (PPB) which is a highly effective breeding method well suited to organic systems (Wolfe *et al*., 2008). PPB can be broadly defined as breeding "based on a set of methods that involve close farmer-researcher collaboration to bring about plant genetic improvement within a crop" (Morris and Bellon, 2004). PPB involves a close collaboration between farmers (end users) and researchers, with much of the breeding work often done in the farmers' fields. It enables farmers to select and adopt crop varieties to specific environmental conditions and organic cultural practices of their regions.

Farmer-researcher collaboration strengthens both parties to create useful varieties in an efficient and economic manner. The best farmer partners are experts in their crops and cropping systems, and are often better than researchers in identifying the requirements for a new variety. For this location farmers can also identify the ideal time to evaluate the traits. Further, in organic farming, many of the advances in production are due to farmers rapid adoption of new techniques. So farmer partners are often best equipped to identify the most up-to-date production systems to test in. Formally trained breeders can improve the efficiency and quality of the program.

A decentralized, on-farm approach of PPB leads to development of varieties that are better adapted to environments and systems of organic farms. When breeders select plants in the controlled high-input conditions of a research farm, they are assuming that the best varieties on their ground will translate as the best varieties in farmers' fields. But many organic farmers' fields are managed differently than research ground. This leads to research farm varieties being not as good for organic farms as they could be. Murphy *et al*., (2007) found that the highest yielding soft white wheat varieties on organic farms were different than the highest yielding varieties on conventional farms. PPB can successfully strengthen all participants with clear planning and communication.

From the experiences of past PPB project participants, it is known that there are practices that can lead to more successful partnerships. It is vital to the success of participatory plant breeding projects that regular and clear communication exists between all parties, from project inception to completion. PPB empowers farmers who were usually neglected in selection of developed varieties at the early stages of development.

Organic farming is at its development stage and more and more farmers are in the process of conversion from conventional farming to organic farming. Kasaragod district of Kerala was already declared as organic district and Kerala state is in the procedure of declaring as organic state by 2016. However, varieties developed for organic farming are meager and organic varietal traits in the rice have not yet been identified. The present study intends to address some of these problems.

Objectives:

1. To identify best rice genotypes among conventional rice genotypes suitable for organic farming/cultivation.
2. To identify organic rice varietal traits suited to organic farming.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The present study, "Evaluation of a collection of *indica* rice genotypes under organic management adopting farmer participatory evaluation strategy" was undertaken with the main objective of identification of rice genotypes and the key varietal traits suited for organic farming. Beside, study covered various aspects like organic plant breeding and organic varietal traits, correlation studies among yield and growth parameters, organic varietal traits, physico-chemical and cooking quality parameters. A comprehensive review of these aspects is presented in this chapter. Since literature related to these aspects in rice crop is meagre, results of similar studies undertaken in other crops, especially other cereals have also been included.

2.1. Organic plant breeding and Organic varietal traits

Selection of cereal varieties suited to organic farming requires a different, but complementary approach when developing cereals for conventional high input systems. Selection is based on the interaction between a series of desirable plant and crop characteristics, in particular competitive ability against weeds. Certain key characteristics that are generally desirable for organic cereal varieties include: good establishment ability, high tillering ability, increasing plant height, planophile leaf habit, high leaf area index and robustness in yield performance across sites (Hoad *et al.*, 2006). Root traits *viz.*, root volume, root thickness, root length and dry root weight are the major contributors of grain yield by way of their positive and high indirect effects (Karpagam *et al.*, 2014).

Some of the earliest reports in wheat indicated that organic amendments can improve root growth. This may be associated with the improvement of biological activity in crop rhizosphere by amino acid and some physiological active substances in the organic fertilizers (Zhou and Luo, 1997; Prasert, 1997). In addition, plant root growth is greatly affected by soil environment. The incorporation of organic manure into soil can bring beneficial effects on crop root growth by improving physical and chemical environments of rhizosphere soil (Sidiras *et al.*, 2001). Rakesh *et al.* (2001) and Mandal *et al.* (2003) reported that the integrated use of mineral fertilizers and farmyard or green manures can markedly improve crop root length, root volume and root dry weight, as well as the depth of root penetration.

In organic and low-input systems, root system should be able to explore deeper soil layers and be more active than in conventional system. So organic farmers need varieties with a deep root system that is able to exploit unpredictable and stressful soil environments (Brouwer, 1983; Anonymous, 1985). Similarly the number of crown roots is a function of the number of tillers per plant. Consequently, breeders should look for high tillering ability as a selection parameter (Kopke, 2005).

The desirable organic varietal traits suitable for organic farming include adaptation to organic soil fertility management, under low and organic inputs, a better root system and ability to interact with beneficial soil micro-organisms, ability to suppress weeds, ultimately contributing to soil fertility, crop and seed health, good product quality, high stable yield (Bueren *et al.*, 2002) . Similarly more attention needs to be paid to the development of a better root geometry (deeper and finer rooting system), for efficient water and nutrient uptake and the ability to maintain steady plant growth without stress under fluctuating water and nutrient availability (Bueren, 2003).

Yang *et al.* (2004) conducted experiment to determine the effects of different nutrient and water regimes on root growth in paddy revealed that incorporation of organic sources into paddy soil could improve root morphological characteristics and root activity of rice plants by increasing root density, active adsorption area, root oxidation ability and root surface phosphatase activity.

Hoad *et al.* (2006) conducted experiment in organic farm of Haddington to study organic varietal traits in spring wheat and oat, such as (1) early growth habit, including plant number, tillering ability and % ground cover, (2) Canopy expansion and spring/summer growth including mean leaf angle/orientation. This study revealed new varieties for organic agriculture need not only more robust in their establishment under contrasting conditions but also have their ability to produce as high as possible number of shoots per plant: either through additional tiller production or tiller retention.

Siavoshi *et al.* (2013) studied the role of organic fertilizers on morphological and yield parameters in rice, and found that the organic fertilizers had significant effect on the plant height, number of tillers per plant, flag leaf length and dry matter in rice.

A study on nutrient absorption by crop plant and its relation to chlorophyll content (Roy and Singh, 2006) clearly indicated that chlorophyll coloration is related to the amount of nutrients absorbed by the plant from the soil and higher leaf chlorophyll content in organically grown crops than in conventionally grown crops.

The experiment conducted by Kumar and Nilanjaya, (2014) to determine the nature of relationship between grain yield and yield components, in paddy under aerobic condition, revealed that relative water content, chlorophyll content, root length, root volume had significant and positive association with grain yield per plant. However path analysis revealed that chlorophyll content and root volume were the major contributor of grain yield per plant.

Tann *et al.* (2012) conducted an experiment using Sen Pidao rice variety to study the effect of good agricultural practices (GAP) and organic methods on rice cultivation under the system of rice intensification. The results showed that the organic method gave better rice straw weight than non-treated control, GAP and chemicals at 115 days of harvesting. The organic method could increase plant height and tiller number per plant, respectively at 60 days and also the organic method was significantly decreased rice blast disease of 80 %, followed by GAP and chemical methods which were 50 and 40 %respectively.

Sangeetha *et al.* (2013) studied the influence of organic manures and recommended NPK fertilizers on yield and quality of rice and blackgram in rice-blackgram cropping sequence and found that productive tillers and straw yield of rice were significantly higher compared to the conventional method.

Nasser and Ghumaiz (2010) conducted a study in wheat to evaluate selected eight bread wheat genotypes under organic and conventional farming systems. Parameters on plant height (cm), grain yield, straw yield (tons ha^{-1}), grain filling rate (GFR), days to heading (DTH) and days to maturity (DTM) were observed and the results showed that there were significant differences in straw yield between the two systems and among genotypes, and there were no differences in grain yield between conventional and organic systems and among genotypes.

2.2. Yield and growth parameters

Knowledge of correlation between yield and its contributing characteristics are basic and foremost endeavor to find out guidelines for plant selection. Partitioning of correlation into direct and indirect effect by path coefficient analysis helps in making the selection more effective (Priya and Joel, 2009). Complete knowledge on interrelationship of plant characteristics is of paramount importance to the rice breeder for making improvement in complex quantitative characters like grain yield for which direct selection is not much effective (Karpagam *et al.*, 2014). Such inter correlation may affect the selection for component traits either in favorable or unfavorable direction. This may facilitate breeders to decide upon the intensity and direction of selection pressure to be given on related traits for their simultaneous improvement (Kumar and Nilanjaya, 2014).

Nayak *et al.* (2001) studied the association among yield and its component characteristics along with the nature and extent of direct and indirect effects of yield components on yield through correlation and path analysis in scented rice. They found that grain yield/plant showed significant positive correlation with plant height, panicle number per plant, panicle length, total number of spikelets panicle^{-1} and total number of grain panicle^{-1} at both genotypic and phenotypic levels.

Babu *et al.* (2002) studied correlation and path analysis in twenty one popular hybrids of rice (*Oryza sativa* L.) showed positive association of grain yield per plant with number of productive tillers per plant. Path coefficient analysis revealed that panicle length and number of productive tillers per plant exhibited positive direct effect on yield. Among these characters, number of productive tillers per plant possessed both positive association and high direct effects. Hence, selection for this character could bring improvement in yield and yield components.

Lakshmi *et al.* (2014) conducted an experiment using 70 genetically diverse genotypes of rice to study the nature and extent of correlation among yield and yield attributing characters. Results revealed grain yield per plant was positively and significantly associated with days to maturity, number of productive tillers per plant, plant height and kernel length indicating importance of these traits as selection criteria in yield improvement programmes.

Twenty genotypes of rice (*Oryza sativa* L.) were evaluated for genetic variability and correlation in Pakistan by Naseem *et al.* (2014). The results showed that flag leaf area, number of productive tillers per plant, number of spikelets per panicle, number of grains per panicle and 1000 grain weight had a high positive significant genotypic correlation with grain yield per plant and also concluded that characters like number of productive tillers per plant, number of spikelets per panicle could be used as direct selection criteria for higher grain yield.

Akhtar *et al.* (2011) conducted a study to find the interrelationship between different yield contributing factors for developing new varieties with better combinations of these traits using ten rice genotypes for different parameters. The results revealed that paddy yield had strong genetic correlation with number of grains panicle^{-1}, days to maturity and 1000-grain weight. They concluded that number of grains panicle^{-1} , 1000-grain weight and days to maturity are important plant traits which should be considered when any breeding program for higher yield in rice is to be planned.

The experiment conducted by Ramakrishnan *et al.*(2006) comprising ten rice hybrids and their fourteen parents revealed that pollen fertility, grains per panicle and spikelet fertility exhibited positive and significant correlation with yield; similar results were reported by Thirumeni and Subramanian, (1999) while working with saline rice. Days to flowering had positive correlation with plant height, flag leaf area, kernel length, L/B ratio and grain weight. Similar findings were reported by Kennedy and Rangasamy (1998) while working with rice hybrids under low temperature condition. Panicle per plant expresses significantly negative correlation with kernel L/B ratio and positively correlated with panicle length, kernel length and grain weight, which is in accordance with the report of Ganesan, (1995).

A study was conducted in order to estimate genetic variability and relationships among some agronomic traits of rice by Abarshahr *et al.* (2011) using 30 varieties of rice under two irrigation regimes. The results showed that number of spikelet per panicle and flag leaf length had positive direct effects and days to complete maturity and plant height had negative direct effects on paddy yield, while flag leaf width and number of filled grains per panicle had positive direct effects, and days to 50% flowering had negative direct effect on paddy yield. Similarly in earlier reports panicle number per plant (Paul and Nanda, 1994; Yadav and Bhushan, 2001) and also number of spikelet per panicle (Yolanda and Das, 1995; Zheng *et al.,* 2003) have been considered as effective traits with the highest direct effect on grain yield.

Field experiment was conducted to evaluate the growth performance and grain quality of six aromatic rice varieties by Ashrafuzzaman *et al.* 2009. Where they found that grain yield had positive significant correlation with panicle length and number of panicles per hill. On the other hand, it had negative correlation with flag leaf area and flag leaf angle.

Karpagam *et al.* (2014) studied the nature and extent of association among various traits and grain yield under drought stress condition. They found grain yield per plant had positive association with number of productive tillers per plant (Surek and Beser, 2003), root length (Sheeba, 2005; Yogameenakshi and Vivekanandan, 2010; Devi *et al.,* 2013) and root volume. Panicle length was positively correlated with 1000 grain weight, biomass yield, root length and root volume (Muthuramu *et al.,* 2010). Among root traits, dry root weight recorded high positive significant association with root: shoot ratio, root length, root thickness and root volume (Sinha *et al.*, 2000; Yogameenakshi *et al.*, 2004; Muthuramu *et al.*, 2010).

A study of interrelationship and cause-effect analysis of grain yield and its component traits was carried out using thirty aerobic rice genotypes by Kumar *et al.* (2009). The results indicated that relative water content, chlorophyll content, root length, panicles per plant, 1000 grain weight, grains per panicle, spikelet fertility and root volume had significant and positive association with grain yield per plant. Path analysis revealed that chlorophyll content, tillers per plant, panicles per plant, root volume, grains per panicle and 1000 grain weight were the major contributors of grain yield per plant.

A study of correlation and path analysis was undertaken in 23 genotypes of Basmati rice for grain yield, its component traits and grain quality traits by Allam *et al.* 2015. They found that yield per plant had highly significant positive genotypic and phenotypic correlation with days to maturity, effective panicles (Kole *et al.*, 2008), spikelets per panicle (Reddy *et al.*, 2013) and amylose content. Kernel L/B ratio showed positive and significant correlation with KLAC (Kernel length after cooking) and showed negative and significant correlation with elongation ratio. It was also seen that days to maturity, effective panicles, spikelets per panicle, spikelet fertility, test weight, kernel length, kernel L/B ratio, Kernel length after cooking, elongation ratio are important traits which should be used as selection criteria to develop high yielding and better quality varieties in Basmati rice group.

Ezeaku and Mohammed, (2006) studied character association and path analysis in30 varieties of sorghum for grain yield. Hill count, bloom, plant height, panicle length, panicle count, 1000 seed mass, head weight and grain yield showed significant high positive correlation between grain yield and head weight, grain yield and 1000 grain weight and 1000 grain weight and head weight. Similarly, significant but negative correlation was observed between number of panicles and panicle length.

A field experiment was conducted by Chandra *et al.* (2009) to know the inter-relation among different yield contributing characters and their association with grain yield in forty nine genotypes of rice. The results showed that character association was significantly positive for grain yield per plant with number of productive tillers per plant, 1000-grain weight, panicle length and number of grains per panicle. Similar results also reported by Nayak *et al.* (2001), Madhavilatha (2002) and Sankar *et al.* (2006).

The experiment conducted by Sarker *et al.* (2013) to study the genetic variability among different fifteen rice genotypes, interrelationship between yield and yield contributing characters and their direct and indirect effect on yield and to find out suitable parents for further hybridization program to obtain high yield potential, the results showed that grain yield per plant has significant and positive correlation with secondary branches/plant, effective tillers/plant, total tillers/plant and panicle weight(Karad and Pol, 2008).

An investigation was carried out in 32 rice genotypes to understand the association among fourteen contributing traits for yield and quality and their direct and indirect influence on the grain yield under organic fertilizer management by Dhurai *et al.* (2014). The results found that grain yield was significantly associated with harvest index (Shashidhar *et al.*, 2005; Tandekar *et* *al.*, 2008), number of grains per panicle (Chandra *et al.*, 2009; Akhtar *et al.*, 2011), and days to maturity (Naik *et al.*, 2005). Path coefficient analysis revealed that kernel elongation ratio, kernel length, kernel L/B ratio, kernel breadth, days to maturity, harvest index, panicle length and plant height had positive direct effect on grain yield.

The study conducted in Andra Pradesh by Nagaraju *et al.* (2013) to establish the nature of relation between grain yield and yield components by partitioning the correlation coefficients between grain yield and its components into direct and indirect effects by using simple correlation and path analysis using six diverse parental lines indicated that number of grains per panicle (Ullah *et al.*, 2011), total number of productive tillers per plant (Selvaraj *et al.*, 2011), harvest index, kernel L/B ratio, milling percentage and panicle length showed highly significant positive association with grain yield per plant.

Devi *et al.* (2013) in a study to find out association among yield and quality components, their direct and indirect influence on grain yield in 32 genotypes of rice under organic fertilizer management revealed that grain yield per plant was significantly and positively correlated with its component characters like days to 50% flowering, days to maturity, number of effective tillers per plant, panicle length, number of grains per panicle and harvest index.

The experiment conducted at the Sudan University of Science and Technology by Idris *et al.* (2012) to study genetic variability and correlation between yield, yield components in some rice genotypes showed positive phenotypic and genotypic correlation coefficient between grain yield and number of filled grains per panicle, harvest index, panicle length and number of grains per panicle.

Kumar and Nilanjayain 2014 conducted an experiment to determine the nature of relationship between grain yield and yield components, direct and indirect contribution of these parameters towards paddy yield and to identify better combination as selection criteria for developing high yielding rice genotypes under aerobic condition. The results found that relative water content, chlorophyll content, root length, panicle per plant, 1000 grain weight, grains per panicle, spikelet fertility and root volume showed significant and positive association with grain yield per plant. However path analysis revealed that chlorophyll content, tillers per plant, panicles per plant, root volume, grains per panicle and 1000 grain weight were the major contributor of grain yield per plant. Similar results reported by Pantuwan *et al.* (2002), Jonaliza *et al.* (2004), Manickavelu *et al.* (2006), Kato *et al.* (2008) and Zhao *et al.* (2006).

2.3. Physico-chemical and cooking quality parameters

Grain quality has always been an important consideration in rice variety selection and development. The physico-chemical characteristics of rice grains are important indicators of grain quality. The consumer mainly prefers good quality rice. The cooking quality is a complex character which is very much influenced by physico-chemical characteristics of rice grain (Tomar and Nanda, 1981; Hussain *et al.,*1987). The most important quality components, common to all users, include appearance, milling, and cooking, processing and nutritional quality. Further grain quality has become an important issue affecting domestic consumption and international trade of rice (Lodh, 2002).

Based on the survey of 11 major rice growing countries, Juliano and Duff, (1991) concluded that grain quality is second only to yield as the major breeding objective. In future grain quality will be even more important as once the very poor , many of whom depend largely on rice for their staple food become better off and begin to demand higher quality rice (Juliano and Villarreal , 1993). Grain quality in rice is very difficult to define with precision as preferences for quality vary from country to country. The cooking quality preferences vary in different countries (Azeez and Shafi, 1966).The concept of quality varies according to the preparations for which grains are to be used.

Batey and Curtin (2000) while working with effects on pasting viscosity of starch and flour from different operating conditions for the Rapid Visco-Analyzer, observed that rice eating and cooking quality is predicted by the amylose content which is the single main vital factor. Amylose operate as diluent as well at the same time as an inhibitor of swelling of rice starch granules. The amylose content method is more precise to point out the difference in cooking quality of different rice varieties.

A study conducted using sixty two fine rice varieties for different cooking and eating characteristics by Chordhuym and Ghosh, (1978) revealed that amylose content varied from 18.6 to 26% and Basmati varieties showed lower amylose content. Most varieties showed 3.1 to 7.0% alkali spreading value, and also reported positive correlation between water uptake and alkali spreading value.

El-Hissewy *et al.* (1992) conducted an experiment to study the cooking and eating quality characteristics of 10 Egyptian rice varieties and new strains and recorded grain length, grain width, grain shape, gelatinization temperature (GT), gelatinization consistency (GC), amylose content, sensory tests namely rice: water ratio, cooking time, kernel expansion, breakage percentage, whiteness, hardness, stickiness, odour and taste. The results found that the short grain varieties had lower amylose content than the long ones, and observed low differences for the other traits. The short grain varieties required less water and shorter cooking time. The results recorded significant correlation coefficients between the amylose content and rice: water ratio, cooking time, hardness and stickiness.

Vanaja and Babu (2006) studied genetic variability for 10 quality parameters in a set of 56 high yielding diverse rice genotypes. The genotypes showed significant difference among them for the parameters like alkali spreading value, L/B ratio, milling percentage, amylose content, volume expansion ratio and water uptake. The phenotypic and genotypic coefficients of variation revealed the existence of large variability in alkali-spreading value and moderate variability in L/B ratio of grain, milling percentage, amylose content, water uptake and volume expansion. All quality attributes exhibited high broad sense heritability, and high expected genetic gain. Moderate genotypic coefficient of variation was noticed for alkali spreading value, L/B ratio of grain, milling percentage, amylose content, volume expansion ratio and water uptake.

Binodh *et al.* (2007) studied fifty four rice genotypes for different quality parameters. The results revealed that kernel length showed highly significant positive association with L/B ratio, kernel length after cooking, gelatinization temperature and amylase content, L/B ratio had highly significant positive association with kernel length after cooking, breadth wise elongation ratio and gelatinization temperature. Kernel length after cooking showed significant and positive association with kernel length, L/B ratio and amylose content. The character breadth wise elongation ratio showed high positive association with L/B ratio, kernel breadth after cooking. Gelatinization temperature showed significant positive association with kernel length, L/B ratio, kernel breadth after cooking and breadth wise elongation ratio. Gel consistency showed significant positive association with kernel breadth. Amylose content had positive significant association with kernel length and kernel length after cooking. The study alsoindicated that the above parameters could be used as selection indices for the improvement in grain quality characters of rice. Chordhurym and Ghosh (1979) reported that water uptake is positively correlated to the alkali spreading value.

Ge *et al.* (2008) investigated the genetic relationship between amylose content (AC) and appearance quality traits of *indica* rice (*Oryza sativa* L.) using conditional analysis and unconditional analysis for twelve rice genotypes and reported that amylose content is positively correlated with kernel length, kernel width and thickness, but negatively correlated with the ratio of length to width of dehulled but unmilledrice.

Ahish *et al.* (2007) conducted experiment to study the different genetic parameters and their correlation in fifty five promising genotypes of rice. The genotypes were analyzed for fourteen qualty characteristics *viz.*, hulling %, milling %, head rice recovery, kernel length, kernel breadth, after cooking linear elongation ratio, volume expansion, gelatinization temperature, gel consistency and amylose content. The results showed a strong and positive correlation between all possible pairs of 14 quality characters and concluded that the characters such as kernel length, length / breadth ratio, kernel length after cooking, breadth wise elongation ratio, gelatinization temperature, amylose content and kernel breadth could be used as selection indices for the improvement in grain quality characters of rice.

Hossain *et al.* (2009) reported superior cooking performance for 14 hybrids over DRRH-1 for length of cooked rice, kernel elongation ratio and elongation index. Eleven hybrids showed superiority for water uptake and six hybrids for volume expansion. Among the 14 hybrids, two showed low amylose content (18.8%) and seven showed high amylose content (26–30%), while the remaining eight hybrids showed intermediate amylose content (20–25%). More number of hybrids showed intermediate gelatinization temperature (GT) and intermediate amylose content which is preferred by the consumers. High amylose grains had low GT, intermediate amylose grains had intermediate GT, while low and very low amylose types had high GT.

In the experiment to evaluate the grain quality of 40 kalanamak varieties/lines cultivated in Uttar Pradesh, Bajpai *et al.* (2012) reported wide aroma range for aroma. Three genotypes showed very low aroma, while low aroma was shown by 11 variety/lines, moderate aroma was reported for 12 genotypes and the remaining 14 variety/lines showed strong aroma. The gelatinization temperature in most of genotypes under study was low (33), remaining were grouped as intermediate (6) and also one with gelatinizing temperature Category. Based on Alkali Digestion Score which ranged from 2.0 to 7.0. Cooked kernel length ranging from 8.3 to 10.90 mm, while cooked kernel breadth ranged between 2.4 mm to 3.0 mm with elongation ratio ranged from 1.60 to 2.33.

Manonmani *et al.* (2010) studied 20 rice genotypes for different cooking quality parameters like hulling %, milling %, head rice recovery%, kernel length, kernel breadth, L/B ratio of kernel, kernel length after cooking, kernel breadth after cooking, linear elongation ratio, breadth wise expansion ratio, gelatinization temperature (Alkali spreading value), gel consistency, volume expansion ratio, amylose content and reported significant difference among them at 1 % probability level.

Umadevi *et al.* (2010) studied 110 rice genotypes to assess the genetic variability, heritability and correlation among the genotypes for sixteen grain quality characters and grain yield and reported that single plant yield had highly significant and positive association with L/B ratio, water uptake, breadth-wise expansion ratio, gel consistency and amylose content. These also concluded that the traits viz., single plant yield, volume expansion ratio, gel consistency, alkali spreading value and amylose content possessing high GCV, heritability and genetic advance which could be effectively used in selection.

Hegde *et al.* (2013) in a study involving two traditional red rice varieties evaluated for the nutritional and cooking qualities, observed significant difference with regard to 100 grain weight, grain length and breadth (mm), L/B ratio and bulk density (g/ml). Significant difference in cooking and pasting characteristics between the farming systems were also observed. They concluded that organically grown red rice has the potential to produce high quality products with relevant improvements in terms of nutrients and minerals with no pesticide residues.

2.3.1. Organic farming Vs conventional farming

Quyena and Sharma (2003) revealed that application of inorganic fertilizers at various rates did not affect head rice recovery (HRR), kernel length (KL), kernel breadth (KB) and KL/KB ratio of rice before and after cooking, whereas application of organic manures significantly increased HRR, KL and KL/KB ratio of rice after cooking.

McClung *et al.* (2009) reported the significance of organic production methods in improving the whiteness and texture of rice without any negative impacts on quality.

Surekha *et al.* (2013) in an experiment to study the influence of organic and conventional farming systems on productivity, grain quality, soil health and economic returns of super fine rice varieties found that there was an improvement in head rice recovery (HRR) by 9.5% with organics over inorganics. Similarly, there was an improvement in elongation ratio by 4.1% with organics over inorganics, whereas moderate improvement in nutritional quality parameters such as protein, phosphorus and potassium contents was recorded with organics, compared to inorganics.

Usha *et al.* (2012) analyzed the various quality aspects in terms nutrient composition, physical characteristics, milling characteristics, physiological characteristics and cooking quality of organically grown traditional indigenous Indian rice variety Saleem samba, and found the nutrient content of Saleem samba was relatively higher than conventional rice varieties.

2.4. Participatory Plant Breeding (PPB)

Compared to conventional breeding, PPB seems to be the best alternative to fit the principle aims of organic agriculture for production and processing prescribed by IFOAM (Buren *et al.*, 2002).

The term PPB refers to a set of breeding methods usually distinguished by the objectives (functional or process approach), institutional context (farmer-led or formal-led), forms of interaction between farmers and breeders (consultative, collaborative or collegial), location of breeding (centralized or decentralized) and stage of farmers participation in the breeding scheme (participatory varietal selection or participatory plant breeding)(Desclaux, 2005).

PPB can be thus defined as a process with the involvement of several partners (farmers, traders, consumers, breeders, researchers) from the early stages of breeding programs, taking full advantage of the complementarity of skills and knowledge from each partner (Wolfe *et al.,* 2008). The main features of PPB, compared to conventional breeding, are: a) experimental trials are carried out on farms and are managed by farmers; b) farmers participate equally with breeders to the process of selection; c) the process may be repeated in an independent way in a large number of countries and areas, with different methods depending on the crop and the country (Ceccarelli and Grand, 2009). PPB has been applied until now in marginal and disadvantaged environments of developing countries. Organic agriculture in Europe often occurs in marginal environments (Bishawand Turner, 2007).

Participatory Crop Improvement (PCI) emerged in the past decade as an alternative plant breeding approach for developing countries in response to the recognition that conventional breeding of the formal sector institutions had brought little significant crop improvement to small-scale farmers in agro-ecologically and socio-economically marginal and variable environments (Lipton and Longhurst, 1989; Kerr and Kolavalli, 1999).

A farmer can weigh the various characters at least as good as or better than the breeder, since he knows best, the importance of each of the characters in relation to his or her farming system. This shows differences between farmers and breeders in ranking selected materials (Sperling *et al.*, 1993; Ceccarelli *et al.*, 2000). Finally, identification and selection of materials through farmers' collaboration presumably will increase adoption rates.

The advantage of PPB methods derives from the strong links that they generate between scientists and end users. By making selection criteria more relevant to end user needs, PPB can reach poor households that have not yet benefited from modern varieties (Kornegay *et al.*, 1996; Sperling *et al.*, 1993; Oosterom *et al.,* 1996).

Morris and Bellon (2004) reported that the main advantages of Participatory plant breeding (PPB) are that it provides means of assessing so-called 'subjective' traits. In food crops these include taste, aroma, appearance, texture, and other characteristics that determine the suitability of a particular variety for culinary use. These traits are difficult to measure quantitatively because they are a function of human perceptions, hence identification and evaluation of subjective traits requires close collaboration between plant breeders, social scientists, and farmers.

Participatory plant breeding (PPB) methods encourages the maintenance of more diverse, locally adapted plant populations (Berg, 1995; Ceccarelli *et al.*, 1997; Joshi & Witcombe, 1996). To the extent that diverse populations are taken up and grown by farmers, *in-situ* conservation of crop genetic resources is encouraged (Qualset *et al.*, 1997), and genetic diversity is enhanced (Witcombe *et al.*, 2001).

The growing interest towards organic and low input agriculture has highlighted the lack of cereal breeds suitable for these farming systems and their markets. To overcome this problem, new approaches to cereal breeding have been proposed known as Participatory Varietal Selection and Participatory Plant Breeding. Based on the adoption of cereal's landraces and old varieties, these methods involve farmers, researchers and food processors with a participatory method (Malandrin and Dvortsin, 2013).

Ceccarelli *et al.* (2000) conducted a study to compare farmers' and breeder's selections on station and on farmers fields using 208 barley genotypes within a range of environments, most of which are harsh and unfavorable for high yields. The results found that the effectiveness of selection done by farmers in their fields was significantly highest, followed by the selection done by the breeder in farmer fields. This gives a measure of the advantage of farmer participation over decentralized-non participatory selection. Another study found that by introducing farmer participation at the design stage, a three year reduction was achieved in the time taken from the initial crosses to release. In another example he found that, it was faster, less expensive and more reliable to involve farmers directly in the identification of promising accessions for use in the breeding program. Efficiency gains depend also on the extent to which farmer involvement enables the breeding program to minimize its investment in the development of varieties which, after release, turn out to be of little if any interest to farmers Ceccarelli *et al.* (2003).

The study conducted in maize by Witcombe *et al.* (2003) to predict how plant breeders and farmers worked together to produce improved varieties of maize for the low resource farmers of the Panchmahal district of Gujarat, India revealed that a variety GDRM-187 developed by Participatory Plant Breeding(PPB) was earlier to mature than any of those produced by conventional maize breeding and also concluded that returns from PPB compared to conventional breeding are higher because it is cheaper and benefits to farmers.

The study undertaken to breed alternatives to Birsa Gora 102 and Kalinga III rice varieties for the rainfed uplands of eastern India by Collaborative and consultative participatory plant breeding(Virk *et al.*, 2005). The two varieties Ashoka 200F from collaborative breeding and Ashoka 228 from consultative breeding were developed. Both varieties yielded significantly more than control varieties and the results says that the returns from PPB, compared to conventional breeding, were higher because it cost less, the genetic gains per year were higher, and the benefits to farmers were realised earlier.

The experiment conducted in potato (Walker, 2006) adopting Participatory Plant Breeding (PPB) in farmers field to evaluate advanced clonal material from a diverse late-blight resistant population in farmers' fields could select three hot spots for late blight in the Department of Huanuco in central Peru. All participating farmers selected seedling no. 380389.1. This selection was released nationally as Canchan-INIAA in 1990 (Gastelo *et al.* 1991), which is early in bearing, late blight resistant, high yielding, and red flesh in colour. The impact of PPB is that, by the time Canchan-INIAA was released, dozens of farmers were adopted and growing the variety and now Canchan-INIAA is planted on 70,000 hectares accounting for about one-fourth of potato area cultivated in Peru.

The case study from Mali was set-up by researchers and breeders aiming to create a breeding programme that could more effectively develop varieties that are attractive to farmers. It involved setting breeding objectives based on farmers' priorities and developing materials for decentralized PVS on community lands. This revealed that farmers' adoption of newly-bred varieties, particularly those from others than the local *guinea* landraces, was very low. When farmers did adopt new varieties, they were mostly purified *guinea* - race sorghum landraces selected from local materials. These offered little yield advantage but did mature slightly earlier. Most farmers produce their own seed and practice seed selection prior to harvest. Seed exchange between farmers and communities is limited and there is no seed marketing system in the project areas (Almekinder and Hardon, 2006). The Malian case bears many similarities to Ceccarelli's barley programme (Ceccarelli, 2001) which was also highly decentralised.

The Nepal case on maize also started with PVS of 32 advanced breeding lines supplied by CIMMYT and 3 composite varieties from the National Maize Research Programme (NMRP), with added controls of local varieties. The project revealed farmers tended to select tall plants that were prone to lodging, this because of post harvest selection of large cobs. Farmers also appeared unaware of the occurrence of spontaneous crossing between local and introduced varieties in their fields, resulting in heterogeneous populations. This led, after the first year, to mass selection in such populations and in their local varieties and farmers learning how to make controlled crosses. Hence the objectives of the project expanded from PVS to include onfarm selection, hybridization and PPB (Almekinder and Hardon, 2006).

In Netherlands Danial *et al.* (2007) conducted experiments for the production of improved cultivars in food crops through combining durable resistance to plant diseases with a good level of adaptation to the marginal conditions in the Andean highlands through participatory methodology under "Preduza" project. "Preduza" collaborated basically with two types of farmer groups; farmer researcher committees and organized groups, selected by the farmer's community in a particular location. The "Preduza" approach has been successful in increasing the effectiveness of breeding programmes in the Andean region. This is seen in an increased availability of promising entries with a high level of resistance to the most important fungal diseases, improved adaptation to local farming conditions and matching farmers' preferences. In Ecuador, two barley cultivars (Canicapa and Pacha) and one wheat cultivar (Zhalao) were released (Rivadeneira *et al.*, 2003) while in Bolivia the maize cultivar Sintetico 2 was released for the Tarija area (Claure, 2003). In addition, one quinoa cultivar in Bolivia was registered as Jach'agrano for the farmers in the altiplano (Bonifacio, 2003). At this moment, a range of other entries in the pipeline out-perform currently planted cultivars in terms of resistance, yield and farmer preference.

Participatory selection was conducted at the Wheat Research Centre, Bangladesh Agricultural Research Institute (BARI), Dinajpur by Pandit *et al.* (2007) to facilitate farmers in selecting and disseminating their preferable variety and replace widely cultivated disease susceptible Kanchan to increase wheat yield and production. Researches were conducted as mother and baby trials along with farmers, where the farmers emphasized on yield together with bold and white grains, more grains/spike, strong stem and other characters during scoring. However they identified BAW 966, BAW 1006, BAW 1008, and Shatabdi for good chapathi quality. They expected to cultivate BAW1008, Shatabdi, and BAW 1006 in the following years. The result of this study revealed that, farmer to farmer seed dissemination and varietal diversity was increased remarkably and seven varieties were grown in the study villages.

China started with women in two villages where improved maize varieties did not perform well. It very soon expanded to include four more villages in the South-Western part of China. Various actors subsequently became involved in the evaluation of maize materials, including 3 key national research organizations, extension agents and local farmers who organized themselves in groups. A total of 70 local and improved maize varieties of different origins have been incorporated in a large combination of trials, in which the materials were evaluated, improved through selection and base-populations developed. These efforts led to quite a number of varieties being identified as promising by the farmers, who subsequently multiplied them and distributed them to others. These chosen materials were again a combination of local and improved varieties, including old CIMMYT varieties derived from the Mexican landrace Tuxpeno. This case then represents a combination of PVS and PPB, although in maize it could be claimed that any type of selection of seed from any material for next season is a form of PPB (selection from within a genetically heterogeneous population). This case tends to blur the distinction we made earlier between PPB and PVS as well as the line between formal and informal actors, (e.g. breeders and farmers) (Almekinder and Hardon, 2006).

A study was conducted to develop non-lodging and high yielding rice cultures for saline Kaipad paddy tracts of Kerala, by Vanaja *et al.* (2009) using traditional cultivars namely Kuthiru and Orkayama as parents. The cultures namely JK-70, JO-583, JO-532-1, JO-345 and MK-22 were developed by adopting organic plant breeding and participatory plant breeding. The entire experiment including raising filial generations was conducted at the problem area of farmers rather than confining in research stations like in usual variety development programmes.

Shelton *et al.* (2010) conducted a PPB to develop high quality sweet corn varieties programme and to meet the specific needs of each participating farmer. Using a recurrent selection program, the populations are being grown on two organic farms as single row plots. The selection of rows within each population is made based on the farmer's evaluation of the traits of interest. After selection the results found that, varieties that have been selected under organic conditions will contain traits that benefit organic systems, such as cold soil germination, early vigor and pest resistance.

In Kenya, Kimani *et al.* (2011) conducted a study to identify farmer's upland rice preferences, production constraints, and gather other socio-economic information, and to indentify the best lines from the germplasm accessions together with farmers for use as parents in hybridization block. Fourteen varieties were selected by farmers including Nerical, Duorado, IR79913-B-176-B-4, CT16333(1)-CA-20-M, CT16333(1)-CA-22-M, CT16333(2)-CA-18-M, CT16313-CA-19-M, WAB964-B-3A 1.2, CT16317-CA-4-M, CT16307-CA-14-M, CT16337-CA- 12-M, CT16345-CA-3-M, WAB 905-B-4A 1.1 and WAB 450-B-136-HB - NERICA9. Out of the above varieties selected, farmers preferences were high yielding and good grain quality, hybrid rice and high nutrient use efficient varieties.

Participatory Plant Breeding (PPB) studies were conducted by Brockea *et al.* (2010) to identify and examine farmers' selection criteria for sorghum varieties in the Centre-West of Burkina Faso, and to compare these criteria with the breeder's agronomic observations and standard practices and also to show how the criteria of both farmers and breeders can be effectively integrated into the early stages of a pedigree breeding program. Participatory selection was initiated with 53 F3/F4 progenies in field trials managed by farmers using rating and voting exercises, where rating results between farmer groups were variable and disagreement between female and male ratings was especially found for the grain quality traits. The results clearly show that farmers can effectively select for traits on the basis of progeny and single plants while pursuing specific agronomic aims such as adaption.

The study was conducted in Kerala, India by Vanaja *et al.* (2013) to develop rice cultivar (Culture MK-157) suitable for organic farming and at the same time suitable for chemical agriculture as well with favourable cooking and nutritive qualities. The method adopted for varietal development was a combined strategy of pedigree breeding, organic plant breeding and farmer participatory breeding approaches.

In Philippines field studies were conducted by Rodel *et al.* (2014) to train selected organic growers on organic variety development and seed production, to develop organic varieties of selected vegetables through participatory breeding, and to produce seeds of the organic varieties developed selections in table tomato, cherry tomato, lettuce, pepper, cucumber, squash, and eggplant. Segregating lines and populations were given to cooperators for continuous evaluation and selection, breeding for desirable traits, and seed production. Crosses in pole sitao, cucumber, eggplant, and pepper have been evaluated for 2 generations and continuous evaluation and selection are being conducted for these lines. Selections on these crops differ based on the preferences of the consumer eg. small cherry, large cherry, fine curl etc. From this study farmers learned selection, distribution, how to keep records of their produce, sales and selections, as well as the seeds that they were able to produce, sell and distribute to other farmers.

MATERIAL AND METHODS

3. MATERIALS AND METHODS

The present study was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad, Kerala Agricultural University. Field trials were laid during Rabi season in the field of a progressive organic rice farming group (Arayidam padasekharam) in Mayyil Panchayath of Kannur district Kerala. The materials used for the study and the methods followed are presented in this chapter.

3.1. MATERIALS

3.1.1. Germplasm

The materials comprised of 65 genotypes of rice conserved in the Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad (Table 1), which include 15traditional genotypes of Kerala, a collection of 39 improved varieties developed for conventional rice farming, out of which 32 varieties are of Kerala Agricultural University and 11 rice varieties/ cultures developed by Kerala Agricultural University adopting strategies of Organic Plant Breeding (OPB).

Table 1. Rice genotypes used for the investigation

Sl. No.	Genotype	Parentage / Pedigree	Evolved at
Traditional rice genotypes of Kerala			
1	Ayirankana	Traditional cultivar	Kerala
2	Chembav	Traditional variety	Kerala
3	Gandakasala	Traditional cultivar	Kerala
4	Kalladiyaran	Traditional cultivar	Kerala

5	Kandoorkutty	Traditional cultivar	Kerala
6	Kuthiru	Traditional cultivar	Kerala
7	Kuttoos	Traditional cultivar	Kerala
8	Njavara	Traditional variety	Kerala
9	Orkayama	Traditional cultivar	Kerala
10	Red Mahsuri	Traditional variety	Kerala
11	Valankunhivithu	Traditional variety	Kerala
12	Valicha	Traditional variety	Kerala
13	Valichoori	Traditional variety	Kerala
14	Velambalan	Traditional variety	Kerala
15	Vellathondi	Traditional variety	Kerala
Improved rice varieties developed for conventional farming			
16	Aathira	BR 51-46-1 X Culture 23332-2	RARS, Pattambi, KAU
17	Aishwarya	Jyothi x BR 51-46-1	RARS, Pattambi, KAU
18	Anashwara	Mutant of PTB 20 (Vadakkan Chittini)	RARS, Pattambi, KAU
19	Annapurna	TN 1 x PTB 10	RARS, Pattambi, KAU
20	Aruna	Jaya x PTB 33	RRS, Moncompu, KAU

21	Aasha	IR 11-1-66 x Kochuvithu	RRS, Moncompu, KAU
22	Badhra	IR 8 x PTB 20	RRS, Moncompu, KAU
23	Bhagya	Tadukkan x Jaya	ORARS, Kayamkulam, KAU
24	CO-47	IR 50 x CO 43	Tamil NaduAgril. University
25	Dhanu	PTB 20	ORARS, Kayamkulam, KAU
26	FL-478	IR 29 x Pokkali B	IRRI, Philippines
27	Gouri	MO 4 x Cul. 25331	RRS, Moncompu, KAU
28	Haryana Basmati	Sona x Basmati-370	Haryana
29	IR-28	IR 833-6-2-1--1 x IR 2040	IRRI, Philippines
30	Kanakom	IR 1561 x PTB 33	RRS, Moncompu, KAU
31	Kanchana	IR 36 X Pavizham	RARS, Pattambi, KAU
32	Karishma	MO 1 x MO 6	RRS, Moncompu, KAU
33	Karthika	Triveni x IR 1539	RARS, Pattambi, KAU

34	Karuna	CO-25 X H_4	RARS, Pattambi, KAU
35	Kasthuri	Basmati 370 x CRR88-17-1-5	Gujarat
36	Krishnanjana	MO 1 x MO 6	RRS, Moncompu, KAU
37	Mahsuri	Taichung 65 x MayanaEbos 6080/2	Andra Pradesh
38	Makom	ARC 6650 x Jaya	RRS, Moncompu, KAU
39	Neeraja	IR 20 X IR 5	RARS, Pattambi, KAU
40	Onam	Kochuvithu x TN 1 x Triveni	ORARS, Kayamkulam, KAU
41	Prathyasha	IET 4786 x Aruna	RRS, Moncompu, KAU
42	Pusa Basmati	Pusa 1301 x Pusa1121	IARI, New delhi
43	Remanika	Mutant of MO 1	RRS, Moncompu, KAU
44	Remya	Jaya x PTB 33	RRS, Moncompu, KAU
45	Renjini	MO 5 x M 28-1-1	RRS, Moncompu, KAU
46	Revathy	Cul. 12814 x MO 6	RRS, Moncompu, KAU

47	Sagara	Mass selection from Oorumundakan local	ORARS, Kayamkulam, KAU
48.	Samyuktha	Pureline selection from Culture C2	RARS, Pattambi, KAU
49	Swarnaprabha	Bhavani x Triveni	RARS, Pattambi, KAU
50	Swetha	IR 50 X C 14-8	RARS, Pattambi, KAU
51	Uma	MO 6 x Pokkali	RRS, Moncompu, KAU
52	Vaishakh	Pureline selection from Swarnaprabha	RARS, Pattambi, KAU
53	Vytilla-1	Pure line selection from Chettivirippu	RRS, Vyttilla, KAU
54	Vytilla-4	Chettivirippu x IR 4630-22-2-17	RRS, Vyttilla, KAU
Varieties/ cultures developed by KAU adopting strategies of OPB			
55	Culture JK-14	Jaya x Kuthiru	PRS, Panniyur, KAU,Kerala
56	Culture JK-15	Jaya x Kuthiru	PRS, Panniyur, KAU,Kerala
57	Culture JK-59	Jaya x Kuthiru	PRS, Panniyur, KAU,Kerala
58	Culture JK-71	Jaya x Kuthiru	PRS, Panniyur,

			KAU,Kerala
59	Culture JO-532-1 (Ezhome-4)	Jaya x Orkayma	PRS, Panniyur, KAU,Kerala
60	Culture JO-583	Jaya x Orkayma	PRS, Panniyur, KAU,Kerala
61	Culture MK-115	Mahsuri x Kuthiru	KAU, Kerala
62	Culture MK-157 (Jaiva)	Mahsuri x Kuthiru	KAU, Kerala
63	Ezhome-1	Jaya x Kuthiru	PRS, Panniyur, KAU,Kerala
64	Ezhome-2	Jaya x Orkayma	PRS, Panniyur, KAU,Kerala
65	Ezhome-3	Mahsuri x Kuthiru	KAU, Kerala

3.1.2. Methodology

Seeds of 65 rice genotypes were sown during September 2013 in plastic trays which were filled with organic soil. Transplanting of 18 days old seedlings was resorted keeping inter and intra row spacing of 15 cm and 10 cm respectively. Plots consisting of 7 rows of 10 plants each were laid out in a randomized block design with two replications (Fig. 1).

All cultural operations were carried out as per the organic cultural management practices followed by the farming group for the last five years. Observations on growth and yield parameters were recorded on ten randomly selected plants in each replication for each treatment after leaving the border rows.

Observations of 32characteristicswhich include growth and yield parameters, physico-chemical and cooking quality parameters were taken as per the 'Standard Evaluation System for Rice' (IRRI, 1996).

3.2. DESCRIPTION OF THE OBSERVATIONS

3.2.1. Growth parameters

3.2.1.1. Root characteristics

The roots of individual plant are uprooted by removing the soil around the roots after harvest and root length, root spread and dry root weight were measured.

3.2.1.1.1. Root length

It is the measurement of length in centimeters between base of culm and tip of the roots at harvest stage and mean of 10 plants was worked out.

3.2.1.1.2. Root spread

It is the actual measurement of roots spread in centimeters at the widest portion of roots when spread on white paper at harvest stage and mean of 10 plants was worked out.

3.2.1.1.3. Root weight

Dry weight of root of each 10 plants was measured in grams and mean was worked out.

3.2.1.2. Chlorophyll content (SCMR)

Chlorophyll content of flag leaf and third leaf were recorded by SCMR (SPAD chlorophyll meter readings) at flowering stage and mean was worked out. (SPAD- *Soil Plant Analytical Development* – 502)

3.2.1.3. Plant height

Height of the plant was measured in centimeters from soil surface to the tip of the flag leaf before flowering and from soil surface to the tip of the tallest panicle (awns excluded) after flowering at different growth stages. Observations were taken at different growth stages (30, 60, 90 DAT and harvest) and mean was worked out.

3.2.1.4. Total number of tillers

Total number of tillers in each plant was counted at different growth stages (30, 60, 90 DAT and harvest) and mean was worked out.

3.2.1.5. Total biomass per plant

The biomass of each plant, which is sum of total of root weight, straw weight and panicle weight, was measured in grams and mean was worked out.

3.2.1.6. Lodging or Non lodging

Lodging and non-lodging characteristic of plants was measured by visual observations.

3.2.1.7. Duration of crop

Number of days from sowing of seeds to harvest (when 85% of grains on the panicle have matured) was counted.

3.2.2. Yield parameters

3.2.2.1. Number of productive tillers per plant

Number of panicle bearing tillers per plant was counted and mean was worked out.

3.2.2.2. Number of spikelets per panicle

All spikelets including fertile and sterile ones in each panicle were counted and mean was worked out.

3.2.2.3. Number of grains per panicle

Grains in each panicle of randomly selected 10 plants were counted and mean was worked out.

3.2.2.4. Seed setting percentage

Seed setting percentage of randomly selected 10 plants was calculated by using the formula given below and mean was worked out.

$$\text{Seed setting \%} = \frac{\text{Number of grains}}{\text{Total number of spikelets}} \times 100$$

3.2.2.5. Length of panicle

The length of panicle was measured in centimeters from base to tip of the top most spikelet (awns excluded) on panicle and mean was worked out.

3.2.2.6. 1000 grain weight

Weight of randomly selected 1000 numbers of grains was taken in grams and mean was worked out.

3.2.2.7. Grain yield per plant

The ten randomly selected plants from each plot were harvested discarding border rows and the yield was expressed in grams and mean was worked out.

3.2.2.8. Straw yield per plant

The straw of each randomly selected plant is measured in grams and mean of 10 plants was worked out.

3.2.2.9. Harvest index

Harvest index of randomly selected 10 plants was calculated by using the formula given below and mean was worked out.

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield (Straw + Panicle)}}$$

3.2.3. Physico-chemical and cooking quality parameters

3.2.3.1. Length and breadth ratio of kernel

The rice kernel length was estimated by keeping ten rice kernels of uniform size length-wise on a graph paper and the mean length was measured and expressed in mm. The rice kernel breadth was estimated by keeping ten rice kernels of uniform size breadth-wise on a graph paper and the mean breadth was measured and expressed in mm. Length–breadth ratio was determined by dividing the cumulative length and breadth of 10 kernels.

3.2.3.2. Colour of kernel

Dehulled rice was used to record kernel colour as red or white.

3.2.3.3. Hulling percentage

Seeds collected from replicated trials were cleaned and were dried to 14 percent moisture content. These samples were dehulled using laboratory rice dehusker and hulling percentage was calculated as follows.

$$\text{Hulling \%} = \frac{\text{Weight of dehulled grains}}{\text{Weight of paddy}} \times 100$$

3.2.3.4. Volume expansion ratio

The volume of raw rice as well as cooked rice was determined by water displacement using a measuring cylinder.

$$\text{Volume expansion ratio} = \frac{\text{Volume of cooked rice}}{\text{Volume of raw rice}}$$

3.2.3.5. Kernel elongation ratio

Kernel elongation was determined by dividing the cumulative length of 10 cooked kernels by the length of 10 raw kernels.

$$\text{Kernel elongation ratio} = \frac{\text{Average length of cooked kernel}}{\text{Average length of raw kernel}}$$

3.2.3.6. Alkali spreading value

Ten dehulled rice kernels were placed in 10 ml 1.7% KOH in a shallow container (petriplate). The kernels were arranged in such a way that they did not touch each other. They were allowed to stand for 23 hours at 30^0C. The appearance and disintegration of the kernels were rated visually after incubation, based on the following numerical scale (IRRI, 1996) (Table 2).

Table 2. Numerical scale for estimation of alkali spreading value

Description	Score
Kernel not affected	1
Kernel swollen	2
Kernel swollen; collar incomplete or narrow	3
Kernel swollen; collar complete and wide	4
Kernel split or segmented; collar complete and wide	5
Kernel dispersed, merging with collar	6
Kernel completely dispersed and intermingled	7

3.2.3.7. Sensory evaluation (as per nine point Hedonic scale)

The dehulled rice samples of 50gm individually are taken and cooked on hot plate and cooked rice samples were evaluated for taste, colour, aroma and overall appearance by a team of 25 members (include farmers, scientists and research assistants) as per nine point Hedonic Scale (Table 3) and mean was worked out.

Table 3. Nine point Hedonic scale for estimation of sensory evaluation

Scoring/Rating	Std. Hedonic Scale
9	I like extremely
8	I like very much
7	I like moderately
6	I like slightly
5	I neither like or dislike
4	I dislike slightly
3	I dislike moderately
2	I dislike very much
1	I dislike extremely

3.2.4. Incidence of pest and diseases

The major pest and disease incidence was evaluated by visual observation.

3.2.5. Statistical Analysis

The data on various parameters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant, critical differences were worked out at 5% probability level. There is 1% level of significance was found for genotypic and phenotypic correlation coefficients among the twenty six characteristics assessed. (ICAR Research Complex for Goa developed online softwere 'Wasp 2.0' for Variability and 'Indostat' for correlation and path-analysis)

Fig.1 Layout of the field experiment

Replication 1

Culture JK-14	Ayirankana	Vytila-4	Kuthiru	Orkayma	Kalladiyaran	Kandoorkutty	Culture JK-15	Sagara	Aasha
Krishnanjana	Chembav	Kanakom	Badhra	Valichoori	Dhanu	Kuttoos	Karuna	Vellathondi	Ezhome-3
Makam	Culture JK-59	Swetha	Remya	Velambalan	Ezhome-2	Annapurna	Culture JO-583	Valankunhivithu	Renjini
Samyuktha	Red mahsuri	Culture MK-115	Culture JK-71	Ezhome-1	Anaswara	Neeraja	HariyanaBasmathi	Remanika	IR-28
Jaiva	Pusa Basmathi	Kanchana	Bhagya	Revathy	Uma	Aruna	Valicha	Karthika	FL-478
Mahsuri	Aathira	Njavara	Vaishakh	Gouri	Swarnaprabha	CO-47	Gandakasala	Aishwarya	
Onam	Kasthuri	Ezhome-4	Vytila-1	Prathyasha	Karishma				

Replication 2

Aishwarya	Kanchana	Karishma	Aruna	Aathira	Remanika	Aasha	Vaishakh	Culture JK-14	Mahsuri
Bhagya	Renjini	Anaswara	Ezhome-3	Swetha	Karuna	Ezhome-1	Velambalan	Culture JK-59	Valichoori
Kasthuri	Njavara	CO-47	Samyuktha	Ezhome-2	PusaBasmathi	Annapurna	Kuttoos	Ezhome-3	Vellathondi
Hariyana Basmathi	Onam	Neeraja	Badhra	Dhanu	Valankunhivithu	Chembav	Sagara	Vytila-2	Ezhome-4
Swarnaprabha	Culture JO-583	CultureJK-71	Valicha	Orkayma	Culture MK-115	Gandakasala	Remya	Jaiva	Kanakom
Karthika	Red Mahsuri	Kalladiyaran	Culture JK-15	Ayirankana	Kandoorkutty	Kuthiru	Vytila-1	Krishnanjana	Revathy
					Makam	Uma	Prathyasha	FL-478	Gouri

Plate 1. Experiment plot just before transplanting at Mayyil, Kannur

Plate 2. Experiment plot at tillering stage at Mayyil, Kannur

Plate 3. Experiment plot at maturity stage at Mayyil, Kannur

(A) (B)

Plate 4. Experimental view of volume expansion ratio (A) - volume of raw rice,

(B) – volume of cooked rice

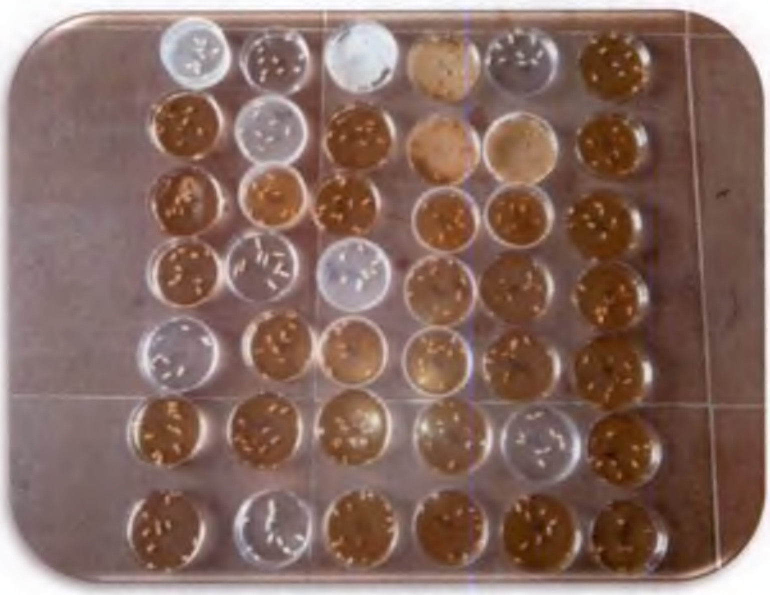


Plate 5. Experimental view of alkali spreading value

Plate 6. Sensory evaluation scoring by panel of members

RESULTS

4. RESULTS

An investigation was conducted for identification of rice genotypes and the key varietal traits suited for organic farming.

In the present investigation 65 rice genotypes including traditional genotypes, improved varieties developed for conventional rice farming, and rice varieties/ Cultures developed by Kerala Agricultural University adopting concepts and strategies of organic plant breeding are evaluated under organic management for 32 parameters. The data on various parameters were statistically analyzed and the result of variance revealed high significant difference among 65 rice genotypes for 27 parameters and is presented in this chapter.

4.1. Variability

4.1.1. Growth parameters

4.1.1.1. Root characteristics at harvest stage

4.1.1.1.1. Root length (cm)

The mean root lengths of 65 rice genotypes recorded at harvest are presented in Table 7 and it varies from 10.6cm to 20.2cm. The highest root length among long duration rice genotypes was recorded for 'Pusa Basmathi'and was found to be on par with with 17 rice genotypes, among medium duration rice genotypes 'Ezhome-1' recorded high root length and was found to be on par with with 11 rice genotypes. Culture MK-115recorded highest root length among short duration rice genotype and was found to be on par with with 6 rice genotypes. 'Vaishakh' short duration rice genotype recorded lowest root length.

4.1.1.1.2. Root weight (gm)

Dry root weights of 65 rice genotypes recorded at harvest and the mean values are presented in Table 7 and it ranges from 3.5gm to 11.3gm. The highest root weight among long duration rice genotypes was recorded for 'Annapurna' and was found to be on par with 'Karthika', 'Vytilla-4' and 'Valicha', among medium duration rice genotypes 'Bhagya' recorded high root weight and was found to be on par with 'Ezhome-3', 'Swarna prabha' and 'Kasthuri'. 'Kalladiyaran' recorded high root weight among the short duration rice genotypes and was found to be on par with Culture JK-15. 'Orkayma' long duration rice genotype recorded lowest root weight.

4.1.1.1.3. Root spread (cm)

The mean root spreads of 65 rice genotypes recorded at harvest are given in Table 7 and it varies from 4.3cm to 9cm. The highest root spread among long duration rice genotypes was recorded for 'Remanika' and was found to be on par with 9 rice genotypes, among medium duration rice genotypes 'FL-478' recorded highest root spread and was found to be on par with 8 rice genotypes. Among short duration rice genotypes Culture JK-15 recorded high root spread and was found to be on par with 3 other rice genotypes. 'Annapurna' long duration rice genotype recorded lowest root spread.

4.1.1.2. Chlorophyll content at flowering stage

4.1.1.2.1. Chlorophyll content of flag leaf (SCMR)

The mean chlorophyll content of flag leaf of 65 rice genotypes at flowering stage are presented in Table 8 and it ranged from 13.4 to 40.6 (SCMR). The highest chlorophyll content among long duration rice genotypes was recorded for 'Pusa Basmathi' and was found to be on par with 4 rice genotypes, among medium duration rice genotypes 'Renjini' recorded high chlorophyll content of flag leaf and was found to be on par with 3 other rice genotypes. 'Vytilla-1' recorded high chlorophyll content of flag leaf among the short duration rice genotypes. 'Dhanu' the medium duration rice genotype recorded lowest chlorophyll content of flag leaf.

Table 4. Analysis of variance for growth parameters of 65 rice genotypes under organic management

Source of variation	Degrees of freedom	Mean sum of squares													
		Root length	Root weight	Root spread	Chlorophyll content of flag leaf	Chlorophyll content of third leaf	Total biomass plant^{-1}	Plant height at 30DAT	Plant height at 60DAT	Plant height at 90DAT	Plant height at harvest	No. of tillers plant^{-1} at 30DAT	No. of tillers plant^{-1} at 60DAT	No. of tillers plant^{-1} at 90DAT	No. of tillers plant^{-1} at harvest
Replication	1	7.730	3.233	3.328	2.895	10.645	916.108	3130.126	1849.185	308.924	165.410	37.800	29.856	31.606	25.080
Genotype	64	10.906	6.955	1.823	52.900	65.585	216.086	436.994	543.446	559.602	553.953	8.489	11.973	12.039	13.203
Error	64	6.230	1.620	1.089	3.425	13.686	46.995	55.615	43.830	9.692	5.280	2.388	3.838	4.094	3.075

Table 5. Analysis of variance for yield parameters of 65 rice genotypes under organic management

Source of variation	Degrees of freedom	Mean sum of squares								
		No. of productive tillers plant^{-1}	No. of spikelets panicle^{-1}	No. of grains panicle^{-1}	Seed setting %	Length of panicle	1000 Grains weight	Grain yield plant^{-1}	Straw yield plant^{-1}	Harvest index
Replication	1	45.964	211.969	91.392	82.930	0.754	0.163	4.655	567.397	0.118
Genotype	64	12.528	6438.391	4797.527	766.528	14.196	30.110	45.532	102.508	0.103
Error	64	4.151	238.672	76.142	69.394	0.154	0.117	2.569	31.176	0.011

Table 6. Analysis of variance for physico- chemical and cooking quality parameters of 65 rice genotypes under organic management

Source of variation	Degrees of freedom	Mean sum of squares			
		L/B ratio of kernel	Hulling %	Volume expansion ratio	Kernel elongation ratio
Replication	1	0.001	96.975	0.228	0.001
Genotype	64	0.333	18.791	0.476	0.028
Error	64	0.009	5.267	0.034	0.000

4.1.1.2.2. Chlorophyll content of third leaf (SCMR)

Chlorophyll content of third leaf of 65 rice genotypes at flowering stage and mean values are presented in Table 8. It ranged from 12.3to 40.5(SCMR). The highest chlorophyll content was recorded in 'Onam' which was an short duration rice genotype and was found to be on par with 'Vytilla-1'. Among long duration rice genotypes high chlorophyll content of third leaf was recorded for 'Orkayama' and was found to be on par with 6 rice genotypes. 'Renjini' recorded high chlorophyll content of third leaf among medium duration rice genotypes and was found to be on par with 6 rice genotypes. 'Dhanu' the medium duration rice genotype recorded lowest chlorophyll content of third leaf.

Table 7. Mean performance of rice genotypes for root characteristics at harvest stage under organic management during Rabi season

Genotype	Root characteristics		
	Root length(cm)	Root weight(gm)	Root spread(cm)
Long duration			
Annapurna	11.7	11.3*	4.3
Aasha	18.1*	4.7	7.7*
Chembav	10.8	5.4	6.5
Culture JK-14	15.5*	7.0	6.3
Culture JO-532-1	11.2	3.8	6.6
Culture MK-157	16.0*	8.1	6.8
Ezhome-2	16.8*	4.9	7.3*
Gandakasala	17.3*	5.3	8.5*
IR-28	16.5*	6.4	5.8
Kanakom	13.8	7.8	6.3
Kandoorkutty	16.0*	4.5	8.3*

Karthika	19.8*	11.1*	6.8
Karuna	14.3	4.4	6.3
Krishnanjana	17.3*	7.3	7.3*
Mahsuri	15.6*	6.3	6.5
Neeraja	18.0	6.3	8.8*
Orkayama	13.5	3.5	5.8
PusaBasmathi	20.2*	8.5	6.8
Red Mahsuri	17.3*	4.7	8.5*
Remanika	18.0*	7.1	9.0*
Revathy	17.8*	7.2	6.4
Swetha	18.0*	6.4	7.1*
Valankunhivithu	13.5	7.8	5.9
Valicha	17.2*	8.9*	6.7
Valichoori	17.9*	5.9	7.6*
Vellathondi	17.8*	4.7	5.3
Vytilla-4	13.3	10.2*	5.7
Medium duration			
Aathira	17.3*	5.9	6.0
Aishwarya	18.5*	5.6	7.3*
Aruna	12.8	6.5	7.0*
Ayirankana	13.1	8.6	5.7
Badhra	14.0	4.5	7.0*
Bhagya	13.2	9.5*	5.0
CO-47	14.2	5.2	6.8
Culture JK-59	13.9	6.0	6.2
Culture JO-583	15.3*	6.8	6.2

Dhanu	12.2	7.3	6.5
Ezhome-1	19.9*	6.3	7.4*
Ezhome-3	13.5	9.2*	6.0
FL-478	17.3*	4.1	9.0*
Gouri	13.9	6.2	5.6
Kanchana	14.0	5.5	6.1
Karishma	15.8*	6.8	7.3*
Kasthuri	13.4	8.8*	7.2*
Prathyasha	13.8	5.2	6.0
Remya	15.7*	4.3	6.3
Renjini	17.7*	7.7	8.0*
Sagara	16.7*	4.3	7.1*
Samyuktha	13.5	3.6	5.8
Swarnaprabha	14.5	9.4*	5.5
Uma	16.7*	6.4	6.8
Velambalan	17.4*	4.6	5.2
Short duration			
Anaswara	12.0	5.0	6.3
Culture JK-15	16.5*	9.0*	7.6*
Culture JK-71	15.3*	7.6	6.6
Culture MK-115	19.0*	6.5	7.0*
Hariyanabasmathi	16.5*	6.0	7.0*
Kalladiyaran	16.9*	9.5*	6.5
Kuthiru	12.0	7.1	6.0
Kuttoos	13.0	3.7	6.1
Makam	14.0	7.3	7.0*

Njavara	15.3*	5.5	6.2
Onam	15.0	5.1	5.5
Vaishakh	10.6	5.0	6.3
Vytilla-1	13.8	6.5	6.4
CV(%)	**16.2**	**19.7**	**15.8**
CD(0.05)	**5.0**	**2.5**	**2.1**

('*'Significant and on par)

Table 8. Mean performance of rice genotypes for Chlorophyll content at flowering stage under organic management during rabi season

Genotype	**Chlorophyll content (*SCMR*)**	
	Flag leaf	**Third leaf**
Long duration		
Annapurna	34.5	31.3
Aasha	27.6	24.3
Chembav	34.9	34.2*
Culture JK-14	35.7	18.5
Culture JO-532-1	31.4	28.3
Culture MK-157	28.0	28.7
Ezhome-2	26.5	25.8
Gandakasala	32.8	30.6
IR-28	32.1	29.5
Kanakom	32.9	29.9
Kandoorkutty	30.8	27.4
Karthika	36.8	34.9*

Karuna	35.6	32.0
Krishnanjana	34.0	31.7
Mahsuri	27.5	21.2
Neeraja	39.7*	34.8*
Orkayama	40.2*	37.8*
PusaBasmathi	40.6*	34.8*
Red Mahsuri	35.2	30.5
Remanika	34.0	32.4
Revathy	34.0	32.8
Swetha	39.8*	35.4*
Valankunhivithu	33.9	31.5
Valicha	33.1	31.4
Valichoori	38.1*	33.9*
Vellathondi	32.9	28.9
Vytilla-4	33.1	30.9
Medium duration		
Aathira	33.2	30.5
Aishwarya	34.8	30.8
Aruna	31.5	28.3
Ayirankana	37.3*	33.4*
Badhra	25.9	21.6
Bhagya	39.0*	33.5*
CO-47	27.3	26.1
Culture JK-59	32.4	29.0
Culture JO-583	29.9	26.0
Dhanu	13.4	12.3

Ezhome-1	25.0	22.3
Ezhome-3	27.9	17.3
FL-478	28.3	21.4
Gouri	31.3	32.8
Kanchana	28.4	24.8
Karishma	24.9	23.4
Kasthuri	34.1	33.2*
Prathyasha	29.4	26.6
Remya	33.6	28.9
Renjini	39.6*	36.9*
Sagara	26.4	20.7
Samyuktha	34.9	33.6*
Swarnaprabha	32.2	27.1
Uma	35.6	34.1*
Velambalan	38.7*	33.8*
Short duration		
Anaswara	21.8	16.5
Culture JK-15	27.1	22.5
Culture JK-71	37.1	33.0
Culture MK-115	29.5	26.3
Hariyana Basmathi	29.7	28.7
Kalladiyaran	32.7	29.0
Kuthiru	36.3	28.7
Kuttoos	26.7	19.5
Makam	22.1	18.7
Njavara	35.5	30.5

Onam	36.2	40.5*
Vaishakh	27.2	23.8
Vytilla-1	38.5*	36.1*
CV (%)	**5.8**	**12.9**
CD(0.05)	**3.7**	7.4

('*'Significant and on par)

4.1.1.3. Plant height at different growth stages

4.1.1.3.1. Plant height at 30DAT

The mean plant height of 65 rice genotypes was recorded at 30DAT and are presented in Table 9 and it ranges from 34.5 cm to 99.6cm. The highest plant height among short duration rice genotypes was recorded in 'Kuttoos' and was found to be on par with Culture JK-71, among medium duration rice genotypes 'Dhanu' recorded high plant height at 30DAT and was found to be on par with 'Sagara'. 'Renjini' the medium duration rice genotype recorded lowest plant height at 30DAT.

4.1.1.3.2. Plant height at 60DAT

Plant height of 65 rice genotypes was recorded at 60DAT and mean values are presented in Table 9. It varies from 39.8cm to 113.1cm. The highest plant height among short duration rice genotypes was recorded in 'Kuttoos' and was found to be on par with Culture MK-115 and Culture JK-15. Among medium duration rice genotypes 'Dhanu' recorded high plant height and 'IR-28' the long duration rice genotype recorded lowest plant height at 60DAT.

4.1.1.3.3. Plant height at 90DAT

The mean plant height of 65 rice genotypes was recorded at 90DAT and are presented in Table 9. It varies from 53.7cm to 131.2cm. The highest plant height was recorded in 'Kandoorkutty' a long duration rice genotype and significantly higher than all other genotypes. 'IR-28' the long duration rice genotype recorded lowest plant height at 90DAT.

4.1.1.3.4. Plant height at harvest

Plant height of 65 rice genotypes was recorded at harvest and mean values are presented in Table 9. It varies from 55.6cm to 134.7cm. The highest plant height was recorded in 'Kandoorkutty' a long duration rice genotype and significantly higher than all other genotypes. 'IR-28' the long duration rice genotype recorded lowest plant height at 90DAT.

Table 9. Mean performance of rice genotypes for plant height at different growth stages under organic management

Genotype	Plant height(cm)			
	30DAT	60DAT	90DAT	Harvest
Long duration				
Annapurna	38.0	45.2	66.2	69.9
Aasha	42.8	62.5	73.2	73.7
Chembav	67.9	80.0	106.1	106.5
Culture JK-14	71.6	83.4	106.2	113.5
Culture JO-532-1	52.4	56.1	80.9	81.4
Culture MK-157	71.6	98.0	110.6	113.1
Ezhome-2	57.7	68.1	99	102.9
Gandakasala	71.4	85.6	110.5	112.6
IR-28	37.1	39.8	53.7	55.6
Kanakom	65.9	68.9	90.0	91.5
Kandoorkutty	77.9	94.5	131.2*	134.7*
Karthika	42.0	52.8	72.4	74.5
Karuna	74.3	86.2	118.8	119.8

Krishnanjana	68.9	81.7	93.8	90.7
Mahsuri	73.1	75.7	103.5	104.2
Neeraja	43.3	54.5	80.1	84.9
Orkayama	65.5	87.2	95.5	97.9
Pusa Basmathi	56.1	69.3	88.2	91.0
Red Mahsuri	62.6	80.2	108.7	111.2
Remanika	41.4	58.5	79.9	82.4
Revathy	57.6	76.6	87.9	89.9
Swetha	60.7	73.8	89.6	95.0
Valan kunhivithu	63.9	75.9	95.5	96.2
Valicha	73.6	91.1	91.7	100.0
Valichoori	50.8	58.3	66.8	71.8
Vellathondi	82.3	93.2	106.8	110.4
Vytilla-4	69.0	79.3	95.5	99.7
Medium duration				
Aathira	62.5	80.2	108.7	110.1
Aishwarya	51.7	69.7	93.2	94.2
Aruna	70.3	73.6	78.1	78.5
Ayirankana	60.8	62.2	68.6	74.1
Badhra	54.4	62.8	68.1	72.9
Bhagya	52.3	56.5	66.8	68.9
CO-47	45.1	55.1	73.5	74.4
Culture JK-59	80.6	87.7	112.7	113.6
Culture JO-583	64.7	75.7	96.7	100.8
Dhanu	93*	103.5*	111.6	114.2
Ezhome-1	58.3	67.5	73.6	76.4

Ezhome-3	81.0	86.6	95.2	97.4
FL-478	66.5	84.1	93.9	97.0
Gouri	64.2	78.6	88.7	89.8
Kanchana	52.2	58.3	69.8	71.1
Karishma	59.5	64.6	85.1	85.8
Kasthuri	40.9	53.1	70.3	72.0
Prathyasha	48.0	55.2	70.2	71.8
Remya	66.8	71.6	84.2	87.6
Renjini	34.5	45.5	66.0	71.1
Sagara	85.8*	99.5	108.8	110.0
Samyuktha	60.5	72.4	90.2	92.4
Swarnaprabha	69.0	84.8	96.5	97.2
Uma	45.8	53.8	70.5	73.1
Velambalan	75.8	83.8	93.0	98.0
Short duration				
Anaswara	81.8	99.4	111.3	114.0
Culture JK-15	92.1	106.8*	114.7	116.0
Culture JK-71	79.9*	88.6	109.3	112.9
Culture MK-115	82.9	105.5*	115.6	118.1
Hariyana basmathi	54.8	69.5	97.8	98.7
Kalladiyaran	77.7	85.6	93.2	95.9
Kuthiru	79.9	84.1	92.3	94.2
Kuttoos	99.6*	113.1*	114.6	118.4
Makam	55.9	67.7	79.1	82.3
Njavara	79.6	91.4	95.4	97.5
Onam	48.1	51.6	66.3	71.7

Vaishakh	55.3	71.1	89.6	92.4
Vytilla-1	67.4	83.6	99.1	102.2
CV (%)	**11.7**	**8.8**	**3.4**	**2.5**
CD(0.05)	**14.9**	**13.3**	**6.2**	**4.6**

('*'Significant and on par)

4.1.1.4. Number of tillers at different growth stages

4.1.1.4.1. Number of tillers per plant at 30DAT

The mean number of tillers plant^{-1} of 65 rice genotypes was recorded at 30DAT and are presented in Table 10. It varies from 4.1 to 14.7. The highest number of tillers plant^{-1}among medium duration rice genotypes was recorded in 'Dhanu' and was found to be on par with 'Badhra'. Among short duration rice genotypes 'Anaswara' recorded high number of tillers plant^{-1}.Culture JO-532-1 the long duration rice genotype recorded lowest number of plant tillers at 30DAT.

4.1.1.4.2. Number of tillers per plant at 60DAT

Number of tillers plant^{-1} of 65 rice genotypes was recorded at 60DAT and mean values are presented in Table 10. It varies from 5.3 to 17.2. The highest number of tillers plant^{-1}among medium duration rice genotypes was recorded in 'Dhanu' and was found to be on par with 'Badhra' and 'Remya'. Among short duration rice genotypes 'Anaswara' recorded high number of tillers plant^{-1}. 'Velambalan' the medium duration rice genotype recorded lowest number of tillers at 60DAT.

4.1.1.4.3. Number of tillers per plant at 90DAT

The mean number of tillers plant^{-1} of 65 rice genotypes was recorded at 90DAT and are presented in Table 10 and it varies from 6.5 to 17.8. The highest number of tillers plant^{-1}among medium duration rice genotypes was recorded in 'Dhanu' and was found to be on par with 'Badhra', Culture MK-157 and 'Remya'. Among short duration rice genotypes 'Anaswara' recorded high number of tillers plant^{-1} and was found to be on par with 'Makam'. 'Valicoori' long duration rice genotype recorded lowest number of tillers at 90DAT.

4.1.1.4.4. Number of tillers per plant at harvest

Number of tillers plant^{-1} of 65 rice genotypes was recorded at harvest and mean values are presented in Table 10. It varies from 6.8 to 18.3. The highest number of tillersplant^{-1} among medium duration rice genotypes was recorded in 'Dhanu' and was found to be on par with 'Badhra' and Culture MK-157. Among short duration rice genotypes 'Anaswara' recorded high number of tillers plant^{-1} and was found to be on par with 'Makam'. 'Remanika' the long duration rice genotype recorded high number of tillersplant^{-1} among long duration rice genotypes. 'Valicoori' the long duration rice genotype recorded lowest plant height at harvest stage.

Table 10. Mean performance of rice genotypes for number of tillers at different growth stages under organic management during Rabi season

Genotype	Number of tillers plant^{-1}			
	30DAT	60DAT	90DAT	Harvest
Long duration				
Annapurna	6.2	7.0	8.1	8.6
Aasha	7.3	7.9	8.7	10.0
Chembav	5.3	6.0	7.9	8.1
Culture JK-14	5.2	7.7	9.7	10.3
Culture JO-532-1	4.1	5.8	8.1	8.4
Culture MK-157	7.5	11.2	14.3*	14.8*
Ezhome-2	4.8	7.1	7.6	8.0
Gandakasala	6.2	6.7	7.5	8.3
IR-28	5.7	8.4	10.2	10.7
Kanakom	8.6	10.6	12.2	12.5

Kandoorkutty	10.8	12.7	13.5	14.0
Karthika	7.0	9.9	12.2	12.7
Karuna	6.9	7.8	8.8	9.1
Krishnanjana	7.1	10.2	12.1	12.4
Mahsuri	5.4	5.9	7.1	7.3
Neeraja	4.4	6.2	9.2	9.7
Orkayama	5.1	6.5	7.5	8.2
Pusa Basmathi	7.9	9.6	11.1	11.6
Red Mahsuri	5.8	7.0	8.2	8.6
Remanika	7.2	10.3	9.3	14.8*
Revathy	6.0	6.7	7.5	7.9
Swetha	5.9	6.7	7.1	7.8
Valan kunhivithu	5.3	7.1	9.0	9.3
Valicha	6.6	8.9	11.5	12.1
Valichoori	4.6	5.6	6.5	6.8
Vellathondi	6.0	8.8	12.1	12.7
Vytilla-4	5.1	6.6	8.2	9.8
Medium duration				
Aathira	6.9	9.4	10.8	11.2
Aishwarya	7.0	7.8	9.6	13.0
Aruna	7.2	11.1	12.1	12.3
Ayirankana	4.8	6.1	7.6	8.1
Badhra	12.3*	15.0*	16.1*	18.0*
Bhagya	5.0	6.1	7.3	12.7
CO-47	6.8	10.6	12.4	13.8
Culture JK-59	5.5	6.7	7.5	7.8

Culture JO-583	6.9	7.5	8.2	8.3
Dhanu	14.7*	17.2*	17.8*	18.3*
Ezhome-1	9.8	10.3	11.0	13.1
Ezhome-3	7.9	9.1	10.2	10.3
FL-478	5.4	6.7	10.2	10.5
Gouri	5.0	6.3	7.2	10.8
Kanchana	8.2	9.9	10.9	11.1
Karishma	8.6	9.6	10.7	11.3
Kasthuri	4.7	6.0	7.3	8.1
Prathyasha	5.4	8.2	10.3	11.9
Remya	9.8	13.4*	14.1*	14.4
Renjini	4.8	6.6	9.6	10.5
Sagara	7.7	10.4	12.1	12.6
Samyuktha	4.6	6.9	9.3	9.9
Swarnaprabha	6.1	6.8	8.2	9.0
Uma	6.4	7.6	8.9	9.7
Velambalan	4.4	5.3	8.5	8.7
Short duration				
Anaswara	12.9*	14.2*	15.1*	15.6*
Culture JK-15	8.2	9.1	12.2	13.1
Culture JK-71	6.9	7.5	8.0	8.5
Culture MK-115	6.6	7.0	8.3	9.2
Hariyana basmathi	7.6	7.5	8.8	9.2
Kalladiyaran	6.5	12.2	12.4	12.8
Kuthiru	4.9	7.0	8.8	9.1
Kuttoos	7.7	10.9	11.8	12.3

Makam	8.9	10	14.5*	15.5*
Njavara	7.9	9.1	10.1	11.4
Onam	5.2	6.4	9.6	10.4
Vaishakh	5.6	7.0	8.0	8.6
Vytilla-1	5.8	8.3	11.9	12.5
CV (%)	**23.0**	**23.2**	**20.2**	**16.1**
CD(0.05)	**3.1**	**3.9**	**4.0**	**3.5**

('*'Significant and on par)

4.1.1.5. Total biomass per plant

The mean total biomass plant^{-1} of 65 rice genotypes was recorded at harvest and are presented in Table 11.It varies from 17.3gm to 67.2gm. The highest total biomass per plant among long duration rice genotypes was recorded in 'Kanakom' and was found to be on par with 'Remanika' and Culture MK-157. 'Dhanu' recorded high biomass plant^{-1}among medium duration rice genotypes and 'Anaswara' recorded high biomass plant^{-1}among short duration rice genotypes. 'Gouri' the medium duration rice genotype recorded lowest total biomass plant^{-1}.

4.1.1.6. Lodging or Non-lodging

The lodging/ non-lodging characteristics of 65 rice genotypes was recorded at harvest and are given in Table 11. Among long duration rice genotypes Culture JK-14, 'Chembav', 'Orkayama', 'Kandoorkutty', 'Valichoori', 'Valicha', 'Vellathondi' and'Vytilla-4' are lodging type. Among medium duration rice genotypes 'Ayirankana', Culture JK-59, 'Sagara' and 'Velambalan' are lodging type. 'Vaishakh', 'Kuthiru', 'Kalladiyaran' and 'Kuttoos' are lodging type among short duration rice genotypes and remaining all other genotypes are non-lodging type.

4.1.1.7. Duration of crop (days)

The duration of crop of 65 rice genotypes was recorded and are presented in Table 11. Thirteen rice genotypes recorded duration of 110 - 120 days,25rice genotypes recorded duration of 120 - 130 days and 27rice genotypes recorded duration of 135 - 150 days.

Table 11. Mean performance of rice genotypes for total biomass plant^{-1}, lodging/Non-lodging and duration of crop under organic management

Genotype	Total biomass plant^{-1}(gm)	Lodging/Non-lodging	Duration of crop
Long duration			
Annapurna	31.5	Non-lodging	135-140
Aasha	39.2	Non-lodging	135-140
Chembav	36.8	Lodging	135-140
Culture JK-14	43.5	Lodging	140-145
Culture JO-583	38.5	Non-lodging	135-140
Culture MK-157	58.6*	Non-lodging	130-135
Ezhome-2	35.9	Non-lodging	135-140
Gandakasala	33.2	Non-lodging	135-140
IR-28	20.6	Non-lodging	130-135
Kanakom	67.2*	Non-lodging	135-140
Kandoorkutty	46.1	Lodging	145-150
Karthika	46.6	Non-lodging	135-140
Karuna	40.8	Non-lodging	140-145
Krishnanjana	41.3	Non-lodging	140-145
Mahsuri	43.8	Non-lodging	130-135
Neeraja	44.3	Non-lodging	135-140

Orkayama	26.5	Lodging	145-150
Pusa Basmathi	30.8	Non-lodging	140-145
Red Mahsuri	49.5	Non-lodging	135-140
Remanika	66.8*	Non-lodging	140-145
Revathy	31.1	Non-lodging	135-140
Swetha	43.3	Non-lodging	130-135
Valan kunhivithu	27.7	Non-lodging	135-140
Valicha	37.3	Lodging	135-140
Valichoori	33.6	Lodging	135-140
Vellathondi	32.8	Lodging	140-145
Vytilla-4	52.6	Lodging	140-145
Medium duration			
Aathira	39.8	Non-lodging	125-130
Aishwarya	49.1	Non-lodging	120-125
Aruna	47.7	Non-lodging	120-125
Ayirankana	31.9	Lodging	125-130
Badhra	47.1	Non-lodging	125-130
Bhagya	36.5	Non-lodging	125-130
CO-47	33.5	Non-lodging	120-125
Culture JK-59	31.1	Lodging	125-130
Culture JO-532-1	21.5	Non-lodging	120-125
Dhanu	63.5*	Non-lodging	120-125
Ezhome-1	35.9	Non-lodging	125-130
Ezhome-3	36.7	Non-lodging	125-130
FL-478	32.6	Non-lodging	120-125

Gouri	17.3	Non-lodging	120-125
Kanchana	36.5	Non-lodging	120-125
Karishma	35.7	Non-lodging	125-130
Kasthuri	38.4	Non-lodging	120-125
Prathyasha	37.2	Non-lodging	120-125
Remya	48.5	Non-lodging	125-130
Renjini	41.0	Non-lodging	120-125
Sagara	49.0	Lodging	125-130
Samyuktha	37.1	Non-lodging	125-130
Swarnaprabha	34.7	Non-lodging	120-125
Uma	39.3	Non-lodging	120-125
Velambalan	24.0	Lodging	120-125
Short duration			
Anaswara	57.9*	Non-lodging	115-120
Culture JK-15	31.9	Non-lodging	115-120
Culture JK-71	33.5	Non-lodging	110-115
Culture MK-115	52.4	Non-lodging	115-120
Hariyana basmathi	49.4	Non-lodging	110-115
Kalladiyaran	37.9	Lodging	110-115
Kuthiru	29.8	Lodging	115-120
Kuttoos	36.0	Lodging	110-115
Makam	49.3	Non-lodging	110-115
Njavara	38.0	Non-lodging	115-120
Onam	32.6	Non-lodging	115-120
Vaishakh	23.7	Lodging	115-120

Vytilla-1	32.3	Non-lodging	115-120
CV (%)	**17.5**		
CD(0.05)	**13.7**		

('*'Significant and on par)

4.1.2. Yield parameters

4.1.2.1. Number of productive tillers per plant

The mean number of productive tillers plant^{-1} of 65 rice genotypes was recorded at harvest and are presented in Table 12, and it varies from 5.0 to 16.6. The highest number of productive tillers plant^{-1}among medium duration rice genotypes was recorded in 'Badhra' and was found to be on par with 'Dhanu'. Among short duration rice genotypes 'Anaswara' recorded high number of productive tillers plant^{-1} and was found to be onpar with 'Makam' and significantly higher than all other genotypes. Culture JK-59 the medium duration rice genotype recorded lowest number of productive tillersplant^{-1}.

4.1.2.2. Number of spikelets per panicle

Spikeletspanicle^{-1} of 65 rice genotypes was recorded after harvest and mean values are presented in Table 12, It varies from 53 to 298. The highest number of spikelets panicle^{-1}among long duration rice genotypes was recorded in 'Swetha' and was found to be on par with 'Mahsuri', 'Chembav' and significantly higher than all other genotypes. 'Valankunhivithu' the long duration rice genotype recorded lowest number of spikelets panicle^{-1}.

4.1.2.3. Number of grains per panicle

The mean number of grains panicle^{-1} of 65 rice genotypes was recorded after harvest and are presented in Table 12, and it ranges from 12 to 282. The highest number of grains per panicle^{-1}among long duration rice genotypes was recorded for 'Mahsuri' and significantly higher than all other genotypes. 'Kandoorkutty' the long duration rice genotype recorded lowest number of grains panicle^{-1}.

4.1.2.4. Seed setting percentage

Seed setting percentage of 65 rice genotypes was recorded after harvest and mean values are presented in Table 12.It varies from 12.5% to 93.7%. The highest seed setting % among long duration rice genotypes was recorded in Culture MK-157and was found to be on par with 6 other rice genotypes. Among medium duration rice genotypes 'Aathira' recorded high seed setting % and was found to be on par with 7 other rice genotypes. 'Vaishakh' recorded high seed setting % among short duration rice genotypes and was found to be on par with other 3 rice genotypes. 'Kandoorkutty' the long duration rice genotype recorded lowest seed setting %.

Table 12. Mean performance of rice genotypes for yield parameters under organic management during Rabi season

Genotype	No. of productive tillers plant^{-1}	No. of spikelets panicle^{-1}	No. of grains panicle^{-1}	Seed setting%
Long duration				
Annapurna	7.0	92.5	77.5	47.9
Aasha	9.2	155.5	118.5	76.5
Chembav	6.5	271.0*	46.5	17.2
Culture JK-14	6.0	185.0	126.5	68.4
Culture JO-583	6.7	187.5	104.5	55.7
Culture MK-157	11.8	215.0	201.5	93.8*
Ezhome-2	6.1	224.0	110.0	49.3
Gandakasala	7.7	156.0	49.5	32.6
IR-28	7.2	101.0	63.5	62.8
Kanakom	9.7	181.0	128.5	70.9
Kandoorkutty	7.8	94.0	12.0	12.5

Karthika	6.6	124.0	79.0	64.0
Karuna	7.3	191.5	72.5	37.9
Krishnanjana	5.4	189.5	112.0	59.2
Mahsuri	6.1	290.0*	282.0*	84.3*
Neeraja	7.5	144.5	111.0	76.8
Orkayama	5.4	73.5	53.0	73.4
Pusa Basmathi	6.1	118.0	31.0	26.0
Red Mahsuri	5.6	257.0	200.0	77.8*
Remanika	7.5	163.0	66.0	40.4
Revathy	5.9	154.0	87.5	56.7
Swetha	5.5	298.0*	207.5	69.7
Valankunhivithu	6.3	53.0	46.0	87.1*
Valicha	10.8	81.0	66.5	82.9*
Valichoori	5.3	107.5	70.0	65.4
Vellathondi	9.3	78.5	68.5	87.6*
Vytilla-4	7.4	157.0	130.5	83.2*
Medium duration				
Aathira	7.9	196.5	181.5	92.3*
Aishwarya	10.5	102.5	51.0	49.8
Aruna	7.6	201.5	167.5	66.9
Ayirankana	7.1	75.5	43.5	57.5
Badhra	16.6*	165.0	120.0	72.7
Bhagya	11.3	90.0	66.5	74.5
CO-47	11.8	105.5	92.5	87.9*
Culture JK-59	5.0	136.5	61.5	45.3
Culture JO-532-1	6.7	160.5	129.5	80.6*

Dhanu	16.5*	116.5	78.0	67.3
Ezhome-1	8.5	98.5	71.5	72.6
Ezhome-3	7.1	230.5	148.5	64.5
FL-478	6.1	166.5	157.0	92.0*
Gouri	9.7	188.5	132.5	69.0
Kanchana	10.3	87.0	69.5	79.7*
Karishma	9.9	188.0	95.5	50.9
Kasthuri	8.1	199.5	81.5	40.9
Prathyasha	10.5	105.0	29.0	28.2
Remya	8.6	179.0	71.5	40.1
Renjini	7.3	119.5	101.0	81.4*
Sagara	10.6	136.0	124.0	91.1*
Samyuktha	7.8	135.0	70.0	52.0
Swarnaprabha	8.0	157.0	130.5	83.2*
Uma	7.4	126.5	96.5	76.2
Velambalan	9.1	79.0	72.5	91.6*
Short duration				
Anaswara	14.9*	132.0	75.5	57.5
Culture JK-15	10.0	101.0	55.0	55.0
Culture JK-71	7.6	84.0	63.0	75.3
Culture MK-115	8.4	153.5	119.0	77.5*
Hariyana basmathi	8.0	260.0	139.0	53.6
Kalladiyaran	9.0	90.5	78.5	87.5*
Kuthiru	5.9	127.0	50.0	39.7
Kuttoos	8.8	151.0	98.0	64.8

Makam	13.4*	163.0	114.0	70.0
Njavara	10.3	80.5	61.0	76.4
Onam	9.6	87.5	41.5	47.3
Vaishakh	7.15	157.5	142.5	90.7*
Vytilla-1	9.4	87.5	68.5	78.8*
CV (%)	**24.3**	**10.5**	**9.0**	**12.8**
CD(0.05)	**4.1**	**30.9**	**17.4**	**16.6**

('*'Significant and on par)

4.1.2.5. Length of panicle

The mean panicle length of 65 rice genotypes was recorded after harvest and are presented in Table 13 and it varies from 18.2cm to 30.1cm. The highest length of panicle among long duration rice genotypes was recorded in 'Vytilla-4' and was found to be on par with 'Chembav' and significantly higher than all other genotypes. 'CO-47' the medium duration rice genotype recorded lowest length of panicle.

4.1.2.6. 1000 grains weight

1000 grains weight of 65 rice genotypes was recorded after harvest and mean values are presented in Table 13. It varies from 16gm to 35.8gm. The highest 1000 grains weight was recorded in 'Valichoori' a long duration rice genotype and significantly higher than all other genotypes. 'Mahsuri' the long duration rice genotype recorded lowest 1000 grains weight.

4.1.2.7. Grain yield per plant

The mean grain yield plant^{-1}of 65 rice genotypes was recorded after harvest and are presented in Table 13 and it varies from 4.3gm to 26.6gm. The highest grain yield plant^{-1}was recorded in 'Anaswara' a short duration rice genotype. Among medium duration rice genotypes Culture MK-157 recorded high grain yield plant^{-1}. 'Kandoorkutty' the long duration rice genotype recorded lowest grain yield plant^{-1}.

4.1.2.8. Straw yield per plant

Straw yield plant^{-1} of 65 rice genotypes was recorded after harvest and mean values are presented in Table 13. It varies from 9.6gm to 45.8gm. The highest straw yield plant^{-1}among long duration rice genotype was recorded in 'Kanakom' and was found to be on par with Culture MK-157, 'Remanika' and 'Vytilla-4'. Among medium duration rice genotypes 'Dhanu' recorded high straw yield plant^{-1}. 'Anaswara' recorded high straw yield plant^{-1}among short duration rice genotypes and was found to be on par with Culture MK-115 and 'Makam'. 'Gouri' the medium duration rice genotype recorded lowest straw yield plant^{-1}.

4.1.2.9. Harvest index

The mean harvest index of65 rice genotypes was recorded after harvest and are presented in Table 13 and it varies from 0.11 to 0.86. The highest harvest index among long duration rice genotypes was recorded in 'IR-28'.Among medium duration rice genotypes 'FL-478' recorded high Harvest Index which was found to be on par with that of 'Aishwarya', 'Prathyasha', 'CO-47' and 'Karishma'. 'Anaswara' the short duration rice genotype recorded high harvest index. 'Kandoorkutty' the long duration rice genotype recorded lowest harvest index.

Table 13. Mean performance of rice genotypes for yield parameters under organic management during Rabi season

Genotype	Length of panicle(cm)	1000 grains weight(gm)	Grain yield plant^{-1} (gm)	Straw yield plant^{-1} (gm)	Harvest index
Long Duration					
Annapurna	19.8	23.6	8.7	19.2	0.32

Aasha	21.6	30.16	16.9	23.4	0.59
Chembav	29.5*	26.7	12.5	20.4	0.46
Culture JK-14	29.1	30.2	8.1	23.8	0.26
Culture JO-583	26.8	26.2	19.3	27.4	0.59
Culture MK-157	26.1	22.8	24.6*	37.1*	0.51
Ezhome-2	26.9	27.4	9.0	21.9	0.31
Gandakasala	24.2	27.5	13.0	21.4	0.47
IR-28	22.8	25.7	12.7	13.1	0.86*
Kanakom	24.8	28.5	20.6	45.8*	0.36
Kandoorkutty	23.6	21.3	4.3	30.9	0.11
Karthika	22.1	26.2	19.4	30.0	0.52
Karuna	27.2	24.5	11.9	25.4	0.35
Krishnanjana	21.5	24.4	14.7	28.6	0.43
Mahsuri	27.4	16.0	16.4	30.5	0.44
Neeraja	23.7	21.7	11.9	23.9	0.36
Orkayama	20.5	27.6	8.3	15.6	0.38
Pusa Basmathi	24.9	30.2	11.0	18.3	0.43
Red Mahsuri	23.8	19.3	17.9	34.4	0.45
Remanika	24.0	21.4	12.5	35.2*	0.22
Revathy	23.8	25.8	12.5	20.8	0.48
Swetha	24.0	21.9	17.9	29.7	0.49
Valan kunhivithu	19.9	21.1	6.1	16.9	0.28
Valicha	19.8	26.6	16.7	27.6	0.49
Valichoori	24.9	35.8*	10.0	20.5	0.39
Vellathondi	27.0	31.9	14.2	24.2	0.50
Vytilla-4	30.1*	31.0	19.0	34.6*	0.43

Medium duration					
Aathira	25.2	29.0	19.5	25.8	0.64
Aishwarya	22.5	29.0	23.2	29.9	0.66*
Aruna	27.5	25.9	22.6	32.3	0.57
Ayirankana	24.3	28.5	13.8	22.6	0.52
Badhra	22.2	23.7	15.1	32.8	0.39
Bhagya	22.9	27.2	15.7	27.2	0.54
CO-47	18.2	18.5	17.3	22.5	0.66*
Culture JK-59	25.3	29.0	12.0	20.8	0.45
Culture JO-532-1	25.0	30.0	17.8	13.5	0.63
Dhanu	21.6	27.2	22.7	45.0*	0.39
Ezhome-1	20.7	28.9	7.9	24.1	0.27
Ezhome-3	27.6	27.7	16.0	23.4	0.55
FL-478	26.8	32.1	19.4	21.3	0.72*
Gouri	22.1	26.1	19.1	9.6	0.49
Kanchana	20.8	30.3	17.4	24.8	0.59
Karishma	23.9	23.7	18.4	23.7	0.67*
Kasthuri	27.9	19.3	11.2	25.1	0.34
Prathyasha	23.8	28.0	19.5	24.8	0.66*
Remya	24.9	28.9	16.9	32.3	0.43
Renjini	21.6	24.3	14.1	23.4	0.43
Sagara	26.0	31.4	20.5	31.8	0.51
Samyuktha	24.3	29.3	12.0	26.6	0.36
Swarnaprabha	25.7	29.6	18.1	24.8	0.62
Uma	19.7	26.1	18.4	25.7	0.58
Velambalan	23.6	29.5	8.3	16.2	0.39

Short duration					
Anaswara	21.5	26.2	26.6*	39.7*	0.55
Culture JK-15	23.4	29.0	13.2	22.7	0.48
Culture JK-71	21.6	27.6	13.8	23.4	0.49
Culture MK-115	29.0	29.9	22.0	36.3*	0.48
Hariyana basmathi	24.7	19.9	20.8	33.3	0.51
Kalladiyaran	25.9	24.7	13.0	27.4	0.40
Kuthiru	28.0	27.1	8.3	18.3	0.32
Kuttoos	27.2	22.1	11.6	19.6	0.43
Makam	23.7	26.6	19.1	35.5*	0.46
Njavara	23.5	23.2	17.4	27.2	0.53
Onam	25.8	18.1	13.1	23.9	0.48
Vaishakh	25.9	28.7	19.9	15.8	0.53
Vytilla-1	23.6	29.4	13.8	21.2	0.52
CV (%)	**1.6**	**1.3**	**10.4**	**21.7**	**20.31**
CD(0.05)	**0.8**	**0.7**	**3.2**	**11.2**	**0.21**

('*'Significant and on par)

4.1.3. Physico-chemical and cooking quality parameters

4.1.3.1. Length/Breadth ratio of kernel

The mean L/B ratio of kernel of 65 rice genotypes was recorded and are presented in Table 14 and it varies from 1.8mm to 4.8 mm. The highest L/B ratio of kernel was recorded in 'Pusa Basmathi' a long duration rice genotype and significantly higher than all other genotypes. This was followed by short duration rice genotype 'Hariyana basmathi'. 'Valankunhivithu' the long duration rice genotype recorded lowest L/B ratio of kernel.

4.1.3.2. Hulling percentage

Hulling % of kernel of 65 rice genotypes was recorded and mean values are presented in Table 14. It varies from 66.3% to 80.9 %. The highest hulling % of among short duration rice genotypes was recorded in Culture JK-71 and was found to be on par with 7 rice genotypes. Among medium duration rice genotypes 'Ezhome-1' recorded high hulling %and was found to be on par with 16 other rice genotypes. 'Kanakom' recorded high hulling % among long duration rice genotypes and was found to be on par with 6 other rice genotypes. 'Karuna' the long duration rice genotype recorded lowest hulling %.

4.1.3.3. Volume expansion ratio

The mean volume expansion ratio of 65 rice genotypes was recorded and are presented in Table 14 and it ranges from 1.97 to 4.07. The highest volume expansion ratio was recorded in 'CO-47' which is a medium duration rice genotype. Among long duration rice genotypes Culture MK-157 and 'Valan Kunhivithu' recorded high volume expansion ratio. 'Kandoorkutty' the long duration rice genotype recorded lowest volume expansion ratio.

4.1.3.4. Kernel elongation ratio

Kernel elongation ratios of 65 rice genotypes was recorded and mean values are given in Table 14. It varies from 1.12 to 1.66. The highest Kernel elongation ratio among long duration rice genotypes was recorded in 'Valan kunhivithu' and was found to be on par with 18 rice genotypes. Among medium duration rice genotypes Culture JO-532-1 recorded high kernel elongation ratio and was found to be on par with 17 other rice genotypes. 'Onam' recorded high kernel elongation ratio among short duration rice genotypes and was found to be on par with 4 other rice genotypes. 'Kandoorkutty' the long duration rice genotype recorded lowest kernel elongation ratio.

Plate 7. The genotype Badhra recorded highest number of panicles (16) per plant under organic management during rabi season

Plate 8. The genotype Mahsuri recorded highest number of grains(282) per panicle under organic management during rabi season

Plate 9. The genotype Vyttila-4 recorded highest panicle length (30.1cm)under organic management during rabi season

Plate 10. The traditional rice genotype Valichoori recorded highest 1000 grains weight (35.8gm) under organic management during rabi season

Table 14. Mean performance of genotypes for Physico-chemical and cooking quality parameters

Genotype	Physico-chemical and cooking quality parameters			
	L/B ratio of kernel	Hulling %	Volume expansion ratio	Kernel elongation ratio
Long duration				
Annapurna	1.8	75.4	3.30	1.43*
Aasha	2.3	78.6*	3.73	1.44*
Chembav	2.4	72.4	2.27	1.32*
Culture JK-14	2.4	70.2	3.73	1.21
Culture JO-583	2.5	75.1	3.83	1.40*
Culture MK-157	2.2	78.0*	4.03*	1.42*
Ezhome-2	2.1	78.9*	3.50	1.25
Gandakasala	2.7	74.3	2.87	1.53*
IR-28	2.1	73.6	3.03	1.60*
Kanakom	2.3	80.7*	3.37	1.26
Kandoorkutty	2.4	74.7	1.97	1.12
Karthika	2.3	78.5*	2.63	1.39*
Karuna	2.3	66.3	2.90	1.36*
Krishnanjana	2.1	74.6	3.80	1.23
Mahsuri	2.2	73.2	3.97	1.40*
Neeraja	2.2	72.7	2.43	1.47*
Orkayama	2.3	76.8*	3.87	1.38*
Pusa Basmathi	4.8*	68.3	3.57	1.12
Red Mahsuri	2.5	73.8	3.53	1.27

Remanika	2.5	70.7	2.50	1.27
Revathy	2.3	75	2.87	1.32
Swetha	2.2	74.8	3.70	1.31*
Valankunhivithu	1.8	69.5	4.03*	1.66*
Valicha	2.5	69.9	4.00	1.52*
Valichoori	2.3	75.1	3.20	1.33*
Vellathondi	2.2	76.5*	2.43	1.36*
Vytilla-4	2.3	75.9	3.40	1.34*
Medium duration				
Aathira	2.5	76.4*	3.03	1.24
Aishwarya	2.5	77.4*	3.23	1.33*
Aruna	2.8	76.5*	3.07	1.34*
Ayirankana	2.3	75.7	3.13	1.37*
Badhra	2.3	77.3*	3.20	1.37*
Bhagya	2.2	76	2.41	1.36*
CO-47	2.3	73.7	4.07*	1.50*
Culture JK-59	2.2	78.1*	3.93	1.42*
Culture JO-532-1	2.1	79.9*	3.50	1.56*
Dhanu	2.1	77.7*	3.47	1.32*
Ezhome-1	2.3	80.6*	3.33	1.39*
Ezhome-3	2.3	78.1*	3.60	1.45*
FL-478	2.6	77.8*	3.53	1.52*
Gouri	2.1	79.3*	2.77	1.38*
Kanchana	2.9	77.9*	3.43	1.15
Karishma	2.1	76.3	2.83	1.24
Kasthuri	2.9	75.7	3.70	1.37*

Prathyasha	2.2	74.4	3.40	1.23
Remya	2.6	78.4*	3.00	1.21
Renjini	2.4	76.4*	3.07	1.52*
Sagara	1.9	78.3*	2.67	1.37
Samyuktha'	2.1	76.5*	3.47	1.23
Swarnaprabha	2.8	75.8	3.20	1.42*
Uma	2.4	78.3*	3.60	1.54*
Velambalan	2.2	74.3	3.13	1.39*
Short duration				
Anaswara	2.1	78.5*	3.23	1.39*
Culture JK-15	2.5	77.6*	3.33	1.39*
Culture JK-71	2.2	80.9*	3.33	1.37*
Culture MK-115	2.4	79.9*	3.33	1.15
Hariyana basmathi	3.6	76.1	2.70	1.24
Kalladiyaran	2.45	76.3	2.63	1.18
Kuthiru	2.3	79.3*	3.77	1.32*
Kuttoos	2.2	76.1	2.70	1.23
Makam	2.4	79.9*	2.87	1.28
Njavara	2.5	77.2*	2.57	1.17
Onam	2.0	72.4	3.33	1.48*
Vaishakh	2.4	75.5	3.67	1.28
Vytilla-1	2.1	80.2*	3.30	1.25
CV (%)	**4.0**	**3.0**	**5.71**	**1.63**
CD(0.05)	**0.2**	**4.6**	**0.37**	**0.04**

('*'Significant and on par)

4.1.3.5. Colour of kernel

The Colour of kernel of 65 rice genotypes was recorded and are presented in Table 15. The genotypes Culture JK-14, 'Krishnanjana', 'Makam', 'Samyuktha', 'Kasthuri', 'Aathira', 'Red Mahsuri', Culture JK-59, 'Ayirankana', 'Vytilla-4', 'Kanakom', Culture MK-115, 'Kanchana', 'Njavara', 'Vytilla-1', 'Vaishakh', 'Bhagya', Culture JK-71, 'Remya', 'Badhra', 'Kuthiru', 'Orkayama', 'Valichoori', 'Ezhome-1', 'Revathy', 'Gouri', 'Prathyasha', 'Karishma', 'Uma', 'Anaswara', 'Ezhome-2', 'Dhanu', 'Kalladiyaran', 'Kandoorkutty', 'Kuttoos', 'Annapurna', 'Aruna', 'Gandakasala', 'Valicha', 'Hariyanabasmathi', 'Culture JO-583', 'Karuna', Culture JK-15, 'Sagara', 'Vellathondi', 'Remanika', 'Karthika', 'Aishwarya', 'FL-478', 'Renjini', 'Ezhome-3' and 'Aasha' recorded red kernel colour and remaining all other genotypes recorded white kernel colour.

4.1.3.6. Alkali spreading value

Alkali spreading value of 65 rice genotypes was recorded and mean values are presented in Table 15 and it ranges from 1 to 5. Thirteen rice genotypes recorded alkali spreading value-1, nineteen rice genotypesrecorded alkali spreading value-2. One genotype recorded Alkali spreading value-3, eight genotypes recorded alkali spreading value-4 and twenty one rice genotypes recorded alkali spreading value-5.

4.1.3.7. Sensory evaluation

The average Sensory evaluation scoring for taste, colour, aroma and appearenceof 65 rice genotypes was recorded as per nine point hedonic scale and are presented in Table 15 and it varies from 5.4 to 8.6. The highest Sensory evaluation score (8.6)was recorded in 'PusaBasmathi', followed by 'Culture MK-157' (8.3), 'FL-478' (8.3), 'Ezhome-1' (8.2), 'Mahsuri' (8.1), 'Gouri' (8.1), 'Swarnaprabha' (8.1), 'Dhanu' (8.1), 'IR-28' (8.1), 'Aasha' (8.1) and 'Aishwarya' (8.0). These were followed by remaining all other genotypes ranging from 7.9 to 5.4. Where, 'Makam' recorded lowest Sensory evaluation (5.4) scoring.

Table 15. Mean performance of genotypes for Physico-chemical and cooking quality parameters

Genotype	Physico-chemical and cooking quality parameters		
	Colour of kernel	Alkali spreading value	Sensory evaluation
Annapurna	Red	1	7.4
Aasha	Red	5	8.1
Chembav	White	5	6.4
Culture JK-14	Red	4	7.1
Culture JO-583	Red	2	7.3
Culture MK-157	White	5	8.3
Ezhome-2	Red	2	7.9
Gandakasala	Red	2	6.9
IR-28	White	2	8.1
Kanakom	Red	2	6.6
Kandoorkutty	Red	5	6.5
Karthika	Red	2	7.9
Karuna	Red	4	7.1
Krishnanjana	Red	2	7.5
Mahsuri	white	5	8.1
Neeraja	white	2	6.1
Orkayama	Red	5	7.7
PusaBasmathi	white	4	8.6
Red Mahsuri	Red	1	7.9
Remanika	Red	1	7.3
Revathy	Red	2	6.5

Swetha	white	5	7.8
Valankunhivithu	white	5	6.5
Valicha	Red	1	7.2
Valichoori	Red	2	6.5
Vellathondi	Red	5	7.8
Vytilla-4	Red	5	7.2
Aathira	Red	4	6.4
Aishwarya	Red	5	8.0
Aruna	Red	5	6.5
Ayirankana	Red	2	6.4
Badhra	Red	2	6.9
Bhagya	Red	1	7.1
CO-47	White	5	7.8
Culture JK-59	Red	2	7.1
Culture JO-532-1	White	1	7.8
Dhanu	Red	2	8.1
Ezhome-1	Red	5	8.2
Ezhome-3	Red	4	7.7
FL-478	Red	4	8.3
Gouri	Red	2	8.1
Kanchana	Red	1	6.9
Karishma	Red	3	7.5
Kasthuri	Red	5	7.2
Prathyasha	Red	2	6.7
Remya	Red	1	6.2
Renjini	Red	4	6.8

Sagara	Red	4	7.5
Samyuktha	Red	5	5.9
Swarnaprabha	white	5	8.1
Uma	Red	1	7.9
Velambalan	white	5	5.8
Anaswara	Red	1	7.8
Culture JK-15	Red	2	7.1
Culture JK-71	Red	2	7.1
Culture MK-115	Red	2	7.6
Hariyana Basmathi	Red	1	7.6
Kalladiyaran	Red	2	6.3
Kuthiru	Red	1	7.5
Kuttoos	Red	2	6.4
Makam	Red	4	5.4
Njavara	Red	5	6.8
Onam	white	1	5.9
Vaishakh	Red	5	6.6
Vytilla-1	Red	5	7.4

4.1.4. Incidence of pests and diseases

4.1.4.1. Incidence of pests

4.1.4.1.1. At growth stage

The incidence of pests at growth stage of 65 rice genotypes was recorded on the basis of visual observation and are presented in Table 16. Among the major pests recorded, the BPH attack was more compared to other pests. It was recorded in all most all the rice genotypes except for Culture JK-59, Culture MK-115, 'Remya', 'Badhra', 'Dhanu', 'Kalladiyaran', 'Aruna', 'Karuna', Culture JK-15, 'Sagara' and 'FL-478'. Leaf roller/Leaf folder was also recorded in all most all the genotypes except for 'Mahsuri', 'Aathira', 'Anashwara', Culture MK-115, 'Dhanu' and 'Karuna'. Stem borer attack was less compared to BPH and Leaf roller, it was recorded in few rice genotypes like 'Samyuktha', 'Kanakom', 'Swarnaprabha', 'Bhagya', 'Badhra', 'Aasha', 'Karuna' and 'Sagara' . The pests blue beetle and gall midge also recorded infew rice genotypes namely, 'Samyuktha', 'Kanakom', 'Swarnaprabha', 'Uma', 'Kalladiyaran', 'Kandoorkutty', 'Kuttoos', 'Valicha', Culture JO-583, 'Karthika', 'Aishwarya' and 'Ezhome-3'.At growth stage the genotypes, 'Dhanu' and Culture MK-115 found to be tolerant to all major pests studied. Culture JK-59, Culture JK-15 and 'FL-478' recorded to be tolerant to BPH. Similarly the genotypes 'Mahsuri', 'Aathira', 'Anaswara', Culture JK-59, Culture JK-15 and 'FL-478'found to be tolerant to leaf roller, stem borer and blue beetle.

4.1.4.1.2. At maturity stage

The incidence of pests at maturity stage of 65 rice genotypes was also recorded and are presented in Table 16. At this stage the major pest recorded was rice bug/ear head bug in all most all the rice genotypes except in'Makam', 'Aathira', Culture MK-157 (Jaiva), 'PusaBasmathi', 'Red Mahsuri', Culture JK-59, 'Chembav', 'Ayirankana', 'Vytilla-4', 'Swetha', 'Njavara', Culture JO-532-1 (Ezhome-4), Culture JK-71, 'Remya', 'Revathy', 'Prathyasha', 'Anaswara', 'Neeraja', 'Aruna', 'CO-47', 'Valicha', 'Sagara', 'Karthika'and 'Aishwarya'. The blue beetle attack was also recorded in few rice genotypes namely, 'Samyuktha', 'Kanakom', 'Kuthiru', 'Swarnaprabha', 'Kandoorkutty', Culture JO-583, and 'Ezhome-3'. The genotypes namely, 'Makam', Culture MK-157 (Jaiva), 'Mahsuri', 'Aathira', 'PusaBasmathi', 'Red Mahsuri', Culture JK-59,'Chembav', 'Ayirankana', 'Vytilla-4', 'Swetha', 'Njavara', Culture JO-532-1(Ezhome-4), Culture JK-71, 'Remya', 'Revathy', 'Prathyasha', 'Anashwara', 'Neeraja', 'Aruna', 'CO-47', 'Valicha', 'Sagara' and 'Aishwarya' found to be tolerant to all major pests studied at maturity stage.

4.1.4.2. Incidence of diseases

4.1.4.2.1. At growth stage

The incidence of diseases at growth stage of 65 rice genotypes was recorded and are depicted in Table 16. The major diseases recorded was blast and it recorded in all most all the rice genotypes except in'Makam', Culture MK-157 (Jaiva), 'Kasthuri', 'PusaBasmathi', 'Red Mahsuri', 'Chembav', 'Ayirankana', 'Njavara', 'Kuthiru', 'Ezhome-1', 'Revathy', 'Karishma', 'Anaswara', 'Neeraja', 'CO-47', 'Gandakasala', 'Valicha', Culture JK-15and 'Karthika'. The disease sheath blight was recorded in few rice genotypes namely, 'Makam', 'Samyuktha', 'Onam', 'Aathira', 'Red Mahsuri', 'Chembav', 'Kanakom', 'Kanchana', 'Njavara', 'Vaishakh', 'Remya', 'Badhra', 'Ezhome-1', 'Revathy', 'Gouri', 'Swarnaprabha', 'Uma', 'Dhanu', 'Neeraja', 'Valicha', 'Karuna', 'Sagara', 'Vellathondi', 'Valankunhivithu', 'Karthika', 'Aishwarya' and 'Aasha'. Brown spot was also recorded in few rice genotypes namely, 'Kanchana', 'Velambalan', 'Ezhome-1', 'Dhanu', 'Annapurna' and 'Aruna'. The genotypes namely, Culture MK-157 (Jaiva), 'Kasthuri', 'PusaBasmathi', 'Ayirankana', 'Kuthiru', 'Karishma', 'Anashwara', 'CO-47', 'Gandakasala', and Culture JK-15were found to be tolerant to all the diseases observed on visual evaluation basis.

4.1.4.2.2. At maturity stage

The incidence of diseases at maturity stage of 65 rice genotypes was recorded and are presented in Table 16. The major disease recorded was Blast and it recorded in all most all the rice genotypes except Culture MK-157 (Jaiva), 'Kasthuri', 'PusaBasmathi', 'Red Mahsuri', 'Chembav', 'Ayirankana', 'Njavara', 'Kuthiru', Culture JO-532-1 (Ezhome-4), 'Ezhome-1', Culture JK-71, 'Karishma', 'Anaswara','CO-47', 'Gandakasala', 'Valicha', Culture JO-583, Culture JK-15, 'Karuna' and 'Karthika'. The disease sheath blight was recorded in few rice genotypes namely, 'Onam', 'Vaishakh', 'Uma', 'Dhanu', 'Sagara', 'Karthika' and 'Aasha'. Brown spot was also recorded in few rice genotypes namely, 'Aruna', 'Ezhome-1' and 'Kanchana'. The genotypes namely, Culture MK-157 (Jaiva), 'Kasthuri', 'PusaBasmathi', 'Red Mahsuri', 'Chembav', 'Ayirankana', 'Njavara', Culture JO-532-1(Ezhome-4), 'Kuthiru', 'Karishma', 'Anashwara', 'CO-47', 'Valicha', Culture JO-583 and 'Karuna' recorded as tolerant to all the diseases studied.

Table 16. Incidence of pests and diseases scoring at growth and maturity stagesunder organic management during Rabi season

Genotype	Pest incidence at		Disease incidence at	
	Growth stage	**Maturity stage**	**Growth stage**	**Maturity stage**
Culture JK-14	BPH** Leaf roller** Stem borer Blue beetle	Rice bug*** Blue beetle	Blast* Sheath blight* Brown spot	Blast** Sheath blight Brown spot
Krishnanjana	BPH* Leaf roller*** Stem borer Blue beetle	Rice bug** Blue beetle	Blast* Sheath blight Brown spot	Blast* Sheath blight Brown spot
Makam	BPH** Leaf roller* Stem borer Blue beetle Leaf roller	Rice bug Blue beetle	Blast Sheath blight* Brown spot	Blast* Sheath blight Brown spot
Samyuktha	BPH*** Leaf roller*** Stem borer* Blue beetle*	Rice bug** Blue beetle*	Blast* Sheath blight* Brown spot	Blast** Sheath blight Brown spot
Culture MK-157 (Jaiva)	BPH*** Leaf roller** Stem borer Blue beetle	Rice bug Blue beetle	Blast Sheath blight Brown spot	Blast Sheath blight Brown spot
Mahsuri	BPH*	Rice bug	Blast*	Blast*

	Leaf roller Stem borer Blue beetle	Blue beetle	Sheath blight Brown spot	Sheath blight Brown spot
Onam	BPH*** Leaf roller*** Stem borer Blue beetle	Rice bug** Blue beetle	Blast* Sheath blight* Brown spot	Blast* Sheath blight* Brown spot
Kasthuri	BPH** Leaf roller** Stem borer Blue beetle	Rice bug*** Blue beetle	Blast Sheath blight Brown spot	Blast Sheath blight Brown spot
Aathira	BPH* Leaf roller Stem borer Blue beetle	Rice bug Blue beetle	Blast* Sheath blight* Brown spot	Blast** Sheath blight Brown spot
PusaBasmathi	BPH* Leaf roller* Stem borer Blue beetle	Rice bug Blue beetle	Blast Sheath blight Brown spot	Blast Sheath blight Brown spot
Red Mahsuri	BPH*** Leaf roller* Stem borer Blue beetle	Rice bug Blue beetle	Blast Sheath blight** Brown spot	Blast Sheath blight Brown spot
Culture JK-59	BPH Leaf roller** Stem borer Blue beetle	Rice bug Blue beetle	Blast* Sheath blight Brown spot	Blast* Sheath blight Brown spot
Chembav	BPH* Leaf roller* Stem borer Blue beetle	Rice bug Blue beetle	Blast Sheath blight** Brown spot	Blast Sheath blight Brown spot
Ayirankana	BPH***	Rice bug	Blast	Blast

	Leaf roller*** Stem borer Blue beetle	Blue beetle	Sheath blight Brown spot	Sheath blight Brown spot
Vytilla-4	BPH*** Leaf roller*** Stem borer Blue beetle	Rice bug Blue beetle	Blast* Sheath blight Brown spot	Blast** Sheath blight Brown spot
Kanakom	BPH* Leaf roller** Stem borer* Blue beetle*	Rice bug* Blue beetle*	Blast* Sheath blight* Brown spot	Blast* Sheath blight Brown spot
Swetha	BPH* Leaf roller** Stem borer Blue beetle	Rice bug Blue beetle	Blast* Sheath blight Brown spot*	Blast* Sheath blight Brown spot
Culture MK-115	BPH Leaf roller Stem borer Blue beetle	Rice bug* Blue beetle	Blast* Sheath blight Brown spot	Blast** Sheath blight Brown spot
Kanchana	BPH*** Leaf roller*** Stem borer Blue beetle	Rice bug** Blue beetle	Blast* Sheath blight** Brown spot*	Blast* Sheath blight Brown spot**
Njavara	BPH** Leaf roller* Stem borer Blue beetle	Rice bug Blue beetle	Blast Sheath blight** Brown spot	Blast Sheath blight Brown spot
Culture JO-532-1 (Ezhome-4)	BPH*** Leaf roller***	Rice bug Blue beetle	Blast* Sheath blight Brown spot	Blast Sheath blight

	Stem borer Blue beetle			Brown spot
Vytilla-1	BPH* Leaf roller* Stem borer Blue beetle	Rice bug*** Blue beetle	Blast* Sheath blight Brown spot**	Blast** Sheath blight Brown spot
Vaishakh	BPH* Leaf roller*** Stem borer Blue beetle Gall midge**	Rice bug* Blue beetle	Blast* Sheath blight*** Brown spot	Blast** Sheath blight** Brown spot
Bhagya	BPH*** Leaf roller** Stem borer* Blue beetle	Rice bug*** Blue beetle	Blast** Sheath blight Brown spot	Blast* Sheath blight Brown spot
Culture JK-71	BPH* Leaf roller* Stem borer Blue beetle	Rice bug Blue beetle	Blast** Sheath blight* Brown spot*	Blast* Sheath blight* Brown spot*
Remya	BPH Leaf roller* Stem borer Blue beetle Gall midge*	Rice bug Blue beetle	Blast** Sheath blight* Brown spot	Blast** Sheath blight Brown spot
Badhra	BPH Leaf roller* Stem borer** Blue beetle	Rice bug*** Blue beetle	Blast Sheath blight*** Brown spot	Blast* Sheath blight Brown spot
Kuthiru	BPH* Leaf roller*** Stem borer	Rice bug* Blue beetle*	Blast Sheath blight Brown spot	Blast Sheath blight Brown spot

	Blue beetle			
Orkayama	BPH** Leaf roller*** Stem borer Blue beetle	Rice bug* Blue beetle	Blast** Sheath blight Brown spot	Blast** Sheath blight Brown spot
Valichoori	BPH*** Leaf roller*** Stem borer Blue beetle	Rice bug* Blue beetle	Blast** Sheath blight Brown spot	Blast** Sheath blight Brown spot
Velambalan	BPH*** Leaf roller*** Stem borer Blue beetle	Rice bug** Blue beetle	Blast** Sheath blight* Brown spot	Blast** Sheath blight Brown spot
Ezhome-1	BPH** Leaf roller* Stem borer Blue beetle	Rice bug* Blue beetle	Blast Sheath blight* Brown spot*	Blast Sheath blight Brown spot*
Revathy	BPH* Leaf roller*** Stem borer Blue beetle Gall midge*	Rice bug Blue beetle	Blast Sheath blight** Brown spot	Blast* Sheath blight Brown spot
Gouri	BPH** Leaf roller*** Stem borer Blue beetle	Rice bug** Blue beetle	Blast** Sheath blight* Brown spot	Blast** Sheath blight Brown spot
Prathyasha	BPH*** Leaf roller*** Stem borer Blue beetle	Rice bug Blue beetle	Blast** Sheath blight Brown spot	Blast*** Sheath blight Brown spot
Karishma	BPH** Leaf	Rice bug* Blue beetle	Blast Sheath blight	Blast Sheath

	roller** Stem borer Blue beetle		Brown spot	blight Brown spot
Swarnaprabha	BPH** Leaf roller*** Stem borer** Blue beetle*	Rice bug Blue beetle*	Blast* Sheath blight*** Brown spot	Blast* Sheath blight Brown spot
Uma	BPH** Leaf roller*** Stem borer Blue beetle*	Rice bug** Blue beetle	Blast* Sheath blight* Brown spot	Blast* Sheath blight* Brown spot
Anashwara	BPH* Leaf roller Stem borer Blue beetle	Rice bug Blue beetle	Blast Sheath blight Brown spot	Blast Sheath blight Brown spot
Ezhome-2	BPH** Leaf roller*** Stem borer Blue beetle	Rice bug* Blue beetle	Blast** Sheath blight Brown spot	Blast*** Sheath blight Brown spot
Dhanu	BPH Leaf roller Stem borer Blue beetle	Rice bug* Blue beetle	Blast Sheath blight* Brown spot*	Blast* Sheath blight* Brown spot
Kalladiyaran	BPH Leaf roller*** Stem borer Blue beetle*	Rice bug*** Blue beetle	Blast** Sheath blight Brown spot	Blast* Sheath blight Brown spot
Kandoorkutty	BPH** Leaf roller* Stem borer	Rice bug** Blue beetle	Blast* Sheath blight Brown spot	Blast** Sheath blight

	Blue beetle*			Brown spot
Kuttoos	BPH** Leaf roller* Stem borer Blue beetle*	Rice bug** Blue beetle	Blast** Sheath blight Brown spot	Blast** Sheath blight Brown spot
Annapurna	BPH*** Leaf roller*** Stem borer Blue beetle	Rice bug** Blue beetle	Blast* Sheath blight Brown spot*	Blast** Sheath blight Brown spot
Neeraja	BPH*** Leaf roller** Stem borer Blue beetle	Rice bug Blue beetle	Blast Sheath blight*** Brown spot	Blast* Sheath blight Brown spot
Aruna	BPH Leaf roller** Stem borer* Blue beetle	Rice bug Blue beetle	Blast* Sheath blight Brown spot*	Blast* Sheath blight Brown spot*
CO-47	BPH** Leaf roller** Stem borer Blue beetle	Rice bug Blue beetle	Blast Sheath blight Brown spot	Blast Sheath blight Brown spot
Gandakasala	BPH** Leaf roller** Stem borer Blue beetle	Rice bug*** Blue beetle	Blast Sheath blight Brown spot	Blast* Sheath blight Brown spot
Valicha	BPH*** Leaf roller*** Stem borer Blue beetle*	Rice bug Blue beetle	Blast Sheath blight* Brown spot	Blast Sheath blight Brown spot
Hariyanabasmathi	BPH***	Rice bug**	Blast*	Blast**

	Leaf roller*** Stem borer Blue beetle	Blue beetle	Sheath blight Brown spot	Sheath blight Brown spot
Culture JO-583	BPH*** Leaf roller*** Stem borer Blue beetle*	Rice bug* Blue beetle*	Blast* Sheath blight Brown spot	Blast Sheath blight Brown spot
Karuna	BPH Leaf roller Stem borer* Blue beetle	Rice bug** Blue beetle	Blast* Sheath blight* Brown spot	Blast Sheath blight Brown spot
Culture JK-15	BPH Leaf roller* Stem borer Blue beetle	Rice bug* Blue beetle	Blast Sheath blight Brown spot	Blast** Sheath blight Brown spot
Sagara	BPH Leaf roller*** Stem borer* Blue beetle	Rice bug Blue beetle	Blast* Sheath blight* Brown spot	Blast Sheath blight* Brown spot
Vellathondi	BPH*** Leaf roller* Stem borer Blue beetle	Rice bug* Blue beetle	Blast** Sheath blight* Brown spot	Blast** Sheath blight Brown spot
Valankunhivithu	BPH*** Leaf roller* Stem borer Blue beetle	Rice bug* Blue beetle	Blast Sheath blight** Brown spot	Blast* Sheath blight Brown spot
Remanika	BPH* Leaf roller*** Stem borer	Rice bug* Blue beetle	Blast* Sheath blight Brown spot	Blast** Sheath blight Brown spot

	Blue beetle			
Karthika	BPH*** Leaf roller*** Stem borer Blue beetle*	Rice bug Blue beetle*	Blast Sheath blight* Brown spot	Blast* Sheath blight** Brown spot
Aishwarya	BPH*** Leaf roller*** Stem borer Blue beetle*	Rice bug Blue beetle	Blast** Sheath blight* Brown spot	Blast* Sheath blight Brown spot
FL-478	BPH Leaf roller* Stem borer Blue beetle	Rice bug*** Blue beetle	Blast* Sheath blight Brown spot	Blast* Sheath blight Brown spot
IR-28	BPH** Leaf roller** Stem borer Blue beetle	Rice bug*** Blue beetle	Blast*** Sheath blight Brown spot	Blast** Sheath blight Brown spot
Renjini	BPH* Leaf roller*** Stem borer Blue beetle	Rice bug** Blue beetle	Blast* Sheath blight Brown spot	Blast** Sheath blight Brown spot
Ezhome-3	BPH** Leaf roller* Stem borer Blue beetle*	Rice bug* Blue beetle*	Blast** Sheath blight Brown spot	Blast** Sheath blight Brown spot
Aasha	BPH* Leaf roller*** Stem borer* Blue beetle	Rice bug* Blue beetle	Blast** Sheath blight* Brown spot	Blast*** Sheath blight* Brown spot

( ) – No incidence (*) - Slight/mild (**) - Moderate (***) - High/Severe

4.2. Character association

Studies on association of characters gain importance in plant breeding, because they aim the plant breeders to know the inter-character influence and help to strike economic and reliable balance between various characters. Moreover, genotypic correlations have their own importance because of their stability and reliability as these relationships arise through genetic reasons namely, linkage or pleiotropy (Vanaja *et al.*, 1998). Since yield is a complex character, the practice of unilateral selection often results in retrograde or less optimum progress in isolating superior genotypes. Therefore, the knowledge of inter relationships of characters, play a vital role in developing appropriate selection criteria for the improvement of complex characters like grain yield. The results of correlation and path analysis studies between grain yield palnt^{-1} and different parameters are presented below.

4.2.1. Correlation

Genotypic and phenotypic correlation coefficients among the twenty six characters were assessed and are presented in Table 17.

Grain yield plant^{-1} showed positive association at 1% level of significance, at both genotypic and phenotypic levels with the characters namely, number of tillers plant^{-1} at 30DAT, number of tillers plant^{-1} at 60DAT, number of tillers plant^{-1} at 90DAT, number of tillers plant^{-1} at harvest, number of productive tillers plant^{-1}, number of spikelets panicle^{-1}, number of grains panicle^{-1}, seed setting %, straw yield plant^{-1} and hulling %. At the same time the characters namely, chlorophyll content of flag leaf and chlorophyll content of third leaf showed negative correlation with grain yield plant^{-1} at 1% level of significance, at both genotypic and phenotypic levels.

Root length exhibited positive association at 1% level of significance with root spread and L/B ratio of kernel at both genotypic and phenotypic levels. At the same time the characters namely, chlorophyll content of flag leaf and chlorophyll content of third leaf showed positive correlation at 1% level of significance with root length at genotypic level but chlorophyll content of flag leaf showed positive association with root length at 5% level of significance. Negative correlation was recorded for root length at 1% level of significance with number of productive tillers plant^{-1} at genotypic level, and at the same time plant height at 30DAT, total biomass plant^{-1}, length of panicle and hulling % also recorded negative correlation at 5% level of significance with root length at phenotypic level.

Root weight exhibited positive and significant associated at 5% level of significance with chlorophyll content of flag leaf and chlorophyll content of third leaf at genotypic level. At the same time it recorded negative association at 1% level of significance with plant height at 90DAT, root spread and plant height at harvest, and also shown 5% level of significance with plant height at 60DAT with genotypic level.

Root spread found to have positive association at 1% level of significance with number of spikelets panicle^{-1} and L/B ratio of kernel and 5% level of association with number of grains panicle^{-1} and straw yield plant^{-1} at genotypic level. But at phenotypic level only straw yield plant^{-1} and number of spikelets panicle^{-1} correlated significantly positive at 1% and 5% level of significance respectively. The characters namely, chlorophyll content of flag leaf, chlorophyll content of third leaf, plant height at 30DAT and 1000 grains weight exhibited negative significant association at 5% level of significance with root spread at genotypic level, but there was no correlation at phenotypic level.

At both genotypic and phenotypic levels, chlorophyll content of flag leaf showed positive association at 1% level of significance with chlorophyll content of third leaf. Similarly showed negative association with number of tillers plant^{-1} at 60DAT, number of tillers plant^{-1} at 90DAT, number of tillers plant^{-1} at harvest, total biomass plant^{-1}, number of productive tillers plant^{-1}, number of tillers plant^{-1} at 30DAT, straw yield plant^{-1}, hulling % at 1% level of significance and negative association with plant height at 90DAT, plant height at harvest, number of grains panicle^{-1} and 5% level of significance respectively. At 1% level of significance, plant height at 60DAT and plant height at 90DAT recorded negative association at genotypic level, but they showed positive association at phenotypic level.

Chlorophyll content of third leaf found to have negative association at 1% level of significance with plant height at 30DAT, plant height at 60DAT, plant height at 90DAT, plant height at harvest, number of tillers plant^{-1} at 30DAT, number of tillers plant^{-1} at 60DAT, number of tillers plant^{-1} at 90DAT, number of tillers plant^{-1} at harvest, total biomass plant^{-1}, number of productive tillers plant^{-1}, number of grains panicle^{-1} and straw yield plant^{-1} at both genotypic and phenotypic levels. It also recorded negative association with hulling % at genotypic and phenotypic levels at 1% and 5% level of significance respectively. Similarly, number of spikelets panicle^{-1} and seed setting % exhibited 5% level of significance association with chlorophyll content of third leaf at genotypic level.

Plant height at 30DAT observed to have positive association with plant height at 60DAT, plant height at 90DAT, plant height at harvest, number of tillers plant^{-1} at 30DAT, number of tillers plant^{-1} at 60DAT, number of tillers plant^{-1} at 90DAT, length of panicle at 1% level of significance and also with 1000 grains weight at 5% level of significance, at both genotypic and phenotypic levels. Chlorophyll content of flag leaf, chlorophyll content of third leaf and kernel elongation ratio showed negative association at 1% level of significance at both genotypic and phenotypic levels. Number of productive tillers plant^{-1}, seed setting %, hulling % and straw yield plant^{-1} also exhibited positive association at 5% and 1% level of significance at genotypic level. At the same time root length, root weight and root spread exhibited negative association at 5% level of significance at genotypic level.

Plant height at 60DAT exhibited positive association at 1% level of significance with plant height at 90DAT, plant height at harvest, number of tillers plant^{-1} at 30DAT, number of tillers plant^{-1} at 60DAT, number of tillers plant^{-1} at 90DAT and length of panicle at both genotypic and phenotypic levels. At the same time kernel elongation ratio exhibited negative association at 1% level of significance at both genotypic and phenotypic levels. Straw yield plant^{-1} exhibited positive association at both genotypic and phenotypic levels, at 1% and 5% level of significance respectively. Plant height at 60DAT also exhibited positive association at 5% level of significance with seed setting % at genotypic level.

Plant height at 90DAT observed to have positive association at 1% level of significance with plant height at harvest and length of panicle at both genotypic and phenotypic levels. At the same time kernel elongation ratio exhibited negative association at 1% level of significance at both genotypic and phenotypic levels. Number of tillers plant^{-1} at 30DAT, number of spikelets panicle^{-1} and straw yield plant^{-1} exhibited positive association at both genotypic and phenotypic levels, at 1% and 5% level of significance respectively. Plant height at 90DAT also exhibited positive association at 5% level of significance with number of tillers at 60DAT and seed setting % at genotypic level.

Plant height at harvest showed positive association at 1% level of significance with length of panicle at both genotypic and phenotypic levels. At the same time kernel elongation ratio exhibited negative association at 5% level of significance at both genotypic and phenotypic levels. Number of tillers plant^{-1} at 30DAT and straw yield plant^{-1} exhibited positive association at both genotypic and phenotypic levels at 1% and 5% level of significance respectively. Plant height at harvest also exhibited positive association at 5% level of significance with number of tillers plant^{-1} at 60DAT.

Number of tillers plant^{-1} at 30DAT exhibited positive association at 1% level of significance with number of tillers plant^{-1} at 60DAT, number of tillers plant^{-1} at 90DAT, number of tillers plant^{-1} at harvest, total biomass plant^{-1}, number of productive tillers plant^{-1}, straw yield plant^{-1} and at 5% level of significance association with hulling % at both genotypic and phenotypic levels. Kernel elongation ratio and length of panicle exhibited negative association at both genotypic and phenotypic levels, at 1% and 5% level of significance respectively.

Number of tillers plant^{-1} at 30DAT also exhibited negative association at 5% level of significance with volume expansion.

Number of tillers plant^{-1} at 60DAT exhibited positive association at 1% level of significance with number of tillers plant^{-1} at 90DAT, number of tillers plant^{-1} at harvest, total biomass plant^{-1}, number of productive tillers plant^{-1} and straw yield plant^{-1} at both genotypic and phenotypic levels. Similarly, kernel elongation ratio exhibited negative association at 1% level of significance at both genotypic and phenotypic levels. Length of panicle showed positive association at 1% level of significance at genotypic level, at the same time volume expansion exhibited negative association at 5% level of significance at genotypic level. Number of tillers plant^{-1} at 60DAT also exhibited negative association with length of panicle at both genotypic and phenotypic, at 1% and 5% level of significance respectively.

Number of tillers plant^{-1} at 90DAT observed to have positive associated at 1% level of significance with number of tillers plant^{-1} at harvest, total biomass plant^{-1}, number of productive tillers plant^{-1} and straw yield plant^{-1} at both genotypic and phenotypic levels. Similarly, hulling % also showed positive association at 5% level of significance, at both genotypic and phenotypic levels. Length of the panicle also showed negative association at 1% level of significance at genotypic level, similarly at 5% level of significance, at phenotypic level. Number of tillers plant^{-1} at 90DAT also exhibited negative associated at 1% level of significance with number of spikelets panicle^{-1}.

At both genotypic and phenotypic levels number of tillers plant^{-1} at harvest stage exhibited positive association with total biomass plant^{-1}, number of productive tillers plant^{-1} and straw yield plant^{-1} at 1% level of significance. At the same time length of panicle exhibited negative association at 1% level of significance at both genotypic and phenotypic levels. Number of tillers plant^{-1} at harvest also shown negative association with number of spikelets panicle^{-1} and volume expansion at genotypic and phenotypic levels, at 1% and 5% level of significance respectively. Hulling % also exhibited positive association at 1% level of significance at genotypic level. Similarly kernel elongation ratio exhibited negative association at 5% level of significance at genotypic level.

Total biomass plant^{-1} observed to have positive association at 1% level of significance with number of productive tillers plant^{-1} at both genotypic and phenotypic levels. Similarly, seed setting % exhibited negative association at 1% level of significance at both genotypic and phenotypic levels. Length of panicle and volume expansion also showed negative association at 5% level of significance with total biomass plant^{-1} at genotypic level. At the same time straw yield plant^{-1} exhibited positive association at phenotypic level with total biomass plant^{-1} at 5% level of significance.

At both genotypic and phenotypic levels, number of productive tillers plant^{-1} exhibited positive associated at 1% level of significance with straw yield plant^{-1}and hulling %. At the same time length of panicle exhibited negative association at 1% level of significance at both genotypic and phenotypic levels. Number of productive tillers plant^{-1} also shown negative association at both genotypic and phenotypic levels with number of spikelets panicle^{-1} at 1% and 5% level of significance respectively.

Number of spikelets panicle^{-1} observed to have positive association at 1% level of significance with seed setting % and length of panicle at both genotypic and phenotypic levels. Similarly, 1000 grains weight exhibited negative association at both genotypic and phenotypic levels at 1% level of significance. Number of spikelets panicle^{-1} also exhibited positive association with straw yield plant^{-1} at both genotypic and phenotypic levels, at 1% and 5% level of significance respectively. It also exhibited positive association at genotypic level with seed setting %, at 5% level of significance.

Number of grains panicle^{-1} exhibited positive association at 1% level of significance with seed setting %, length of panicle, straw yield plant^{-1} and volume expansion at both genotypic and phenotypic levels. Similarly, 1000 grains weight also exhibited negative association at 5% level of significance, at both genotypic and phenotypic levels.

Seed setting % observed to have positive association at 1% level of significance with kernel elongation ratio at genotypic level and 5% level of significance at phenotypic level. At the same it also exhibited positive association at 5% level of significance with straw yield plant^{-1} at genotypic level.

Length of panicle exhibited negative association with kernel elongation ratio at both genotypic and phenotypic levels, at 1% level of significance. At both genotypic and phenotypic levels 1000 grains weight exhibited positive association at 1% level of significance with hulling %. It also showed negative association with straw yield plant^{-1} at genotypic level, at 5% level of significance.

Straw yield plant^{-1} observed have positive association at 1% level of significance with number of tillers plant^{-1} at 30DAT, number of tillers plant^{-1} at 60DAT, number of tillers plant^{-1} at 90DAT, number of tillers plant^{-1} at harvest, number of productive tillers plant^{-1}, seed setting % at both genotypic and phenotypic levels. At the same time it also exhibited negative association at 1% level of significance with chlorophyll content of flag leaf, chlorophyll content of third leaf and kernel elongation ratio at both genotypic and phenotypic levels. Straw yield plant^{-1} also exhibited positive association at 1% level of significance with plant height at 30DAT, plant height at 60DAT, plant height at 90DAT, plant height at harvest and number of spikelets panicle^{-1} at genotypic level and 5% level of significance with plant height at 60DAT, plant height at 90DAT, plant height at harvest and number of spikelets panicle^{-1} at phenotypic level. Similarly at 5% level of significance, it also exhibited positive association with root spread and seed setting % and negative association with 1000 grains weight at genotypic level. At the same time it also exhibited positive association at 1% level of significance with root spread and 5% level of significance with total biomass plant^{-1} and hulling % at phenotypic level.

L/B ratio of kernel showed negative association at 1% level of significance with kernel elongation ratio at both genotypic and phenotypic levels. Similarly, it also recorded negative association with hulling % at both genotypic and phenotypic levels, at 1% and 5% level of significance respectively.

Hulling % exhibited positive association at 1% level of significance with grain yield plant^{-1} at both genotypic and phenotypic levels. Similarly, Volume expansion showed positive association at 1% level of significance with kernel elongation ratio at both genotypic and phenotypic levels.

Table 17. Genotypic (rg) and Phenotypic (rp) correlation coefficient between grain yield plant^{-1} and growth, yield and physico-chemical parameters of 65 rice genotypes under organic management during Rabi season

		A	B	C	D	E	F	G	H	I	J	K	L	M
A	r_g	1	0.0319	0.3849**	0.2912**	0.4017**	-0.2195*	-0.0386	-0.0261	0.0062	-0.0927	-0.139	-0.1114	-0.0414
	r_p	1	0.0423	0.5314**	0.1932*	0.1138	-0.1379	-0.0446	-0.0063	0.0028	0.0096	0.0135	0.0157	0.0454
B	r_g	0.0319	1	-0.5172**	0.1804*	0.1804*	-0.1763	-0.1776*	-0.2461**	-0.2382**	-0.04	-0.0573	0.018	0.0702
	r_p	0.0423	1	-0.0755	0.1252	0.0839	-0.0701	-0.1246	-0.1765*	-0.1708	-0.0469	-0.0131	-0.0481	-0.0133
C	r_g	0.3849**	-0.5172**	1	-0.2087*	-0.1864*	-0.2178*	-0.0051	0.141	0.1584	0.1492	0.0103	-0.0274	0.0144
	r_p	0.5314**	-0.0755	1	-0.0604	-0.0534	-0.1013	-0.0041	0.1015	0.0907	0.1349	0.1516	0.1338	0.159
D	r_g	0.2912**	0.1804*	-0.2087*	1	0.9476**	-0.3379**	-0.3105**	-0.2179*	-0.1907*	-0.787**	-0.6951**	-0.6743**	-0.578**
	r_p	0.1932*	0.1252	-0.0604	1	0.8186**	0.2702**	0.2781**	-0.2014*	-0.1822*	-0.5625**	-0.5106**	-0.4631**	-0.4322**
E	r_g	0.4017**	0.1804*	-0.1864*	0.9476**	1	-0.5132**	-0.4481**	-0.3262**	-0.3013**	-0.8034**	-0.7148**	-0.6887**	-0.5397**
	r_p	0.1138	0.0839	-0.0534	0.8186**	1	-0.3680**	-0.3429**	-0.2623**	-0.2664**	-0.4697**	-0.4246**	-0.3802**	-0.3455**
F	r_g	-0.2195* .	-0.1763*	-0.2178*	-0.3379**	-0.5132**	1	0.9823**	0.8601**	0.8639**	0.2997**	0.3128**	0.318**	0.1396
	r_p	-0.1379	-0.0701	-0.1013	-0.2702**	-0.3680**	1	0.9159**	0.7702**	0.7702**	0.3263**	0.2911**	0.2558**	0.1552
G	r_g	-0.0386	-0.1776*	-0.0051	-0.3105**	-0.4481**	0.9823**	1	0.9133**	0.9176**	0.3076**	0.2853**	0.2937**	0.1654
	r_p	-0.0446	-0.1246	-0.0041	-0.2781**	-0.3429**	0.9159**	1	0.8554**	0.8548**	0.3214**	0.2843**	0.2576**	0.1681
H	r_g	-0.0261	-0.2461**	0.141	-0.2179*	-0.3262**	0.8601**	0.9133**	1	0.9979**	0.2505**	0.1832*	0.1678	0.0294
	r_p	-0.0063	-0.1765*	0.1015	-0.2014*	-0.2623**	0.7702**	0.8554**	1	0.9904**	0.2057*	0.1485	0.1087	0.0087
I	r_g	0.0062	-0.2382**	0.1584	-0.1907*	-0.3013**	0.8639**	0.9176**	0.9979**	1	0.2486**	0.1815*	0.1654	0.0254
	r_p	0.0028	-0.1708	0.0907	-0.1822*	-0.2664**	0.7702**	0.8548**	0.9904**	1	0.1957*	0.1405	0.1126	0.0092
J	r_g	-0.0927	-0.04	0.1492	-0.787**	-0.8034**	0.2997**	0.3076**	0.2505**	0.2486**	1	1.0077**	0.9074**	0.8545**
	r_p	0.0096	-0.0469	0.1349	-0.5625**	-0.4697**	0.3263**	0.3214**	0.2057*	0.1957*	1	0.8415**	0.7463**	0.7108**
K	r_g	-0.139	-0.0573	0.0103	-0.6951**	-0.7148**	0.3128**	0.2853**	0.1832*	0.1815*	1.0077**	1	1.0206**	0.9614**
	r_p	0.0135	-0.0131	0.1516	-0.5106**	-0.4246**	0.2911**	0.2843**	0.1485	0.1405	0.8415**	1	0.8709**	0.8275**
L	r_g	-0.1114	0.018	-0.0274	-0.6743**	-0.6887**	0.318**	0.2937**	0.1678	0.1654	0.9074**	1.0206**	1	0.9794**
	r_p	0.0157	-0.0481	0.1338	-0.4631**	-0.3802**	0.2558**	0.2576**	0.1087	0.1126	0.7463**	0.8709**	1	0.8796**
M	r_g	-0.0414	0.0702	0.0144	-0.578**	-0.5397**	0.1396	0.1654	0.0294	0.0254	0.8545**	0.9614**	0.9794**	1
	r_p	0.0454	-0.0133	0.159	-0.4322**	-0.3455**	0.1552	0.1681	0.0087	0.0092	0.7108**	0.8275**	0.8796**	1
N	r_g	-0.1938*	-0.1601	0.1083	-0.3959**	-0.3831**	0.1702	0.1105	0.0311	0.0367	0.6139**	0.6601**	0.5043**	0.3899**
	r_p	-0.0825	-0.1414	0.0595	-0.3494**	-0.2802**	0.1384	0.0971	0.0232	0.0316	0.4534**	0.4623**	0.3828**	0.3386**
O	r_g	-0.4399**	-0.0533	-0.1547	-0.7457**	-0.5173**	0.1749*	0.1598	-0.0285	-0.0312	0.8846**	0.8905**	0.9359**	0.94**
	r_p	-0.1078.	-0.0503	-0.0716	-0.4875**	-0.4091**	0.1275	0.1423	-0.0343	-0.0212	0.5593**	0.5312**	0.5956**	0.7022**
P	r_g	0.0054	-0.0981	0.4606**	-0.171	-0.2017*	0.0213	0.0526	0.2343**	0.2095*	-0.0491	-0.0804	-0.1855*	-0.2394**
	r_p	-0.0278	-0.0977	0.1879*	-0.1507	-0.1627	0.0237	0.0508	0.2163*	0.1972*	-0.0103	-0.0821	-0.1466	-0.1901*

Q	r_g	0.0723	-0.0169	0.2168*	-0.2236	-0.3099**	0.0457	0.0842	0.1257	0.1153	-0.0897	-0.0833	-0.0937	-0.1482
	r_p	0.041	-0.0128	0.1222	-0.1976*	-0.2362**	0.0408	0.0708	0.1233	0.1144	-0.0566	-0.0535	-0.0569	-0.1086
R	r_g	0.1383	0.1382	0.0992	-0.1313	-0.1939*	0.1881*	0.21*	0.1727*	0.1607	-0.0243	-0.2119*	-0.1188	-0.0768
	r_p	0.1047	-0.0601	-0.0331	-0.1068	-0.1098	0.0353	0.1217	0.1216	0.1089	-0.0142	-0.019	0.0086	-0.0153
S	r_g	-0.2153*	-0.0506	-0.0662	0.0127	-0.1436	0.372**	0.3089**	0.3585**	0.3643**	-0.3098**	-0.2603**	-0.2538**	-0.3104**
	r_p	-0.0923	-0.0328	-0.0035	0.0053	-0.1281	0.3247**	0.2812**	0.3536**	0.3607**	-0.2163*	-0.1804*	-0.1734*	-0.2549**
T	r_g	0.0962	-0.0522	-0.2152	0.018	-0.1372	0.1857*	0.1703	0.0294	0.0398	-0.0679	-0.0941	-0.0252	-0.0509
	r_p	0.0479	-0.0352	-0.1067	0.0174	-0.1037	0.1731*	0.1657	0.0323	0.0407	-0.0423	-0.0575	-0.0166	-0.0357
U	r_g	-0.0883	0.1569	0.2129*	-0.4473**	-0.3543**	0.2422**	0.2396**	0.2714**	0.2673**	0.7226**	0.7625**	0.5957**	0.6012**
	r_p	0.1568	0.1176	0.2418**	-0.3105**	-0.2832**	0.1707	0.2090*	0.1942*	0.2008*	0.5309**	0.4756**	0.4995**	0.4983**
V	r_g	0.4327	0.1303	0.3186**	0.1509	0.1029	-0.1143	-0.0596	-0.0052	-0.0105	0.0797	0.0162	-0.015	-0.0371
	r_p	0.2376**	0.0911	0.1685	0.1568	0.081	-0.0772	-0.0171	0.0022	-0.0044	0.0948	0.0483	0.0111	-0.0084
W	r_g	-0.1997	-0.0191	-0.0113	-0.4034	-0.3343**	0.1762*	0.1167	-0.0318	-0.0519	0.2227*	0.2431**	0.2054*	0.2324**
	r_p	-0.0692	-0.0406	-0.0361	-0.2717**	-0.2041*	0.1168	0.1139	-0.0151	-0.0327	0.2249*	0.1399	0.1815*	0.1568
X	r_g	-0.1725*	0.0579	-0.1659	-0.1018	-0.1502	-0.048	-0.0201	-0.0604	-0.057	-0.2172*	-0.2157*	-0.1687	-0.2806**
	r_p	-0.0989	0.0664	-0.0765	-0.0746	-0.0834	-0.0095	0.0008	-0.0514	-0.0549	-0.0828	-0.0911	-0.0805	-0.1775*
Y	r_g	-0.1151	0.1027	-0.0478	0.0285	0.0996	-0.2609**	-0.2792**	-0.2867**	-0.2813**	-0.3159**	-0.3675**	-0.2392**	-0.2174*
	r_p	-0.0477	0.0817	0.0102	0.0325	0.1065	-0.2383**	-0.2490**	-0.2772**	-0.2747**	-0.2144*	-0.2396**	-0.1461	-0.1624
Z	r_g	-0.1203	0.039	-0.0056	-0.4386**	-0.345**	0.0514	0.1056	0.0434	0.0165	0.3282**	0.2749**	0.2829**	0.2723**
	r_p	-0.0316	0.0046	0.0676	-0.3989**	-0.2723**	0.065	0.114	0.0306	0.0082	0.3157**	0.3036**	0.3298**	0.3669**

Table 14. Continued.

		N	O	P	Q	R	S	T	U	V	W	X	Y
A	r_g	-0.1938*	-0.4399**	0.0054	0.0723	0.1383	-0.2153*	0.0962	-0.0883	0.4327**	-0.1997*	-0.1725	-0.1151
	r_p	-0.0825	-0.1078	-0.0278	0.041	0.1047	-0.0923	0.0479	0.1568	0.2376**	-0.0692	-0.0989	-0.0477
B	r_g	-0.1601	-0.0533	-0.0981	-0.0169	0.1382	-0.0506	-0.0522	0.1569	0.1303	-0.0191	0.0579	0.1027
	r_p	-0.1414	-0.0503	-0.0977	-0.0128	-0.0601	-0.0328	-0.0352	0.1176	0.0911	-0.0406	0.0664	0.0817
C	r_g	0.1083	-0.1547	0.4606**	0.2168*	0.0992	-0.0662	-0.2152*	0.2129*	0.3186**	-0.0113	-0.1659	-0.0478
	r_p	0.0595	-0.0716	0.1879*	0.1222	-0.0331	-0.0035	-0.1067	0.2418**	0.1685	-0.0361	-0.0765	0.0102
D	r_g	-0.3959**	-0.7457**	-0.171	-0.2236*	-0.1313	0.0127	0.018	-0.4473**	0.1509	-0.4034**	-0.1018	0.0285
	r_p	-0.3494**	-0.4875**	-0.1507	-0.1976*	-0.1068	0.0053	0.0174	-0.3105**	0.1568	-0.2717**	-0.0746	0.0325
E	r_g	-0.3831**	-0.5173**	-0.2017*	-0.3099**	-0.1939*	-0.1436	-0.1372	-0.3543**	0.1029	-0.3343**	-0.1502	0.0996
	r_p	-0.2802**	-0.4091**	-0.1627	-0.2362**	-0.1098	-0.1281	-0.1037	-0.2832**	0.081	-0.2041*	-0.0834	0.1065
F	r_g	0.1702	0.1749*	0.0213	0.0457	0.1881*	0.372**	0.1857*	0.2422**	-0.1143	0.1762*	-0.048	-0.2609**
	r_p	0.1384	0.1275	0.0237	0.0408	0.0353	0.3247**	0.1731*	0.1707	-0.0772	0.1168	-0.0095	-0.2383**
G	r_g	0.1105	0.1598	0.0526	0.0842	0.21*	0.3089**	0.1703	0.2396**	-0.0596	0.1167	-0.0201	-0.2792**
	r_p	0.0971	0.1423	0.0508	0.0708	0.1217	0.2812**	0.1657	0.2090*	-0.0171	0.1139	0.0008	-0.2490**
H	r_g	0.0311	-0.0285	0.2343**	0.1257	0.1727*	0.3585**	0.0294	0.2714**	-0.0052	-0.0318	-0.0604	-0.2867**
	r_p	0.0232	-0.0343	0.2163*	0.1233	0.1216	0.3536**	0.0323	0.1942*	0.0022	-0.0151	-0.0514	-0.2772**
I	r_g	0.0367	-0.0312	0.2095*	0.1153	0.1607	0.3643**	0.0398	0.2673**	-0.0105	-0.0519	-0.057	-0.2813**
	r_p	0.0316	-0.0212	0.1972*	0.1144	0.1089	0.3607**	0.0407	0.2008*	-0.0044	-0.0327	-0.0549	-0.2747**
J	r_g	0.6139**	0.8846**	-0.0491	-0.0897	-0.0243	-0.3098**	-0.0679	0.7226**	0.0797	0.2227*	-0.2172*	-0.3159**
	r_p	0.4534**	0.5593**	-0.0103	-0.0566	-0.0142	-0.2163*	-0.0423	0.5309**	0.0948	0.2249*	-0.0828	-0.2144*
K	r_g	0.6601**	0.8905**	-0.0804	-0.0833	-0.2119	-0.2603**	-0.0941	0.7625**	0.0162	0.2431**	-0.2157*	-0.3675**
	r_p	0.4623**	0.5312**	-0.0821	-0.0535	-0.019	-0.1804*	-0.0575	0.4756**	0.0483	0.1399	-0.0911	-0.2396**
L	r_g	0.5043**	0.9359**	-0.1855*	-0.0937	-0.1188	-0.2538**	-0.0252	0.5957**	-0.015	0.2054*	-0.1687	-0.2392**
	r_p	0.3828**	0.5956**	-0.1466	-0.0569	0.0086	-0.1734*	-0.0166	0.4995**	0.0111	0.1815*	-0.0805	-0.1461
M	r_g	0.3899**	0.94**	-0.2394**	-0.1482	-0.0768	-0.3104**	-0.0509	0.6012**	-0.0371	0.2324**	-0.2806**	-0.2174*
	r_p	0.3386**	0.7022**	-0.1901*	-0.1086	-0.0153	-0.2549**	-0.0357	0.4983**	-0.0084	0.1568	-0.1775*	-0.1624
N	r_g	1	0.4067**	-0.081	-0.1497	-0.4002**	-0.1738*	-0.0781	0.1668	-0.043	0.0917	-0.1732*	-0.091
	r_p	1	0.3291**	-0.0802	-0.1409	-0.2623**	-0.1684	-0.081	0.1759*	-0.0445	0.1077	-0.1616	-0.094
O	r_g	0.4067**	1	-0.2843**	-0.1291	0.1063	-0.3499**	-0.0498	0.4742**	-0.1723	0.2564**	-0.1647	-0.0447
	r_p	0.3291**	1	-0.1924*	-0.0759	0.0713	-0.2611**	-0.0372	0.4594**	-0.1122	0.2558**	-0.115	-0.0395
P	r_g	-0.081	-0.2843**	1	0.7495**	0.2006*	0.5004**	-0.2934**	0.3253**	0.1286	-0.0423	0.0937	-0.1538
	r_p	-0.0802	-0.1924*	1	0.7170**	0.1214	0.4758**	-0.2811**	0.2137*	0.1289	-0.0466	0.0716	-0.1379
Q	r_g	-0.1497	-0.1291	0.7495**	1	0.4057**	0.29**	-0.2132*	0.3268**	-0.0694	0.1457	0.2912**	0.0461

	r_p	-0.1409	-0.0759	0.7170**	1	0.3143**	0.2785**	-0.2095*	0.2281**	-0.0616	0.1231	0.2601**	0.0489
R	r_g	-0.4002**	0.1063	0.2006*	0.4057**	1	0.0712	0.0957	0.2032*	-0.0373	-0.0214	0.0847	0.2366**
	r_p	-0.2623**	0.0713	0.1214	0.3143**	1	0.0176	0.0669	-0.001	-0.0208	0.057	0.0584	0.1880*
S	r_g	-0.1738*	-0.3499**	0.5004**	0.29**	0.0712	1	0.1506	0.0888	0.1454	-0.0781	-0.1294	-0.2959**
	r_p	-0.1684	-0.2611**	0.4758**	0.2785**	0.0176	1	0.1463	0.0775	0.1403	-0.0577	-0.1123	-0.2890**
T	r_g	-0.0781	-0.0498	-0.2934**	-0.2132*	0.0957	0.1506	1	-0.1748*	0.0854	0.406**	0.0022	-0.1025
	r_p	-0.081	-0.0372	-0.2811**	-0.2095*	0.0669	0.1463	1	-0.1363	0.0831	0.2887**	0.0076	-0.1005
U	r_g	0.1668	0.4742**	0.3253**	0.3268**	0.2032*	0.0888	-0.1748*	1	0.0128	0.1505	-0.085	-0.3837**
	r_p	0.1759*	0.4594**	0.2137*	0.2281**	-0.001	0.0775	-0.1363	1	0.0218	0.1811*	-0.0629	-0.2745**
V	r_g	-0.043	-0.1723	0.1286	-0.0694	-0.0373	0.1454	0.0854	0.0128	1	-0.2692**	-0.0197	-0.3475**
	r_p	-0.0445	-0.1122	0.1289	-0.0616	-0.0208	0.1403	0.0831	0.0218	1	-0.2006*	-0.0204	-0.3264**
W	r_g	0.0917	0.2564**	-0.0423	0.1457	-0.0214	-0.0781	0.406	0.1505	-0.2692**	1	-0.019	-0.1101
	r_p	0.1077	0.2558**	-0.0466	0.1231	0.057	-0.0577	0.2887**	0.1811*	-0.2006*	1	0.0006	-0.0647
X	r_g	-0.1732*	-0.1647	0.0937	0.2912**	0.0847	-0.1294	0.0022	-0.085	-0.0197	-0.019	1	0.2999**
	r_p	-0.1616	-0.115	0.0716	0.2601**	0.0584	-0.1123	0.0076	-0.0629	-0.0204	0.0006	1	0.2776**
Y	r_g	-0.091	-0.0447	-0.1538	0.0461	0.2366**	-0.2959**	-0.1025	-0.3837**	-0.3475**	-0.1101	0.2999**	1
	r_p	-0.094	-0.0395	-0.1379	0.0489	0.1880*	-0.2890**	-0.1005	-0.2745**	-0.3264**	-0.0647	0.2776**	1
Z	r_g	-0.0312	0.5092**	0.3122**	0.4769**	0.3863**	0.0343	0.0732	0.6088**	0.0522	0.4221**	0.0729	-0.0236
	r_p	-0.0063	0.4273**	0.2839**	0.4409**	0.2762**	0.0242	0.0688	0.5016**	0.056	0.3174**	0.0659	-0.0255

(Significance Levels 5% '*', 1% '')(r_p- Phenotypic correlation , r_g - Genotypic correlation)**

(**A** - Root length, **B** - Root weight, **C** - Root spread, **D** - Chlorophyll content of flag leaf, **E** - Chlorophyll content of third leaf, **F** - Plant height at 30DAT, **G** - Plant height at 60DAT, **H** - Plant height at 90DAT, **I** - Plant height at harvest, **J** - Number of tillers at 30DAT, **K** - Number of tillers at 60DAT, **L** - Number of tillers at 90DAT, **M** - Number of tillers at harvest, **N** - Total biomass plant^{-1}, **O** - Number of productive tillers plant^{-1}, **P** - Number of spikelets panicle^{-1}, **Q** - Number of grains panicle^{-1}, **R** - Seed setting %, **S** - Length of panicle, **T** - 1000 grains weight (gm), **U** - Straw yield plant^{-1}, **V** - L/B ratio of kernel, **W** - Hulling %, **X** - Volume expansion, **Y** - Kernel elongation ratio, **Z** - Grain yield plant^{-1})

4.2.2. Path analysis

Grain yield, which is the major economic characteristic in rice, depends on several component traits, which are mutually related. Mere change in any one of the component would ultimately disturb the complex. Hence, these related traits have to be analyzed for its action namely direct effect of component character on grain yield and the indirect effects through other component traits on grain yield. The estimate of direct and indirect effect of 25 parameters, which include growth, yield and physico-chemical and cooking quality parameters on grain yield plant^{-1} are presented in Table 18.

The residual effect of path analysis was found to be 0.2572 and 0.6097 for genotypic level and phenotypic level respectively. The parameters those exhibit direct positive effect on grain yield plant^{-1} at both genotypic and phenotypic levels are chlorophyll content of third leaf, plant height at 30DAT, plant height at 60DAT, plant height at 90DAT, number of tillers plant^{-1}at 60DAT, number of tillers plant^{-1} at harvest, number of productive tillers plant^{-1}, 1000 grains weight (gm), number of grains panicle^{-1}, straw yield plant^{-1}, L/B ratio of kernel and kernel elongation ratio. However the parameters like root length, chlorophyll content of flag leaf, plant height at harvest, number of tillers plant^{-1} at 30DAT, number of tillers plant^{-1} at 90DAT, total biomass plant^{-1}, seed setting % and volume expansion exhibited direct negative effect on grain yield plant^{-1} at both genotypic and phenotypic levels. While other characteristics namely, root weight and root spread exhibited direct positive effect on grain yield plant^{-1} at genotypic level, but direct negative effect at phenotypic level. Similarly, the characteristics number of spikelets panicle^{-1}, seed setting % and hulling % shared direct negative effect on grain yield plant^{-1} at genotypic level, but direct positive effect at phenotypic level.

At genotypic level, plant height at 90DAT had the highest positive direct effect (3.567) on grain yield plant^{-1}, followed by number of grains panicle^{-1} (1.047), chlorophyll content of third leaf (1.0062), plant height at 60DAT

(0.9318), straw yield plant^{-1} (0.8254), 1000 grains weight (0.7635), L/B ratio of kernel (0.4742), number of productive tillers plant^{-1} (0.3858), number of tillers plant^{-1} at harvest(0.378), kernel elongation ratio (0.2083), number of tillers plant^{-1} at 60DAT (0.1066), plant height at 30DAT (0.0782), root weight (0.0582) and root spread (0.0574). However plant height at harvest had the highest negative direct effect (-4.1605) on grain yield plant^{-1}, followed by chlorophyll content of flag leaf (-1.2839), number of tillers plant^{-1} at 90DAT (-1.0862), length of panicle (-0.5537), hulling % (-0.4668), root length (-0.4514), seed setting % (-0.444), number of tillers plant^{-1} at 30DAT (-0.4259), volume expansion (-0.3846), number of spikelets panicle^{-1} (-0.233) and total biomass plant^{-1} (-0.0771).

At phenotypic level plant height at 90DAT had the highest positive direct effect (0.5517) on grain yield plant^{-1}, followed by straw yield plant^{-1}(0.3786), number of grains panicle^{-1} (0.3636), chlorophyll content of third leaf (0.2894), 1000 grains weight (0.241), number of productive tillers plant^{-1} (0.2272), L/B ratio of kernel (0.2037), number of tillers plant^{-1} at harvest (0.1661), number of tillers plant^{-1} at 60DAT (0.1355), kernel elongation ratio (0.119), number of spikelets panicle^{-1} (0.1027), hulling % (0.0811), seed setting % (0.0733), plant height at 30DAT (0.0443) and plant height at 60DAT (0.0436). However plant height at harvest had the highest negative direct effect (-0.649) on grain yield plant^{-1}, followed by root length (-0.4514), chlorophyll content of flag leaf (-0.3505), number of tillers plant^{-1} at 30DAT (-0.1838), number of tillers plant^{-1} at 90DAT (-0.1202), total biomass plant^{-1} (-0.1078), length of panicle (-0.0988), volume expansion (-0.0512), root weight (-0.0346) and root spread (-0.0278).

The highest positive indirect effect with grain yield plant^{-1} was exhibited by plant height at 90DAT via. plant height at harvest (3.5593). This was followed by plant height at 90DAT via. plant height at 60DAT (3.2579), plant height at 90DAT via. plant height at 30DAT (3.0681), plant height at 90DAT via. length of panicle (1.2788), plant height at harvest via. chlorophyll content of third leaf (1.2536), plant height at harvest via. kernel elongation ratio (1.1705), number of tillers at 90DAT via. number of productive tillers plant^{-1} (1.0166), chlorophyll content of flag leaf via. number of tillers $plant^{-1}$ at 30DAT (1.0104), plant height at harvest via. root weight (0.991), plant height at 90DAT via. straw yield $plant^{-1}$ (0.9682), chlorophyll content of flag leaf via. number of productive tillers $plant^{-1}$(0.9575), chlorophyll content of third leaf via. chlorophyll content of flag leaf (0.9534), plant height at 60DAT via. plant height at 30DAT (0.9153), plant height at 90DAT via. number of tillers $plant^{-1}$ at 30DAT (0.8935), chlorophyll content of flag leaf via. number of tillers at 60DAT (0.8925), chlorophyll content of flag leaf via. number of tillers at 90DAT (0.8658), plant height at 60DAT via. plant height at harvest (0.855), plant height at 60DAT via. plant height at 90DAT (0.851), plant height at 90DAT via. number of spikelets $panicle^{-1}$ (0.8356), plant height at harvest via. chlorophyll content of flag leaf (0.7933), number of grains $panicle^{-1}$ via. number of spikelets $panicle^{-1}$ (0.7847), number of tillers $plant^{-1}$ at 90DAT via. chlorophyll content of third leaf (0.7481), chlorophyll content of flag leaf via. number of tillers $plant^{-1}$ at harvest (0.742), number of tillers at 90DAT via. chlorophyll content of flag leaf (0.7325) and straw yield $plant^{-1}$ via. number of tillers $plant^{-1}$ at 60DAT (0.6294).

The highest negative indirect effect with grain yield $plant^{-1}$ was exhibited by plant height at harvest via. plant height at 90DAT(-4.1515), plant height at harvest via. plant height at 60DAT (-3.8176), plant height at harvest via. plant height at 30DAT (-3.5942), plant height at harvest via. length of panicle (-1.5155), chlorophyll content of flag leaf via. chlorophyll content of third leaf (-1.2166), plant height at 90DAT via. chlorophyll content of third leaf (-1.1634), plant height at harvest via. straw yield $plant^{-1}$ (-1.1121), number of tillers $plant^{-1}$ at 90DAT via. number of tillers at $plant^{-1}$ 60DAT (-1.1086), number of tillers $plant^{-1}$ at 90DAT via. number of tillers $plant^{-1}$ at harvest (-1.0638), plant height at harvest via. number of tillers $plant^{-1}$ at 30DAT (-1.0344), plant height at 90DAT via. kernel elongation ratio (-1.0228), number of tillers $plant^{-1}$ at 90DAT via. number of tillers $plant^{-1}$ at 30DAT (-0.9856), plant height at 90DAT via. root weight (-0.8777), plant height at harvest via. number of spikelets $panicle^{-1}$ (-0.8717), chlorophyll content of third leaf via. number of tillers $plant^{-1}$ at 30DAT (-0.8084), plant height at 90DAT via. chlorophyll content of flag leaf (-0.7772), plant height at harvest via. number of tillers plant^{-1} at 60DAT (-0.7549), chlorophyll content of third leaf via. number of tillers plant^{-1} at 60DAT (-0.7192), chlorophyll content of third leaf via. number of tillers plant^{-1} at 90DAT (-0.693), plant height at harvest via. number of tillers plant^{-1} at 90DAT(-0.6881), plant height at harvest via. seed setting % (-0.6688) and plant height at harvest via. root spread (-0.6592).

Table 18. Direct and indirect effects of 25 parameters (growth, yield and physico-chemical) on grain yield plant^{-1} of 65 rice genotypes under organic management during Rabi season

		A	B	C	D	E	F	G	H	I	J	K	L	M
A	G	**-0.4514**	-0.0144	-0.1738	-0.1314	-0.1813	0.0991	0.0174	0.0118	-0.0028	0.0418	0.0627	0.0503	0.0187
	P	**-0.0993**	-0.0042	-0.0527	-0.0192	-0.0113	0.0137	0.0044	0.0006	-0.0003	-0.001	-0.0013	-0.0016	-0.0045
B	G	0.0019	**0.0582**	-0.0301	0.0105	0.0105	-0.0103	-0.0103	-0.0143	-0.0139	-0.0023	-0.0033	0.001	0.0041
	P	-0.0015	**-0.0346**	0.0026	-0.0043	-0.0029	0.0024	0.0043	0.0061	0.0059	0.0016	0.0005	0.0017	0.0005
C	G	0.0221	-0.0297	**0.0574**	-0.012	-0.0107	-0.0125	-0.0003	0.0081	0.0091	0.0086	0.0006	-0.0016	0.0008
	P	-0.0148	0.0021	**-0.0278**	0.0017	0.0015	0.0028	0.0001	-0.0028	-0.0025	-0.0037	-0.0042	-0.0037	-0.0044
D	G	-0.3739	-0.2317	0.2679	**-1.2839**	-1.2166	0.4338	0.3986	0.2797	0.2448	1.0104	0.8925	0.8658	0.742
	P	-0.0677	-0.0439	0.0212	**-0.3505**	-0.2869	0.0947	0.0975	0.0706	0.0639	0.1971	0.1789	0.1623	0.1515
E	G	0.4042	0.1815	-0.1875	0.9534	**1.0062**	-0.5164	-0.4509	-0.3282	-0.3032	-0.8084	-0.7192	-0.693	-0.543
	P	0.0329	0.0243	-0.0155	0.2369	**0.2894**	-0.1065	-0.0992	-0.0759	-0.0771	-0.1359	-0.1229	-0.11	-0.1
F	G	-0.0172	-0.0138	-0.017	-0.0264	-0.0401	**0.0782**	0.0768	0.0673	0.0676	0.0234	0.0245	0.0249	0.0109
	P	-0.0061	-0.0031	-0.0045	-0.012	-0.0163	**0.0443**	0.0406	0.0341	0.0341	0.0145	0.0129	0.0113	0.0069
G	G	-0.036	-0.1654	-0.0048	-0.2893	-0.4176	0.9153	**0.9318**	0.851	0.855	0.2866	0.2659	0.2737	0.1541
	P	-0.0019	-0.0054	-0.0002	-0.0121	-0.015	0.04	**0.0436**	0.0373	0.0373	0.014	0.0124	0.0112	0.0073
H	G	-0.0929	-0.8777	0.5028	-0.7772	-1.1634	3.0681	3.2579	**3.567**	3.5593	0.8935	0.6535	0.5986	0.1048
	P	-0.0035	-0.0974	0.056	-0.1111	-0.1447	0.4249	0.4719	**0.5517**	0.5464	0.1135	0.082	0.06	0.0048
I	G	-0.0259	0.991	-0.6592	0.7933	1.2536	-3.5942	-3.8176	-4.1515	**-4.1605**	-1.0344	-0.7549	-0.6881	-0.1059
	P	-0.0018	0.1108	-0.0589	0.1182	0.1729	-0.4999	-0.5548	-0.6428	**-0.649**	-0.127	-0.0912	-0.0731	-0.006
J	G	0.0395	0.017	-0.0635	0.3352	0.3422	0.1276	-0.131	-0.1067	-0.1059	**-0.4259**	-0.4292	-0.3864	-0.3639
	P	-0.0018	0.0086	-0.0248	0.1034	0.0863	-0.06	-0.0591	-0.0378	-0.036	**-0.1838**	-0.1547	-0.1372	-0.1306
K	G	-0.0148	-0.0061	0.0011	-0.0741	-0.0762	0.0333	0.0304	0.0195	0.0193	0.1074	**0.1066**	0.1088	0.1025
	P	0.0018	-0.0018	0.0206	-0.0692	-0.0575	0.0395	0.0385	0.0201	0.019	0.1141	**0.1355**	0.118	0.1122
L	G	0.1211	-0.0195	0.0298	0.7325	0.7481	-0.3454	-0.319	-0.1823	-0.1797	-0.9856	-1.1086	**-1.0862**	-1.0638
	P	-0.0019	0.0058	-0.0161	0.0557	0.0457	-0.0307	-0.031	-0.0131	-0.0135	-0.0897	-0.1047	**-0.1202**	-0.1057
M	G	-0.0156	0.0265	0.0054	-0.2185	-0.204	0.0528	0.0625	0.0111	0.0096	0.323	0.3634	0.3702	**0.378**

	P	0.0075	-0.0022	0.0264	-0.0718	-0.0574	0.0258	0.0279	0.0014	0.0015	0.1181	0.1375	0.1461	0.1661
N	G	0.0149	0.0123	-0.0083	0.0305	0.0295	-0.0131	-0.0085	-0.0024	-0.0028	-0.0473	-0.0509	-0.0389	-0.0301
	P	0.0089	0.0152	-0.0064	0.0377	0.0302	-0.0149	-0.0105	-0.0025	-0.0034	-0.0489	-0.0498	-0.0413	-0.0365
O	G	-0.1697	-0.0206	-0.0597	-0.2877	-0.1996	0.0675	0.0616	-0.011	-0.012	0.3413	0.3436	0.3611	0.3627
	P	-0.0245	-0.0114	-0.0163	-0.1108	-0.093	0.029	0.0323	-0.0078	-0.0048	0.1271	0.1207	0.1353	0.1596
P	G	-0.0013	0.0229	-0.1073	0.0398	0.047	-0.005	-0.0123	-0.0546	-0.0488	0.0114	0.0187	0.0432	0.0558
	P	-0.0029	-0.01	0.0193	-0.0155	-0.0167	0.0024	0.0052	0.0222	0.0203	-0.0011	-0.0084	-0.0151	-0.0195
Q	G	0.0757	-0.0176	0.227	-0.2341	-0.3244	0.0479	0.0881	0.1317	0.1208	-0.0939	-0.0872	-0.0981	-0.1552
	P	0.0149	-0.0047	0.0444	-0.0718	-0.0859	0.0148	0.0257	0.0448	0.0416	-0.0206	-0.0195	-0.0207	-0.0395
R	G	-0.0614	-0.0613	-0.044	0.0583	0.0861	-0.0835	-0.0933	-0.0767	-0.0714	0.0108	0.0941	0.0527	0.0341
	P	0.0077	-0.0044	-0.0024	-0.0078	-0.008	0.0026	0.0089	0.0089	0.008	-0.001	-0.0014	0.0006	-0.0011
S	G	0.1192	0.028	0.0367	-0.007	0.0795	-0.206	-0.171	-0.1985	-0.2017	0.1715	0.1441	0.1405	0.1719
	P	0.0091	0.0032	0.0003	-0.0005	0.0127	-0.0321	-0.0278	-0.0349	-0.0356	0.0214	0.0178	0.0171	0.0252
T	G	0.0735	-0.0399	-0.1643	0.0138	-0.1047	0.1418	0.13	0.0224	0.0304	-0.0518	-0.0718	-0.0192	-0.0389
	P	0.0116	-0.0085	-0.0257	0.0042	-0.025	0.0417	0.0399	0.0078	0.0098	-0.0102	-0.0139	-0.004	-0.0086
U	G	-0.0729	0.1295	0.1757	-0.3692	-0.2924	0.1999	0.1978	0.2241	0.2206	0.5965	0.6294	0.4917	0.4962
	P	0.0594	0.0445	0.0915	-0.1176	-0.1072	0.0646	0.0791	0.0735	0.076	0.201	0.18	0.1891	0.1886
V	G	0.2052	0.0618	0.1511	0.0716	0.0488	-0.0542	-0.0283	-0.0025	-0.005	0.0378	0.0077	-0.0071	-0.0176
	P	0.0484	0.0186	0.0343	0.032	0.0165	-0.0157	-0.0035	0.0004	-0.0009	0.0193	0.0098	0.0023	-0.0017
W	G	0.0932	0.0089	0.0053	0.1883	0.1561	-0.0822	-0.0545	0.0148	0.0242	-0.104	-0.1135	-0.0959	-0.1085
	P	-0.0056	-0.0033	-0.0029	-0.022	-0.0166	0.0095	0.0092	-0.0012	-0.0027	0.0182	0.0113	0.0147	0.0127
X	G	0.0663	-0.0223	0.0638	0.0391	0.0578	0.0185	0.0077	0.0232	0.0219	0.0835	0.0829	0.0649	0.1079
	P	0.0051	-0.0034	0.0039	0.0038	0.0043	0.0005	0	0.0026	0.0028	0.0042	0.0047	0.0041	0.0091
Y	G	-0.024	0.0214	-0.01	0.0059	0.0207	-0.0544	-0.0582	-0.0597	-0.0586	-0.0658	-0.0766	-0.0498	-0.0453
	P	-0.0057	0.0097	0.0012	0.0039	0.0127	-0.0283	-0.0296	-0.033	-0.327	-0.0255	-0.0285	-0.0174	-0.0193

Table 15. Continued.

		N	O	P	Q	R	S	T	U	V	W	X	Y
A	G	0.0875	0.1986	-0.0024	-0.0326	-0.0624	0.0972	-0.0434	0.0398	-0.1953	0.0901	0.0778	0.0519
	P	0.0082	0.0107	0.0028	-0.0041	-0.0104	0.0092	-0.0048	-0.0156	-0.0236	0.0069	0.0098	0.0047
B	G	-0.0093	-0.0031	-0.0057	-0.001	0.008	-0.0029	-0.003	0.0091	0.0076	-0.0011	0.0034	0.006
	P	0.0049	0.0017	0.0034	0.0004	0.0021	0.0011	0.0012	-0.0041	-0.0031	0.0014	-0.0023	-0.0028
C	G	0.0062	-0.0089	0.0264	0.0124	0.0057	-0.0038	-0.0124	0.0122	0.0183	-0.0007	-0.0095	-0.0027
	P	-0.0017	0.002	-0.0052	-0.0034	0.0009	0.0001	0.003	-0.0067	-0.0047	0.001	0.0021	-0.0003
D	G	0.5083	0.9575	0.2195	0.2871	0.1685	-0.0163	-0.0231	0.5743	-0.1938	0.5179	0.1307	-0.0366
	P	0.1225	0.1709	0.0528	0.0692	0.0374	-0.0019	-0.0061	0.1088	-0.055	0.0952	0.0261	-0.0114
E	G	-0.3855	-0.5205	-0.2029	-0.3118	-0.1951	-0.1445	-0.138	-0.3564	0.1035	-0.3364	-0.1511	0.1002
	P	-0.0811	-0.1184	-0.0471	-0.0684	-0.0318	-0.0371	-0.03	-0.082	0.0234	-0.0591	-0.0241	0.0308
F	G	0.0133	0.0137	0.0017	0.0036	0.0147	0.0291	0.0145	0.0189	-0.0089	0.0138	-0.0038	-0.0204
	P	0.0061	0.0056	0.0011	0.0018	0.0016	0.0144	0.0077	0.0076	-0.0034	0.0052	-0.0004	-0.0106
G	G	0.103	0.1489	0.049	0.0784	0.1957	0.2878	0.1587	0.2233	-0.0555	0.1087	-0.0187	-0.2601
	P	0.0042	0.0062	0.0022	0.0031	0.0053	0.0123	0.0072	0.0091	-0.0007	0.005	0	-0.0109
H	G	0.111	-0.1016	0.8356	0.4485	0.616	1.2788	0.1047	0.9682	-0.0186	-0.1133	-0.2156	-1.0228
	P	0.0128	-0.0189	0.1193	0.068	0.0671	0.1951	0.0178	0.1071	0.0012	-0.0083	-0.0284	-0.153
I	G	-0.1525	0.1296	-0.8717	-0.4799	-0.6688	-1.5155	-0.1658	-1.1121	0.0439	0.216	0.2371	1.1705
	P	-0.0205	0.0138	-0.128	-0.0742	-0.0707	-0.2341	-0.0264	-0.1303	0.0028	0.0212	0.0356	0.1783
J	G	-0.2614	-0.3767	0.0209	0.0382	0.0104	0.1319	0.0289	-0.3077	-0.0339	-0.0949	0.0925	0.1345
	P	-0.0833	-0.1028	0.0019	0.0104	0.0026	0.0398	0.0078	-0.0976	-0.0174	-0.0413	0.0152	0.0394
K	G	0.0704	0.0949	-0.0086	-0.0089	-0.0226	-0.0277	-0.01	0.0813	0.0017	0.0259	-0.023	-0.0392
	P	0.0627	0.072	-0.0111	-0.0073	-0.0026	-0.0244	-0.0078	0.0645	0.0066	0.019	-0.0123	-0.0325
L	G	-0.5478	1.0166	0.2015	0.1018	0.129	0.2757	0.0274	-0.647	0.0162	-0.2231	0.1832	0.2599
	P	-0.046	-0.0716	0.0176	0.0068	-0.001	0.0208	0.002	-0.06	-0.0013	-0.0218	0.0097	0.0176
M	G	0.1474	0.3553	-0.0905	-0.056	-0.029	-0.1173	-0.0192	0.2272	-0.014	0.0879	-0.1061	-0.0822
	P	0.0562	0.1166	-0.0316	-0.018	-0.0025	-0.0423	-0.0059	0.0828	-0.0014	0.0261	-0.0295	-0.027
N	G	-0.0771	-0.0313	0.0062	0.0115	0.0308	0.0134	0.006	-0.0129	0.0033	-0.0071	0.0133	0.007
	P	-0.1078	-0.0355	0.0086	0.0152	0.0283	0.0182	0.0087	-0.019	0.0048	-0.0116	0.0174	0.0101

O	G	0.1569	**0.3858**	-0.1097	-0.0498	0.041	-0.135	-0.0192	0.183	-0.0665	0.0989	-0.0635	-0.0172
	P	0.0748	**0.2272**	-0.0437	-0.0172	0.0162	-0.0593	-0.0085	0.1044	-0.0255	0.0581	-0.0261	-0.009
P	G	0.0189	0.0662	**-0.233**	-0.1746	-0.0467	-0.1166	0.0684	-0.0758	-0.0299	0.0098	-0.0218	0.0358
	P	-0.0082	-0.0198	**0.1027**	0.0736	0.0125	0.0489	-0.0289	0.0219	0.0132	-0.0048	0.0074	-0.0142
Q	G	-0.1568	-0.1351	0.7847	**1.047**	0.4247	0.3037	-0.2232	0.3422	-0.0726	0.1526	0.3049	0.0483
	P	-0.0512	-0.0276	0.2607	**0.3636**	0.1143	0.1013	-0.0762	0.0829	-0.0224	0.0448	0.0945	0.0178
R	G	0.1777	-0.0472	-0.0891	-0.1801	**-0.444**	-0.0316	-0.0425	-0.0902	0.0166	0.0095	-0.0376	-0.105
	P	-0.0192	0.0052	0.0089	0.023	**0.0733**	0.0013	0.0049	-0.0001	-0.0015	0.0042	0.0043	0.0138
S	G	0.0962	0.1937	-0.2771	-0.1606	-0.0395	**-0.5537**	-0.0834	-0.0492	-0.0805	0.0432	0.0716	0.1638
	P	0.0166	0.0258	-0.047	-0.0275	-0.0017	**-0.0988**	-0.0145	-0.0077	-0.0139	0.0057	0.0111	0.0285
T	G	-0.0596	-0.038	-0.224	-0.1628	0.0731	0.115	**0.7635**	-0.1334	0.0652	0.31	0.0017	-0.0782
	P	-0.0195	-0.009	-0.0677	-0.0505	0.0161	0.0353	**0.241**	-0.0329	0.02	0.0696	0.0018	-0.0242
U	G	0.1377	0.3914	0.2685	0.2698	0.1677	0.0733	-0.1443	**0.8254**	0.0105	0.1242	-0.0702	-0.3167
	P	0.0666	0.1739	0.0809	0.0864	-0.0004	0.0293	-0.0516	**0.3786**	0.0082	0.0686	-0.0238	-0.1039
V	G	-0.0204	-0.0817	0.061	-0.0329	-0.0177	0.0689	0.0405	0.006	**0.4742**	-0.1276	-0.0093	-0.1648
	P	-0.0091	-0.0228	0.0263	-0.0125	-0.0042	0.0286	0.0169	0.0044	**0.2037**	-0.0409	-0.0042	-0.0665
W	G	-0.0428	-0.1197	0.0197	-0.068	0.01	0.0365	-0.1895	-0.0702	0.1257	**-0.4668**	0.0089	0.0514
	P	0.0087	0.0208	-0.0038	0.01	0.0046	-0.0047	0.0234	0.0147	-0.0163	**0.0811**	0.0001	-0.0052
X	G	0.0666	0.0633	-0.036	-0.112	-0.0326	0.0498	-0.0009	0.0327	0.0076	0.0073	**-0.3846**	-0.1154
	P	0.0083	0.0059	-0.0037	-0.0133	-0.003	0.0057	-0.0004	0.0032	0.001	0	**-0.0512**	-0.0142
Y	G	-0.019	-0.0093	-0.032	0.0096	0.0493	-0.0616	-0.0213	-0.0799	-0.0724	-0.0229	0.0625	**0.2083**
	P	-0.0112	-0.0047	-0.0164	0.0058	0.0224	-0.0344	-0.012	-0.0327	-0.0388	-0.0077	0.033	**0.119**

(Residual effect (Genotypic) = 0.2572, Residual effect (Phenotypic) = 0.6097, Bold: Direct effects, Normal: Indirect effect)

(**A** - Root length, **B** - Root weight, **C** - Root spread, **D** - Chlorophyll content of flag leaf, **E** - Chlorophyll content of third leaf, **F** - Plant height at 30DAT, **G** - Plant height at 60DAT, **H** - Plant height at 90DAT, **I** - Plant height at harvest, **J** - Number of tillers at 30DAT, **K** - Number of tillers at 60DAT, **L** - Number of tillers at 90DAT, **M** - Number of tillers at harvest, **N** - Total biomass plant^{-1}, **O** - Number of productive tillers plant^{-1}, **P** - Number of spikelets panicle^{-1}, **Q** - Number of grains panicle^{-1}, **R** - Seed setting %, **S** - Length of panicle, **T** - 1000 grains weight (gm), **U** - Straw yield plant^{-1}, **V** - L/B ratio of kernel, **W** - Hulling %, **X** - Volume expansion, **Y** - Kernel elongation ratio, **Z** - Grain yield plant^{-1})

DISCUSSION

5. Discussion

Improvement over existing varieties is a continuous process in plant breeding. Any successful hybridization programme for varietal improvement depends mainly on the selection of suitable parents and the key varietal trait is more important. The estimates of correlation coefficients are necessary pre-requisite in formulating a successful breeding programme. For improvement of any plant character in breeding programme, it is necessary to understand the key varietal traits of the parents. With this objective an attempt has been made through variability and character association studies to identify the rice genotypes and the key varietal traits suitable for organic farming, The results generated from the study on evaluation of a collection of *indica* rice genotypes under organic management adopting farmer participatory evaluation strategy are discussed below.

5.1. Variability

The analysis of variance showed highly significant differences among the genotypes for all the characters suggesting the presence of substantial genetic variability among the genotypes. The wide range of variation noticed in all the characters confirmed that the material selected were genetically diverse and shows variability under organic management. Variability for different characters was previously observed by several workers like Vanaja *et al.* (1998), Nayak *et al.* (2001), George *et al.* (2005), Babu *et al.* (2012), Sarker *et al.* (2013), Lakshmi *et al.* (2014) and Dhurai *et al.* (2014) for plant height, panicle length, number of grains panicle^{-1}, 1000 grains weight and grain yield plant^{-1}.

5.1.1. Growth parameters

5.1.1.1. Root parameters

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes for root parameters, range varied from 10.55cm to 20.15cm for root length (Fig. 2), 3.5gm to 11.25gm for root weight (Fig. 3) and 4.3cmto

9cm for root spread (Fig. 4). The deep roots of rice plant help to explore different levels of soil moisture (Bashar, 1987). Similarly variations in root length results were reported by Kumar and Nilanjaya (2014). From the study the genotype 'JK-15' recorded significantly higher value for all the root parameters (i.e. root length, root weight and root spread). The JK-15 is saline tolerant rice culture, may be the reason for high diverse root system. This indicates that, Culture JK-15 can be used as parental material while practicing selection aimed at the improvement of root parameters. For root length and root weight, the genotypes 'Karthika', 'Valicha', Culture JK-15 and 'Kalladiyaran' can be selected as parents. Similarly, for root length and root spread, the genotypes 'Aishwarya', Culture MK-115, 'Hariyana basmathi', 'Sagara', 'FL-478', 'Karishma', 'Red Mahsuri', 'Swetha', 'Aasha', 'Krishnanjan', 'Renjini', 'Gandakashala', 'Culture JK-15', 'Remanika', 'Neeraja', 'Valichoori', 'Ezhome-2', 'Ezhome-1', and 'Kandoorkutty'can be selected as parents. And for root weight and root spread, the genotypes 'Culture JK-15' and 'Kasthuri' can be selected as parents. 'PusaBasmathi' which exhibited highest root length is an aromatic rice. At the same time 'Vaishakh' which exhibited lowest root length is an upland rice. The variety 'Annapurna' which exhibited highest root weight is a wetland variety and the variety which exhibited lowest root weight is 'Orkayama' which is an saline tolerant traditional land race.

5.1.1.2. Chlorophyll content at flowering stage

Chlorophyll content in leaves of higher plants are the main pigments of photosynthesis in the chloroplasts, and have important functions in the absorption and exploitation of the light energy, thereby influence photosynthetic efficiency (Pan and Dong 1995). Some studies have demonstrated that chlorophyll content is positively correlated with photosynthetic rate (Araus *et al.* 1997, Thomas *et al.* 2005). In the current programme, analysis of variance of 65 genotypes revealed significant differences at 5% level of significance for all the genotypes for chlorophyll content in flag leaf and third leaf at flowering stage. It varies from 13.4 to 40.6 for flag leaf (Fig. 5) and 12.3to 40.5for third leaf (Fig. 6). Increasing

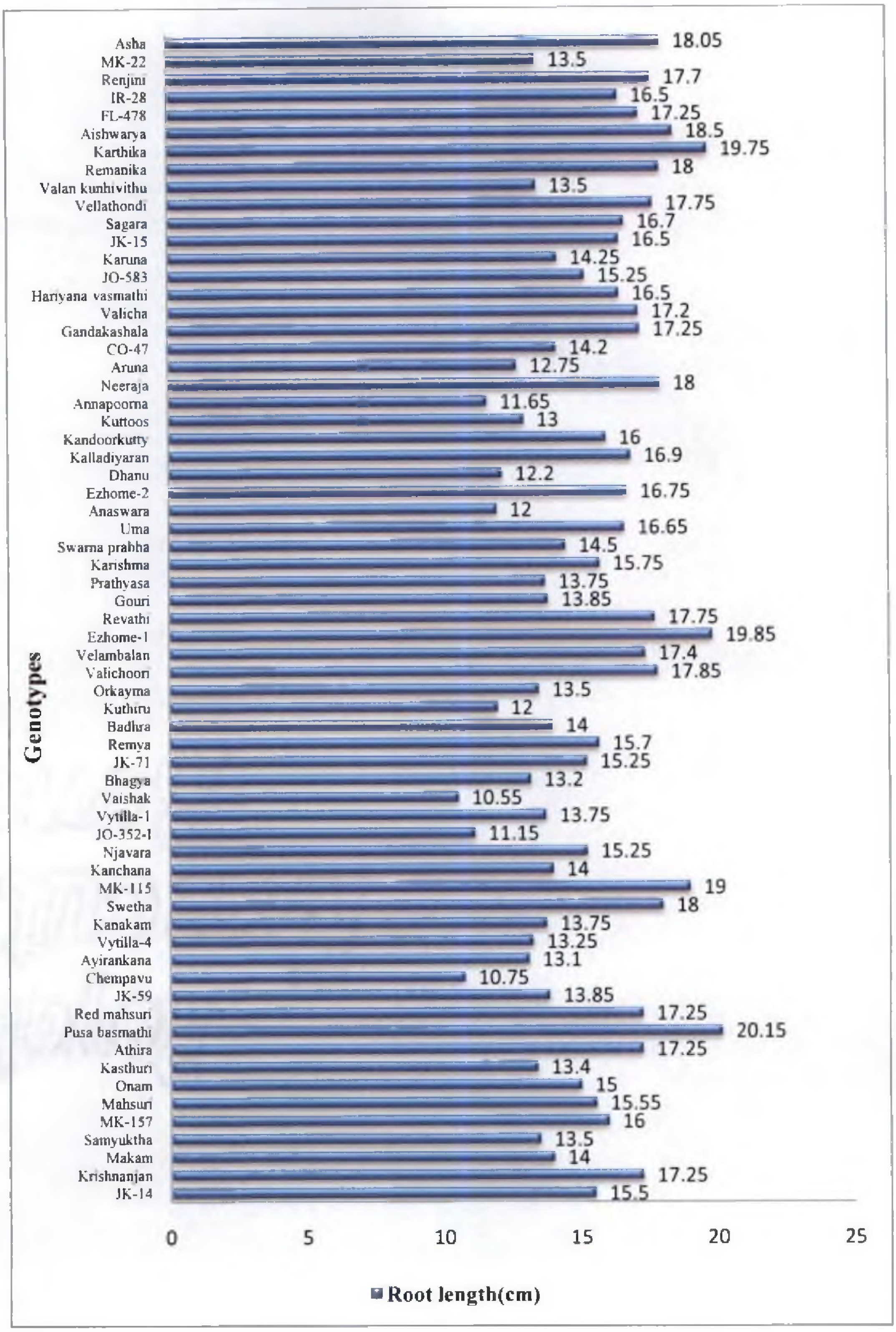


Fig.2. Variation in root length (cm) of 65 rice genotypes grown under organic management during Rabi season

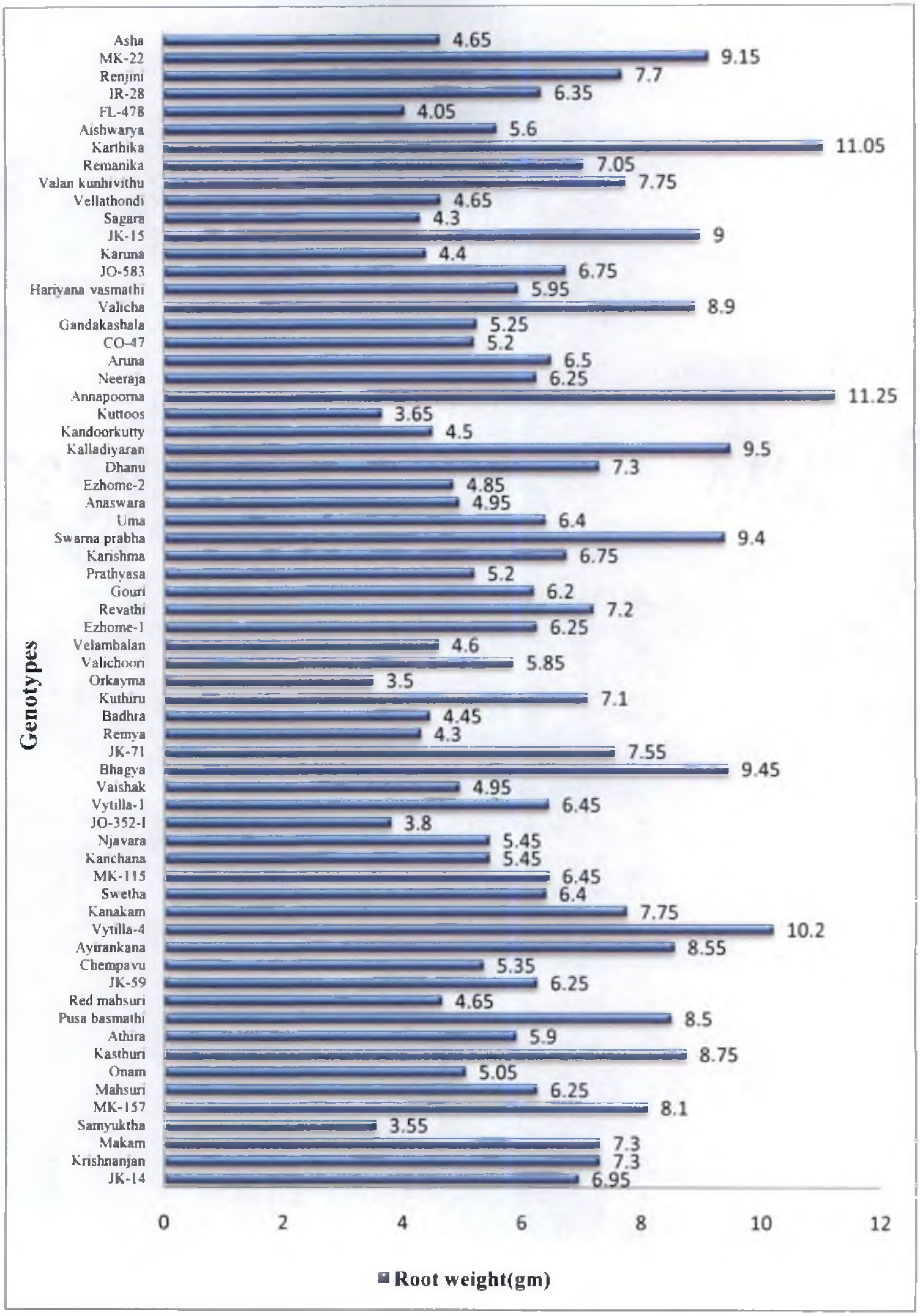


Fig.3. Variation in root weight (gm) of 65 rice genotypes grown under organic management during Rabi season

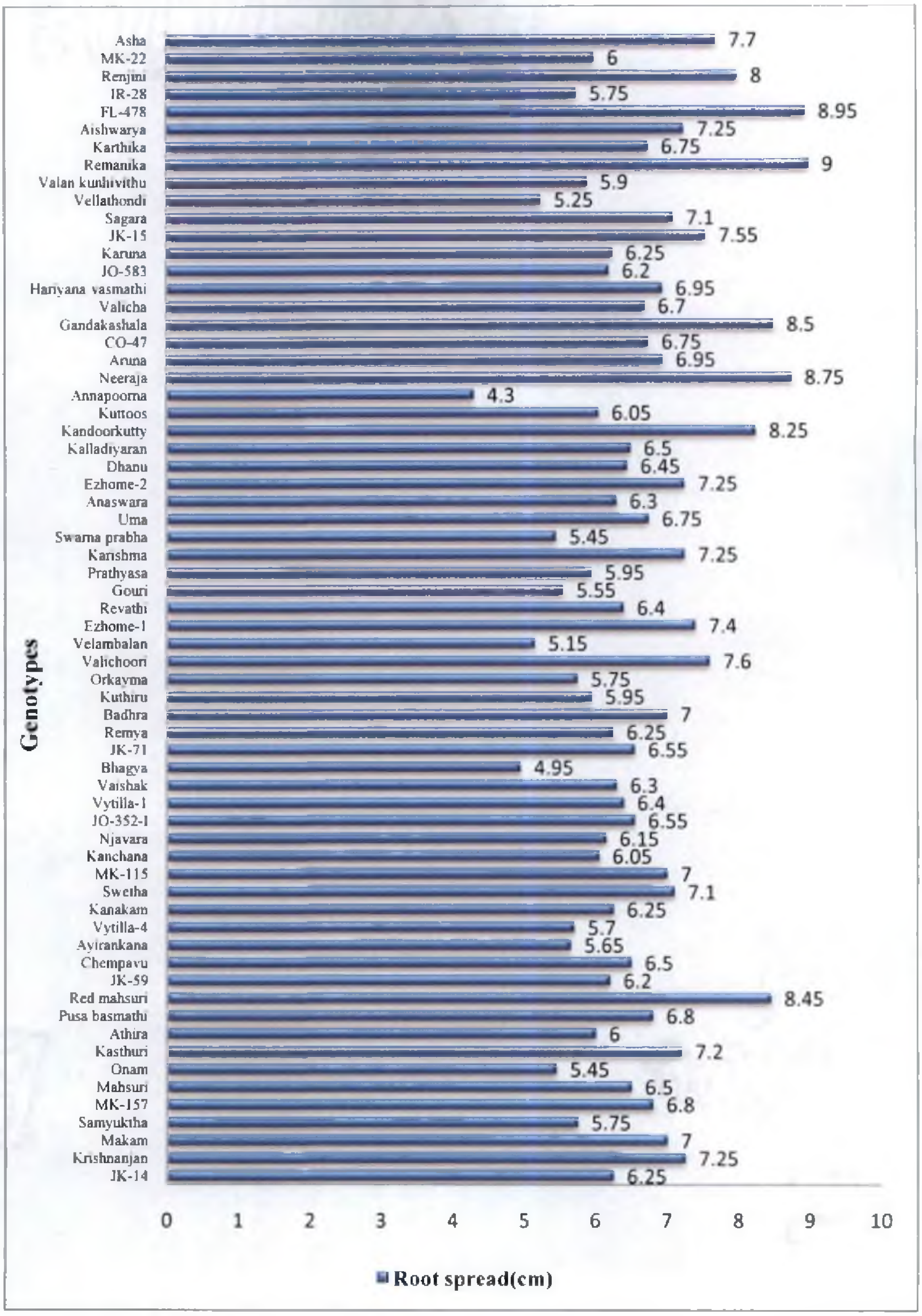


Fig.4. Variation in root spread (cm) of 65 rice genotypes grown under organic management during Rabi season

the chlorophyll content in crops may be an effective way to increase biomass production and grain yield (Wang *et al.* 2008). The genotypes 'Pusabasmathi', 'Orkayma', 'Swetha', 'Neeraja', 'Renjini', 'Bhagya', 'Velambalan', 'Vytila-4', 'Valichoori' and 'Ayirankana' found to have significantly high chlorophyll content both in flag and third leaves. Hence, these genotypes can be used as parents for improvement of chlorophyll content in crop improvement programmes. Similar observationswere reported by Ashrafuzzaman *et al.* (2009).

5.1.1.3. Plant height

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes at all the four growth stages i.e. 30DAT, 60DAT, 90DAT and harvest stage. It varies from 34.5cm to 99.6cm at 30DAT (Fig. 7), 39.8cm to 113.1cm at 60DAT (Fig. 8), 53.7cm to 131.2cm at 90DAT (Fig. 9), and 55.6cm to 134.7cm at harvest stage (Fig. 10). Up to the stage of 30DAT the growth of the genotypes 'Kuttoos', 'Dhanu', 'Culture JK-15' and 'Sagara' was the highest, where as the growth of 'Annapurna', 'IR-28' and 'Renjini' was the lowest. Between the stages of 30DAT and 60DAT, compared to other genotypes the growth of the genotypes 'Culture MK-157' (26.5cm) and 'Culture MK-115' (22.6cm) showed more enhancement in height. The short stature character of these genotypes at the time of planting makes them amenable for machine transplanting and enhancement in height after 30DAT helps them to produce more straw and biomass and also to smother away weeds. In the similar way between 60DAT and 90DAT the growth of the genotype 'Kandoorkutty' was increased by 36.7cm which was followed by 'Karuna' (32.6cm). When height enhancement is considered from 30DAT to 90DAT the growth of the genotype 'Kandoorkutty' was increased by 53.4cm which was followed by 'Aathira' (46.2cm).The growth of the genotypes 'Kuttoos', 'Dhanu', 'Culture JK-15', Culture MK-115 and 'Sagara' was higher up to the stage of 60DAT, similar results reported by Tann *et al.* (2012) in organic rice. But from 60DAT to harvest stage the growth of the genotype 'Kandoorkutty' was superior compared to all the remaining 64 genotypes. Tallness leads to increase in straw yield, but increased growth at

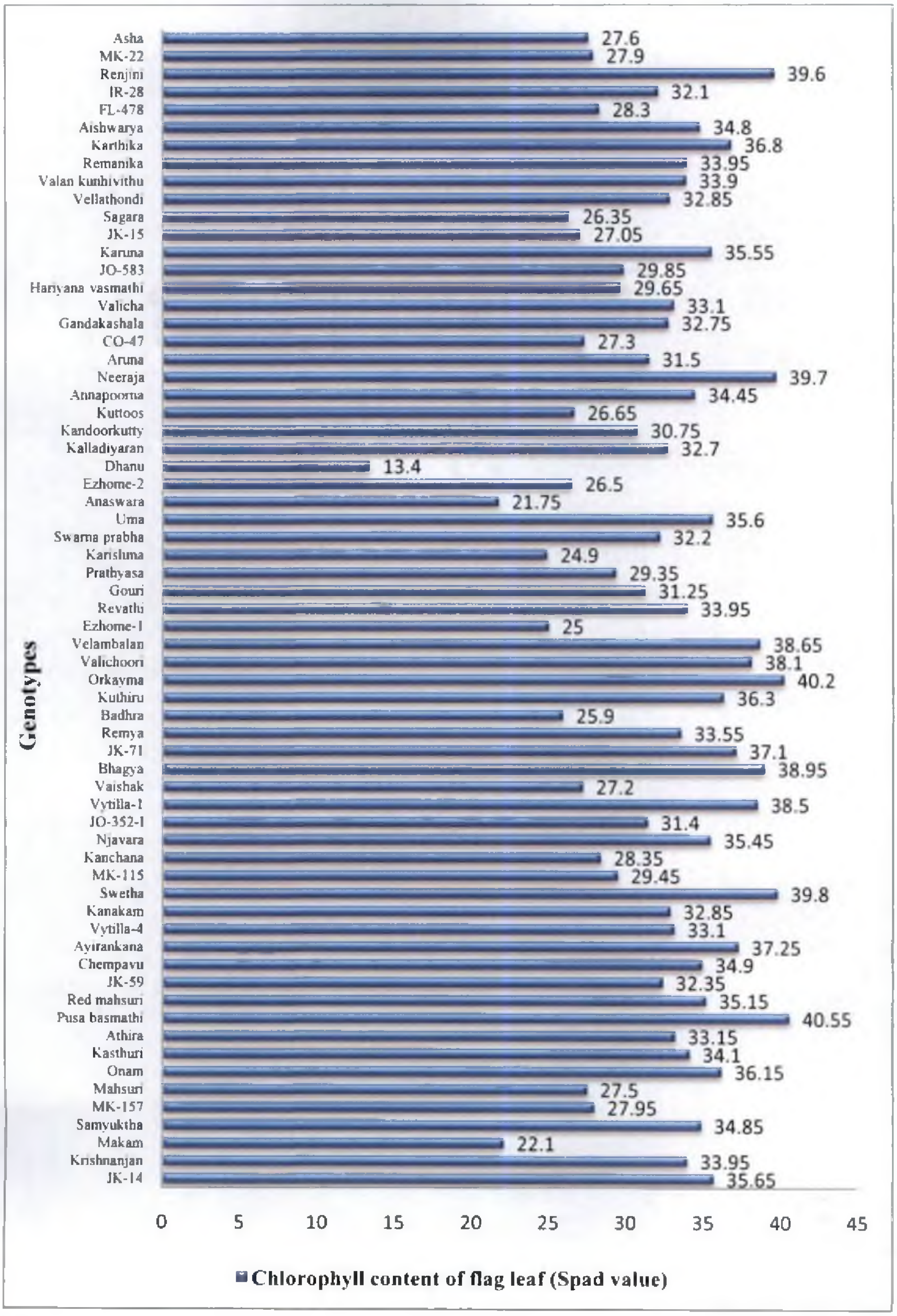


Fig.5.Variation in chlorophyll content of flag leaf of 65 rice genotypes grown under organic management during Rabi season

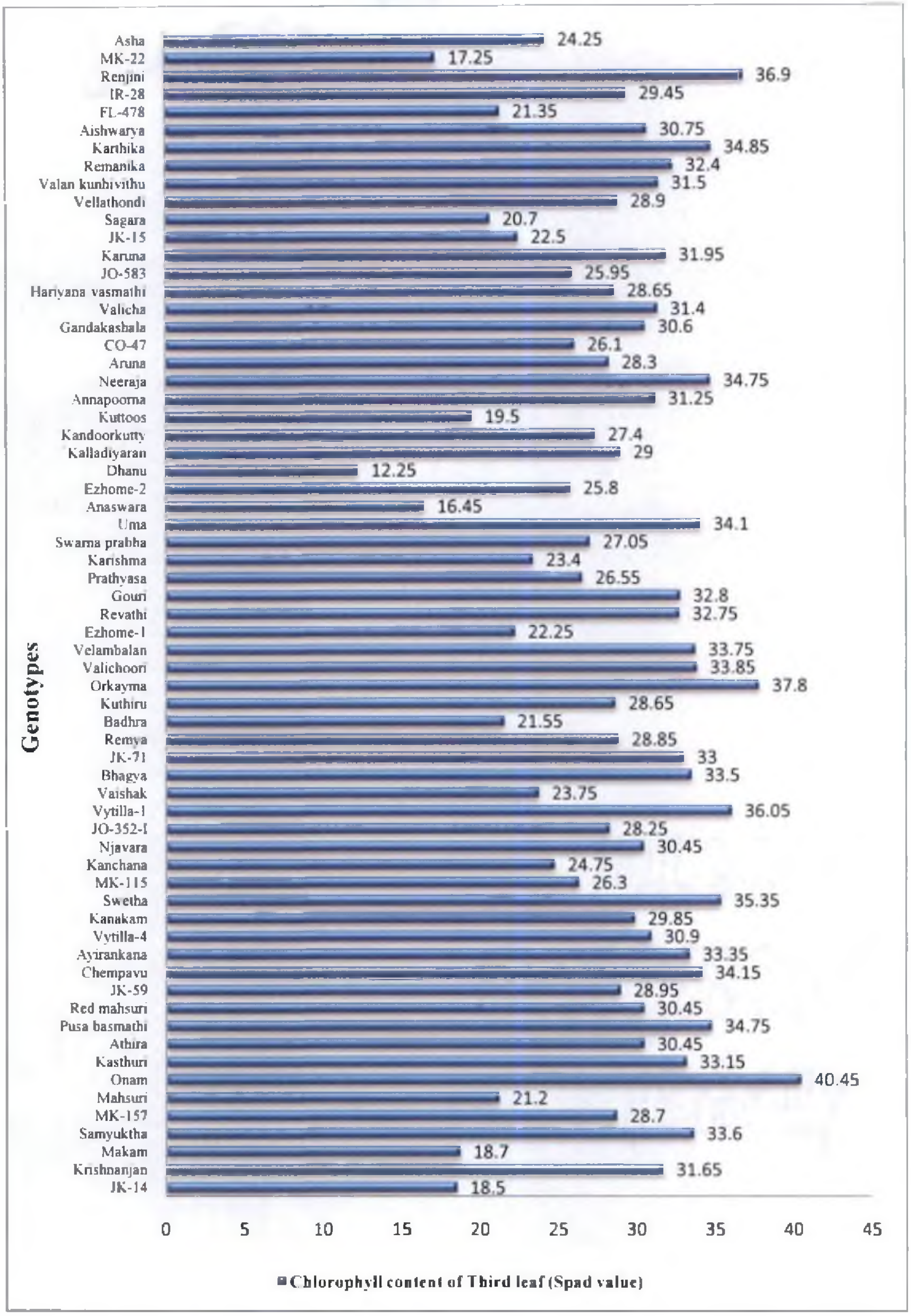


Fig.6. Variation in chlorophyll content of third leaf of 65 rice genotypes grown under organic management during Rabi season

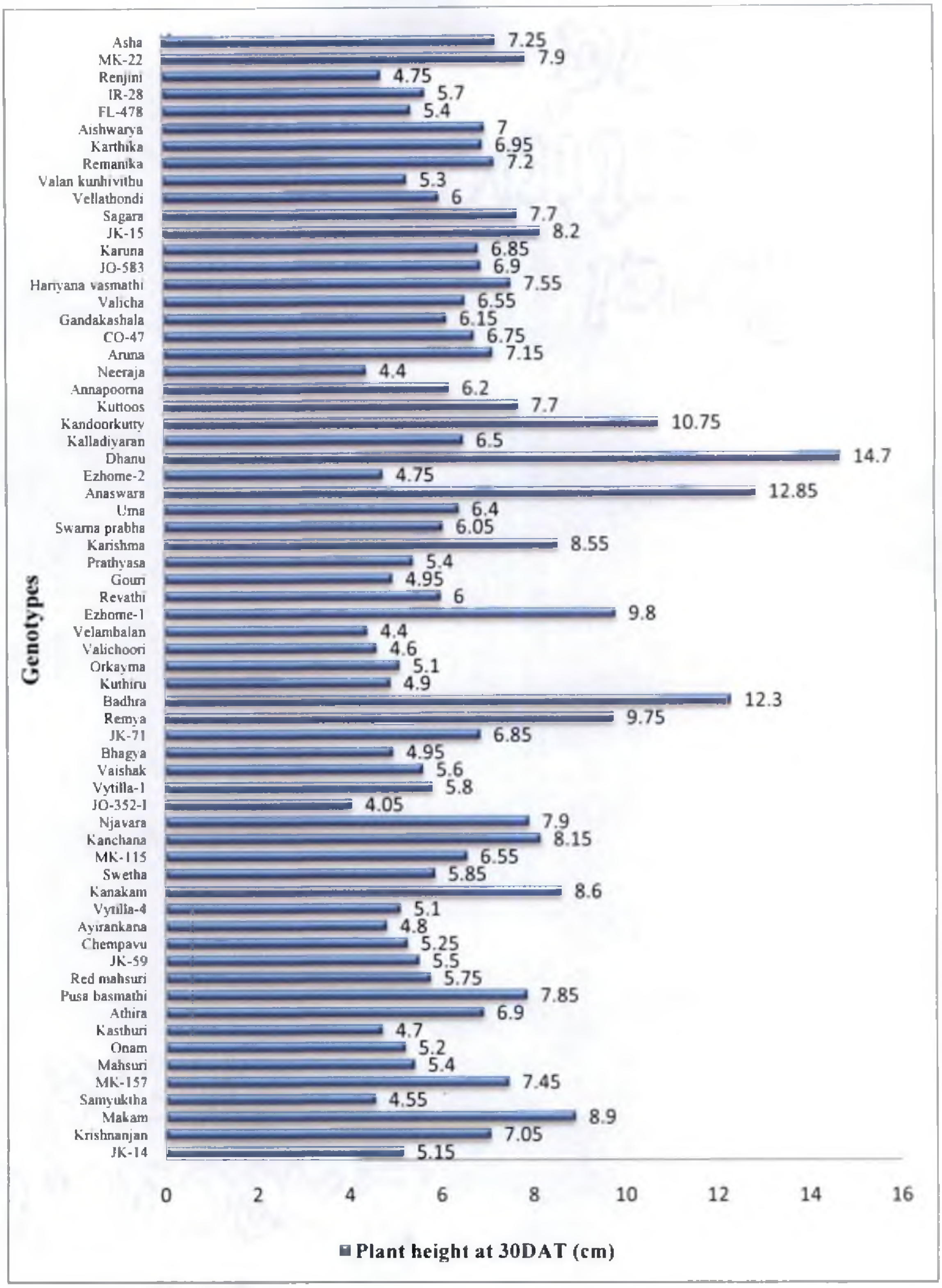


Fig.7. Variation in plant height at 30DAT (cm) of 65 rice genotypes grown under organic management during Rabi season

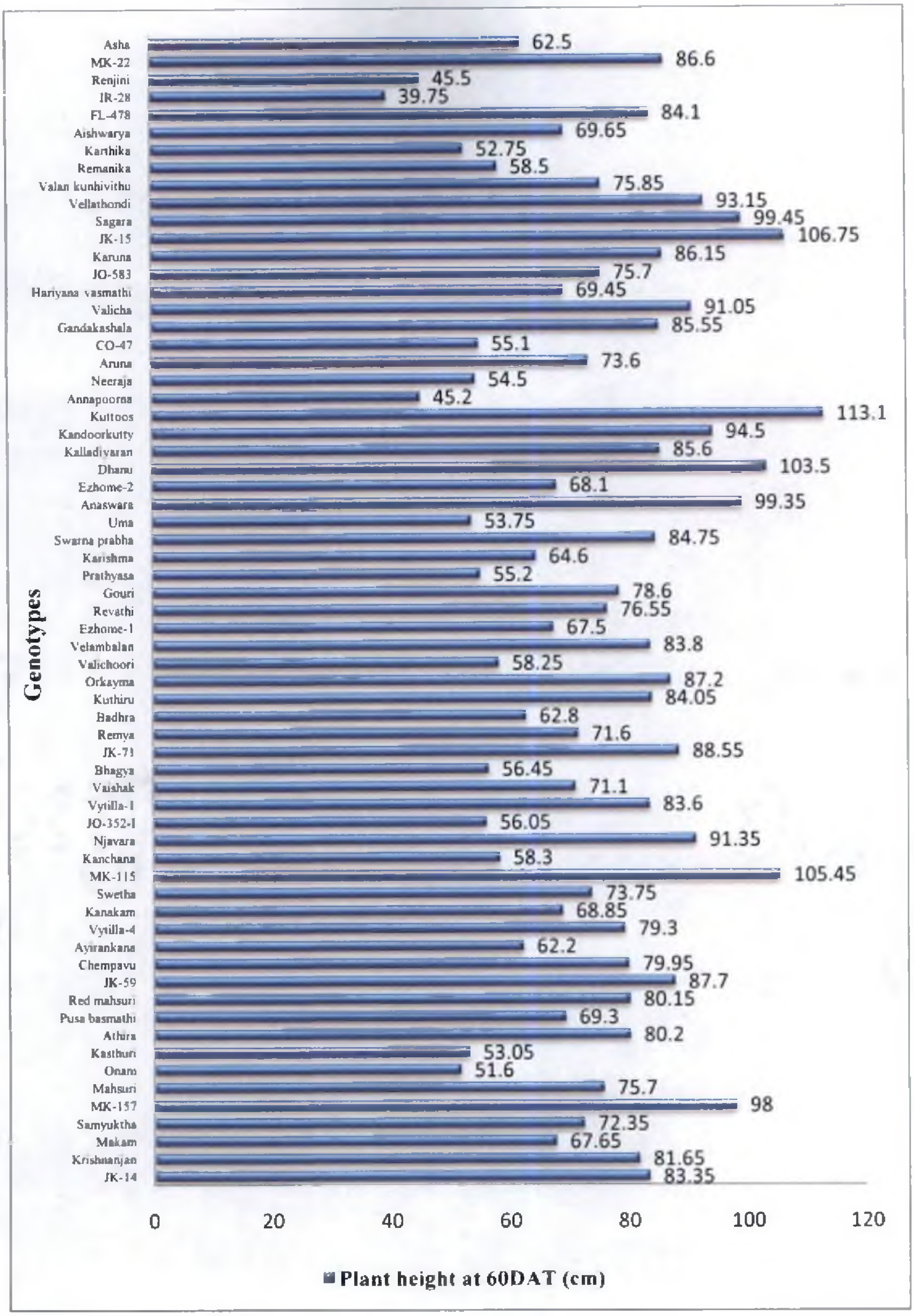


Fig.8. Variation in plant height at 60DAT (cm) of 65 rice genotypes grown under organic management during Rabi season

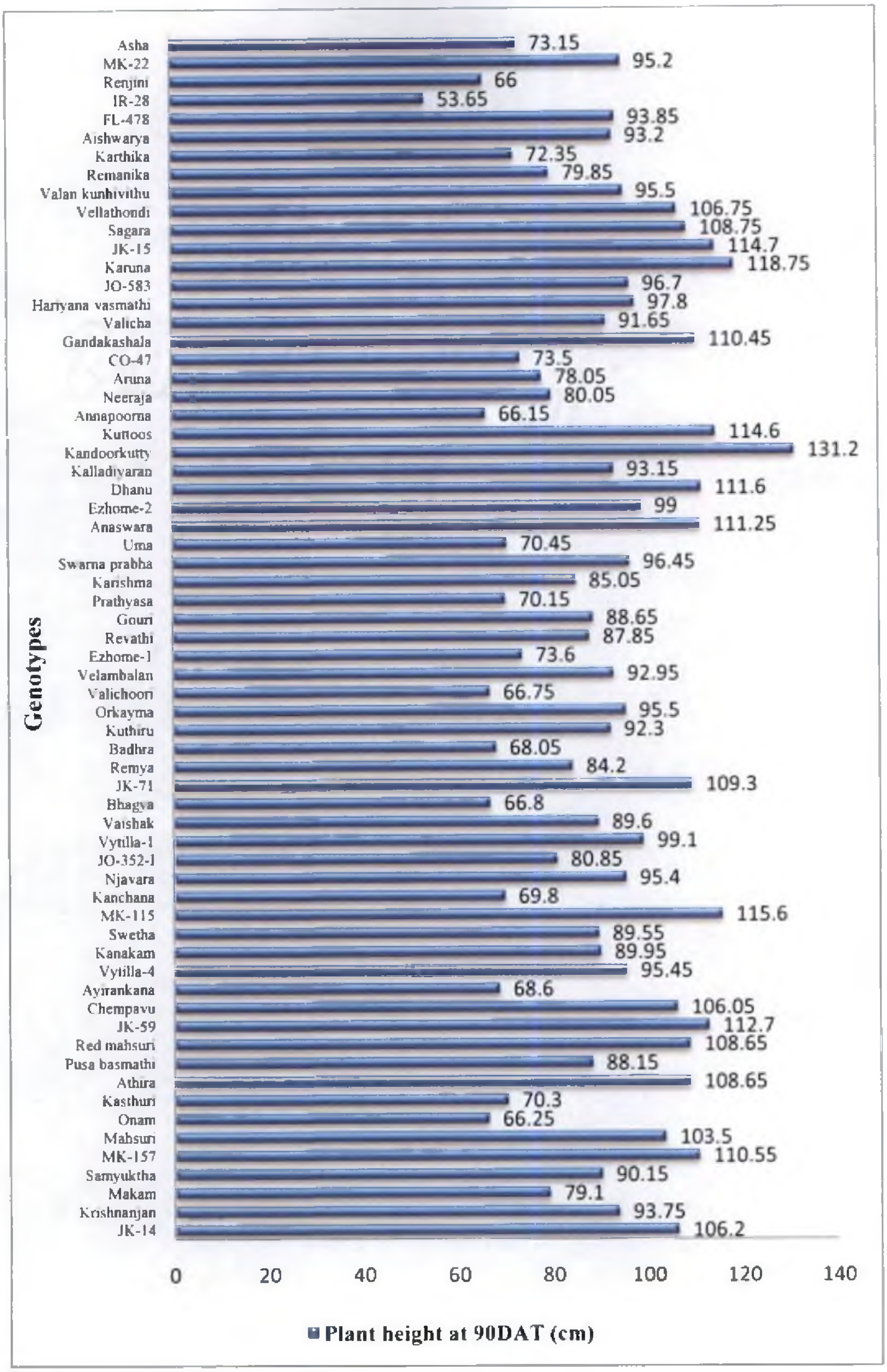


Fig.9. Variation in plant height at 90DAT (cm) of 65 rice genotypes grown under organic management during Rabi season

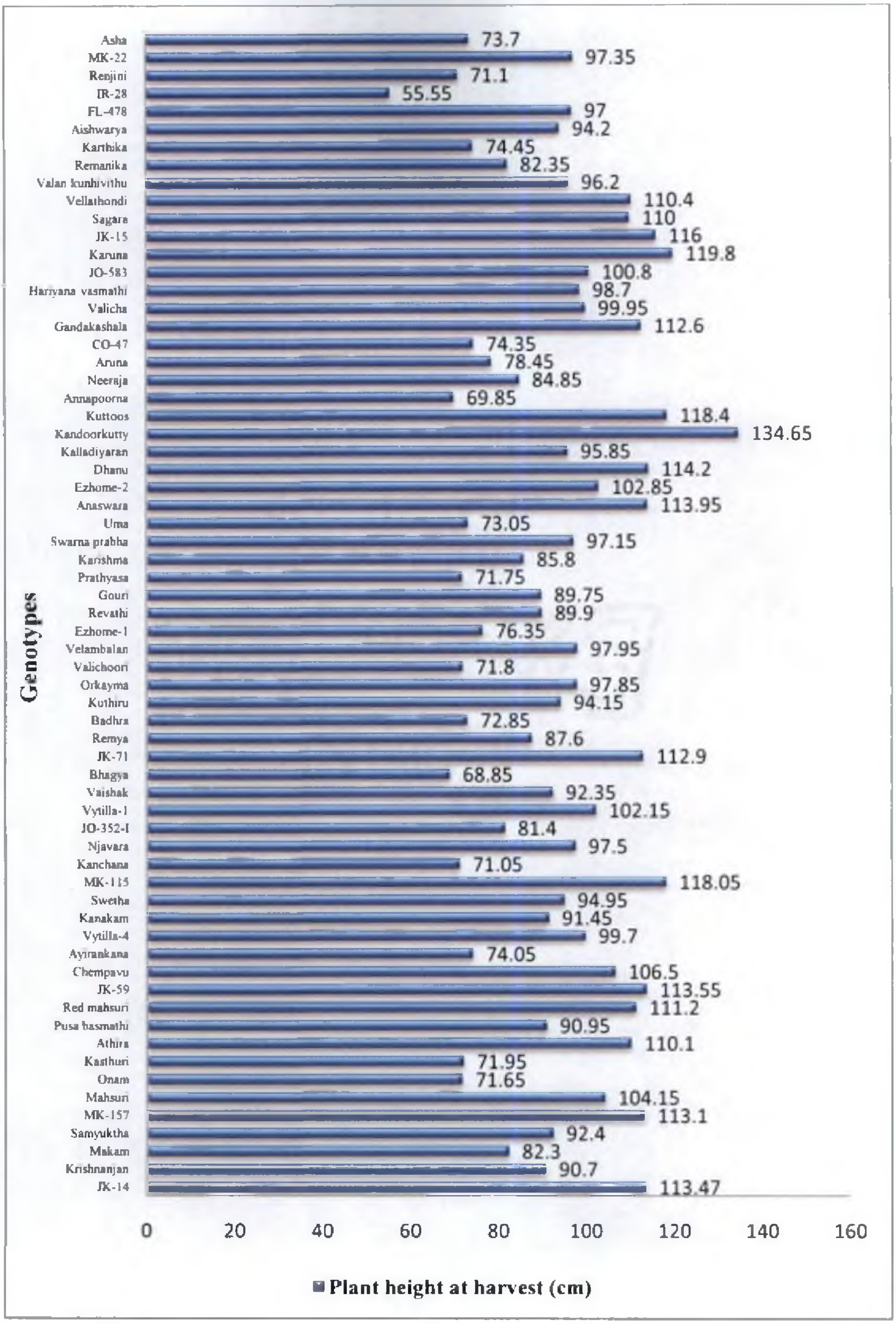


Fig.10. Variation in plant height at harvest stage (cm) of 65 rice genotypes grown under organic management during Rabi season

reproductive stage reduces the paddy yield due to high accumulation of photosynthetes in vegetative parts as compared to reproductive parts (i.e. seed formation and grain filling) and lodging susceptibility (Tahir *et al.*, 1988 and Zahid *et al.*, 2006). Hence these genotypes having higher growth up to 60DAT should be selected to get both higher straw and grain yield. The variation in plant height may be due to the internodes length i.e. the shorter plant height was due to shorter internodes length and taller plant height due to longer internodes. Similar observations were reported by Ashrafuzzaman *et al.* (2009).

5.1.1.4. Number of tillers

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes at all growth stages i.e. 30DAT, 60DAT, 90DAT and harvest stage. It varies from 4.1 to 14.7 at 30DAT (Fig. 11), 5.3 to 17.2 at 60DAT (Fig. 12), 6.5 to 17.8 at 90DAT (Fig. 13), and 6.8 to 18.3 at harvest stage (Fig. 14). Bueren *et al.*, 2002 stated that higher number of plant tillers at early stages leads to increased ground cover to suppress the weed occurrence. It was formed that from transplanting to 30DAT the number of tillers was higher for 'Dhanu', 'Anaswara' and 'Badhra'. Between 30DAT to 60DAT the number of tillers was found to be higher for 'Kalladiyaran' followed by 'Aruna'. Between 60DAT to 90DAT the number of tillers found to be higher for 'Makom' followed by 'Vytila-1'. Considering the period between 30DAT to 90DAT the number of tillers was found to be higher for 'CultureMK-157' which is the first organic rice variety which was followed by 'Vellathondi' and 'Vytila-1'.At all the growth stages 'Dhanu', 'Badhra' and 'Anaswara' recorded highest number of plant tillers including 'Makom' and Culture MK-157recorded higher number of tillers at 60DAT hence these seven genotypes may have the capacity to suppress the weed occurence. (Bueren *et al.*, 2002) and can be considered in breeding programme of organic variety development in order to incorporate weed tolerance ability. Similar observations were reported by Hoad *et al.* (2006) in oats.

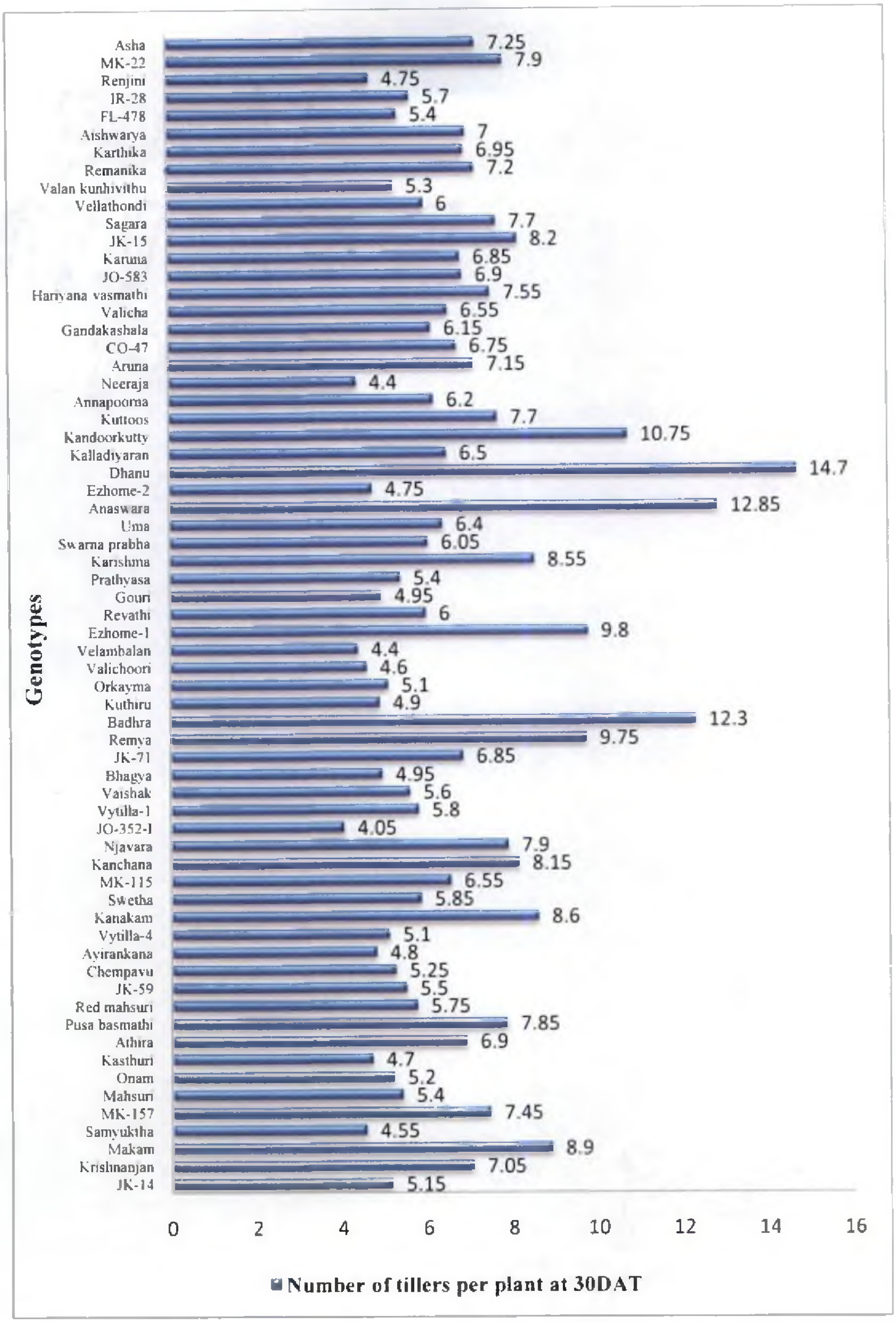


Fig.11. Variation in number of tillers at 30DAT (cm) of 65 rice genotypes grown under organic management during Rabi season

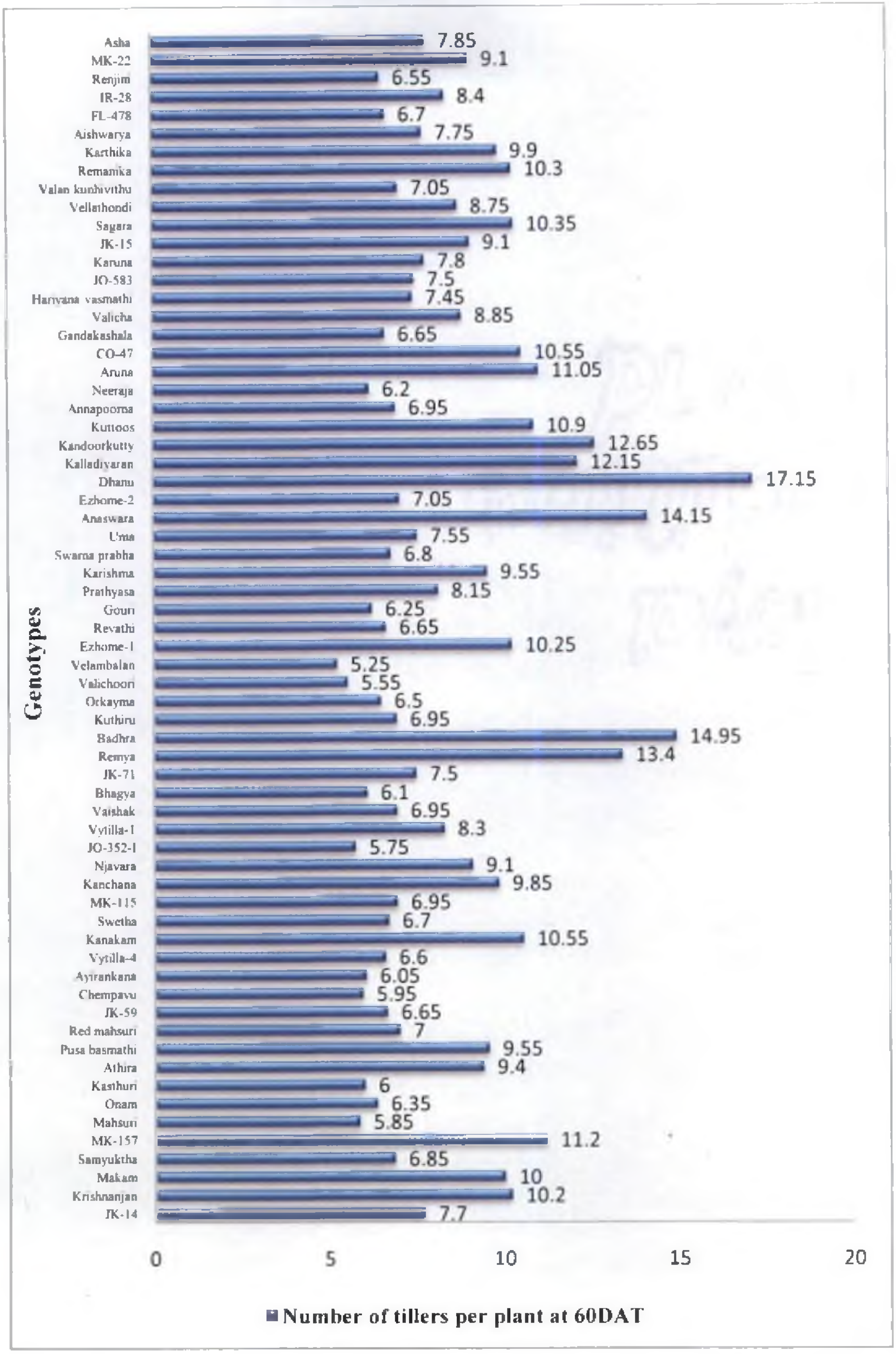


Fig.12. Variation in number of tillers at 60DAT (cm) of 65 rice genotypes grown under organic management during Rabi season

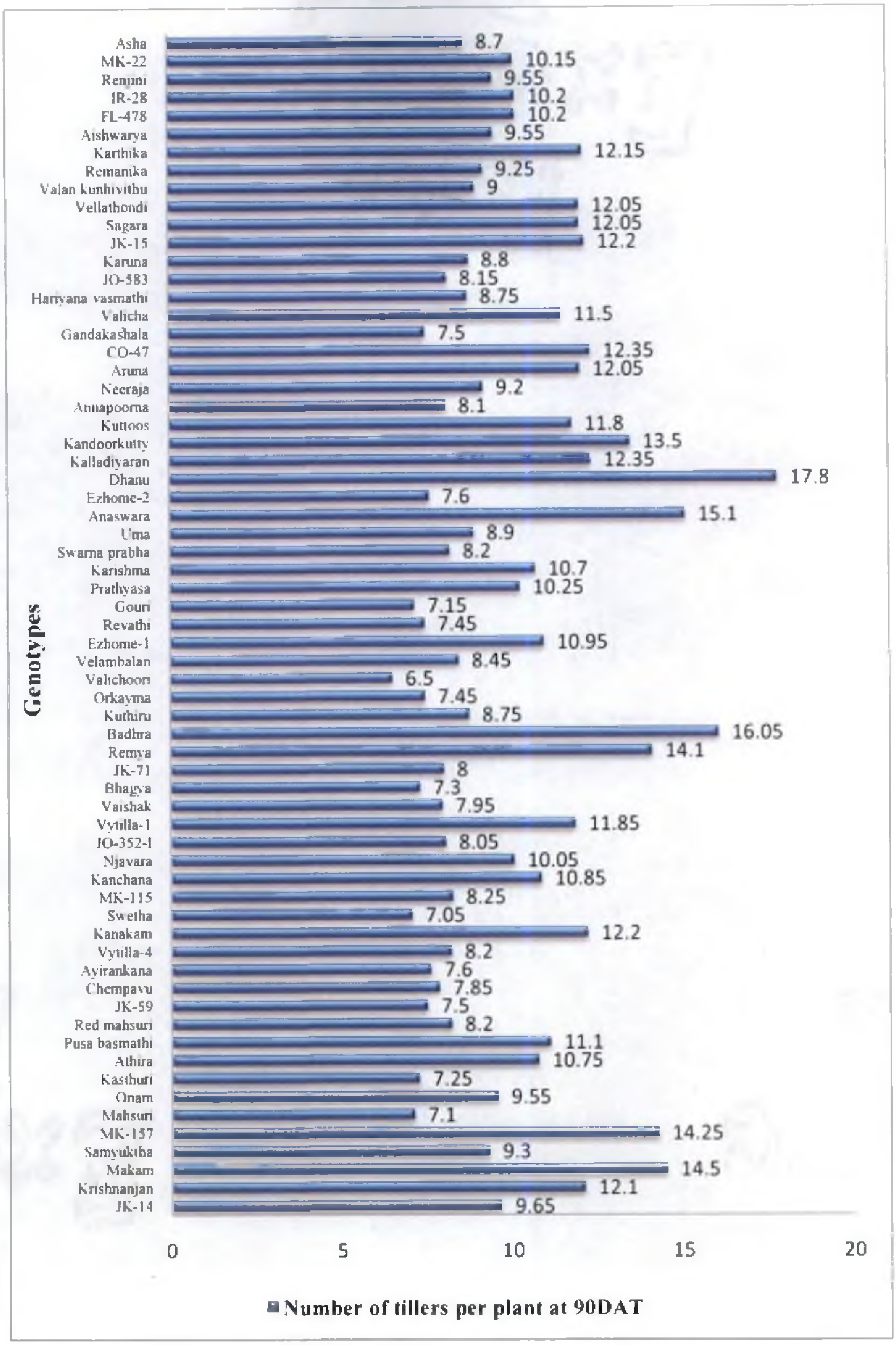


Fig.13. Variation in number of tillers at 90DAT (cm) of 65 rice genotypes grown under organic management during Rabi season

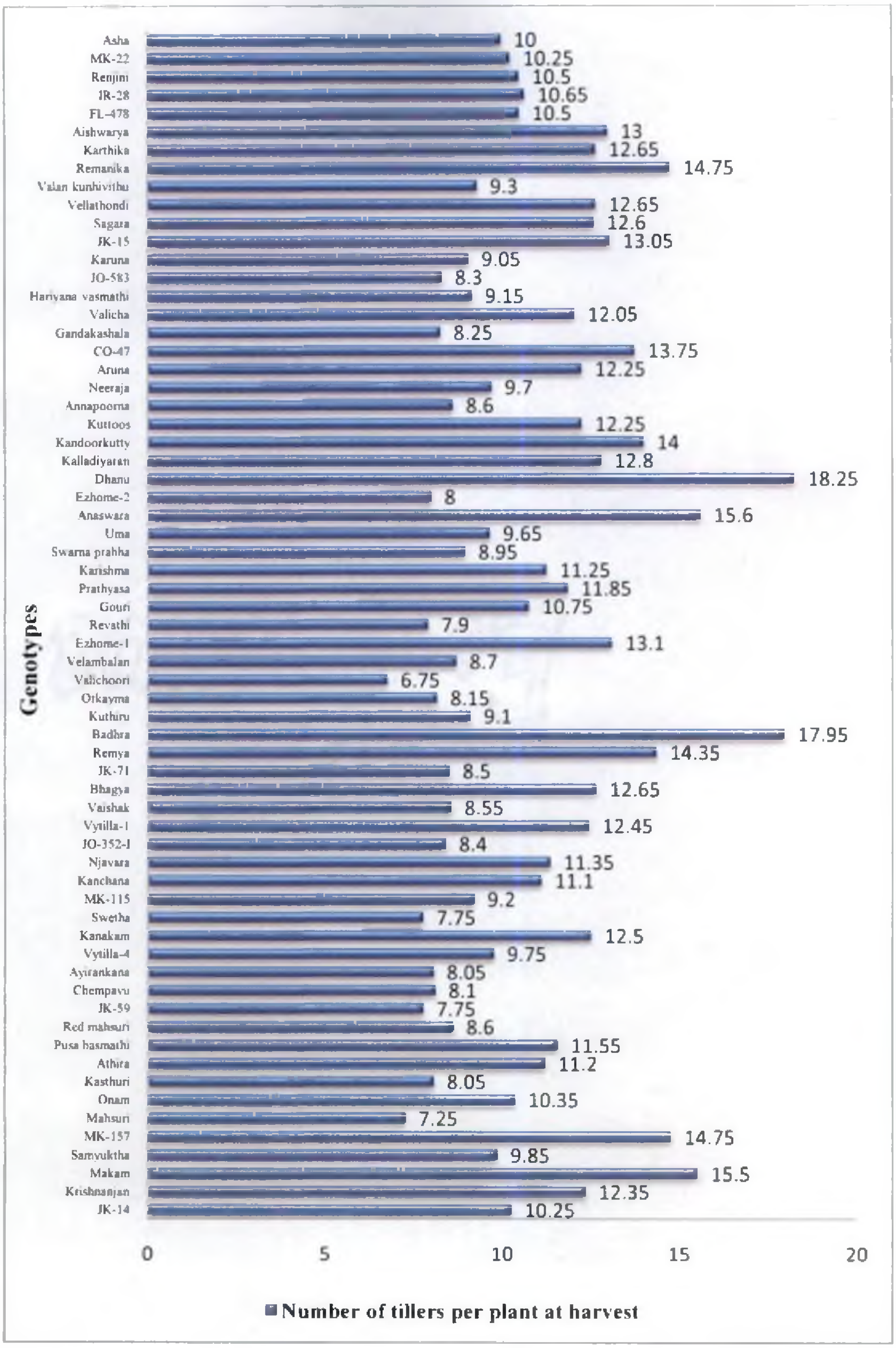


Fig.14. Variation in number of tillers at harvest stage (cm) of 65 rice genotypes grown under organic management during Rabi season

5.1.1.5. Total biomass per plant

In the case of total biomass plant^{-1} there was significant differences at 5% level of significance for all the genotypes. The range of variation is 17.3gm to 67.2gm (Fig. 15). Rice produces a lot of biomass which is an important trait in increasing grain yield. Plant height, erect leaves and tiller number are important plant architectural traits in increasing biomass (Yuan *et al.*, 2008; Fernandez *et al.*, 2009). In the present investigation, the genotypes 'Kanakom', 'Dhanu', 'Remanika', Culture MK-157 (Jaiva), and 'Anaswara' recorded highest biomass, out of which 'Dhanu', Culture MK-157 (Jaiva) and 'Anaswara' found to have significantly higher plant height, number of tillers which are the biomass contributing characters. The highest biomass of 'Kanakom' and 'Remanika' may be due to strong culm nature rather than plant height or number of tillers. Similar observations were reported by Kumar *et al.* (2009).

5.1.1.6. Lodging/ Non-lodging

Phenotypic selection for lodging resistance will be effective in crop improvement programme in the development of non-lodging type varieties. In the study, out of 65 genotypes studied, 16 genotypes found to be lodging type and remaining 49 genotypes are non-lodging type. Similar observations reported by Atanu and Sabesan (2010). In the present era farmers prefer non-lodging varieties for easy harvest both manually and mechanically.

5.1.1.7. Duration of crop

Thirteen genotypes found to be short duration (< 120 days), 25 genotypes are medium duration (120 - 130 days) and remaining 27 genotypes are long duration (>130 days). The dispersity in reported duration of some of the varieties released by KAU may be due to organic management.

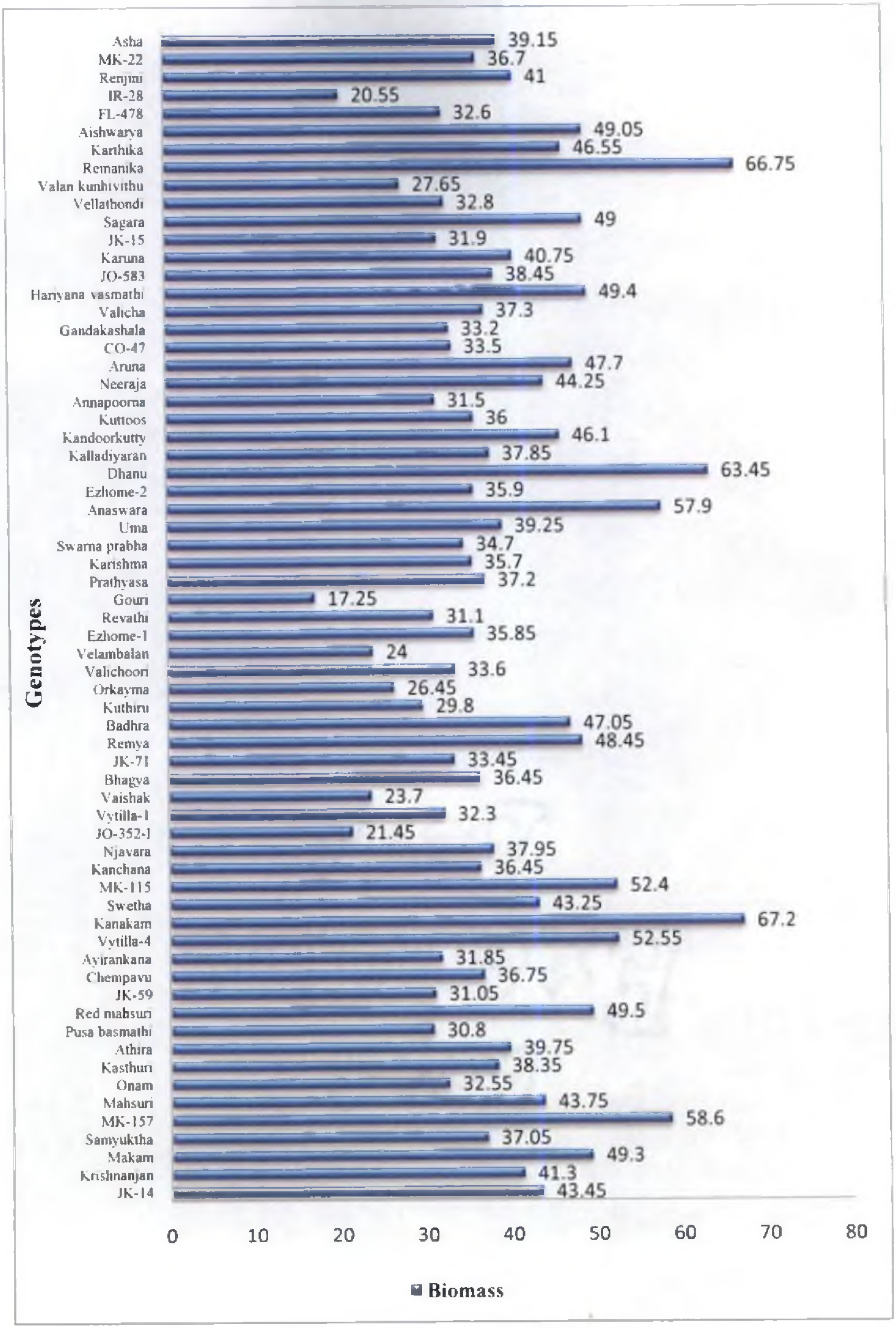


Fig.15. Variation in total biomass plant^{-1} (gm) of 65 rice genotypes grown under organic management during Rabi season

5.1.2. Yield parameters

5.1.2.1. No. of productive tillers per plant

There was significant difference at 5% level of significance for all the genotypes studied for number of productive tillers plant^{-1}. It varies from 4.95 to 16.6 (Fig. 16). Number of panicles was the result of the number of tillers produced and the proportion of effective tillers, which survived to produce panicle (Hossaina *et al.*, 2009). The genotypes 'Badhra', 'Dhanu', 'Anaswara', ' Makam' and Culture MK-157 (Jaiva) recorded higher number of tillers, may be the reason for significantly higher number of productive tillers plant^{-1}. In the same way, Ashrafuzzaman *et al.* (2009) while working with six aromatic rice varieties reported that there had been significant variation in number of productive tillers plant^{-1}.

5.1.2.2. No. of spikelets per panicle

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes for number of spikelets per panicle. It varies from 53 to 298 (Fig. 17).Number of spikelets panicle^{-1} is considered as an yield contributing characteristic, contributing maximum towards genetic diversity. Hence this characteristic could be given due importance for selection of genotypes for further crop improvement programme (Sandhya *et al.*, 2014).The genotypes 'Swetha', 'Mahsuri' and 'Chembav' recorded higher number of spikelets panicle^{-1} may be due to higher length of the panicle. 'Valankunhivithu' a traditional land race recorded the lowest number of spikelets indicating its poor grain yield ability.

5.1.2.3. No. of grains per panicle

Number of grains panicle^{-1} is an important plant trait which should be considered in any breeding program for higher paddy yield in rice (Akhtar *et al.*, 2011). In this study significant difference at 5% level of significance for all the genotypes was observed for number of grains panicle^{-1}. It varies from 12 to 282 (Fig. 18). The genotype 'Mahsuri' recorded significantly higher number of grains panicle^{-1}, and 'Kandoorkutty' recorded significantly lower number of grains panicle^{-1}. 'Kandoorkutty' is a traditional land race popularly grown in saline prone Kaipad tract of North Kerala. Similar observations were reported in rice by Ashrafuzzaman *et al.* (2009), Akhtar *et al.* (2011) and Idris *et al.* (2012).

5.1.2.4. Seed setting percentage

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes for seed setting %. It varies from 12.5% to 93%(Fig. 19).The genotypes Culture MK-157 (Jaiva), 'Aathira', 'FL-478', 'Velambalan', 'Sagara', 'Vaishakh', 'CO-47', 'Vellathondi', 'ValanKunhivithu', 'Mahsuri', 'Vytilla-4', 'Swarnaprabha', 'Valicha', 'Renjini', 'Ezhome-4', 'Kanchana', 'Vytila-1', 'Red Mahsuri' and 'Culture MK-115' recorded significantly higher seed setting %.'Kandoorkutty' recorded significantly lowerseed setting % may be due to its lowest number of grains panicle^{-1}. Similar observations were reported by Vanaja *et al.* (1998) and Abarshahr *et al.* (2011) in different groups of rice genotypes.

5.1.2.5. Length of the panicle

In the case of length of panicle there existed significant differences at 5% level of significance for all the genotypes. It varies from 18.2cm to 30.1cm (Fig. 20).The genotypes 'Vytila-4' and 'Chembav' recorded higher length of the panicle and 'CO-47' recorded lower length of panicle. Shrirame and Muley (2003) observed that panicle length had no significant difference among the genotypes he studied. On the other hand Sharma (2002) while working with fine grain rice reported that there had been significant variation in panicle length.

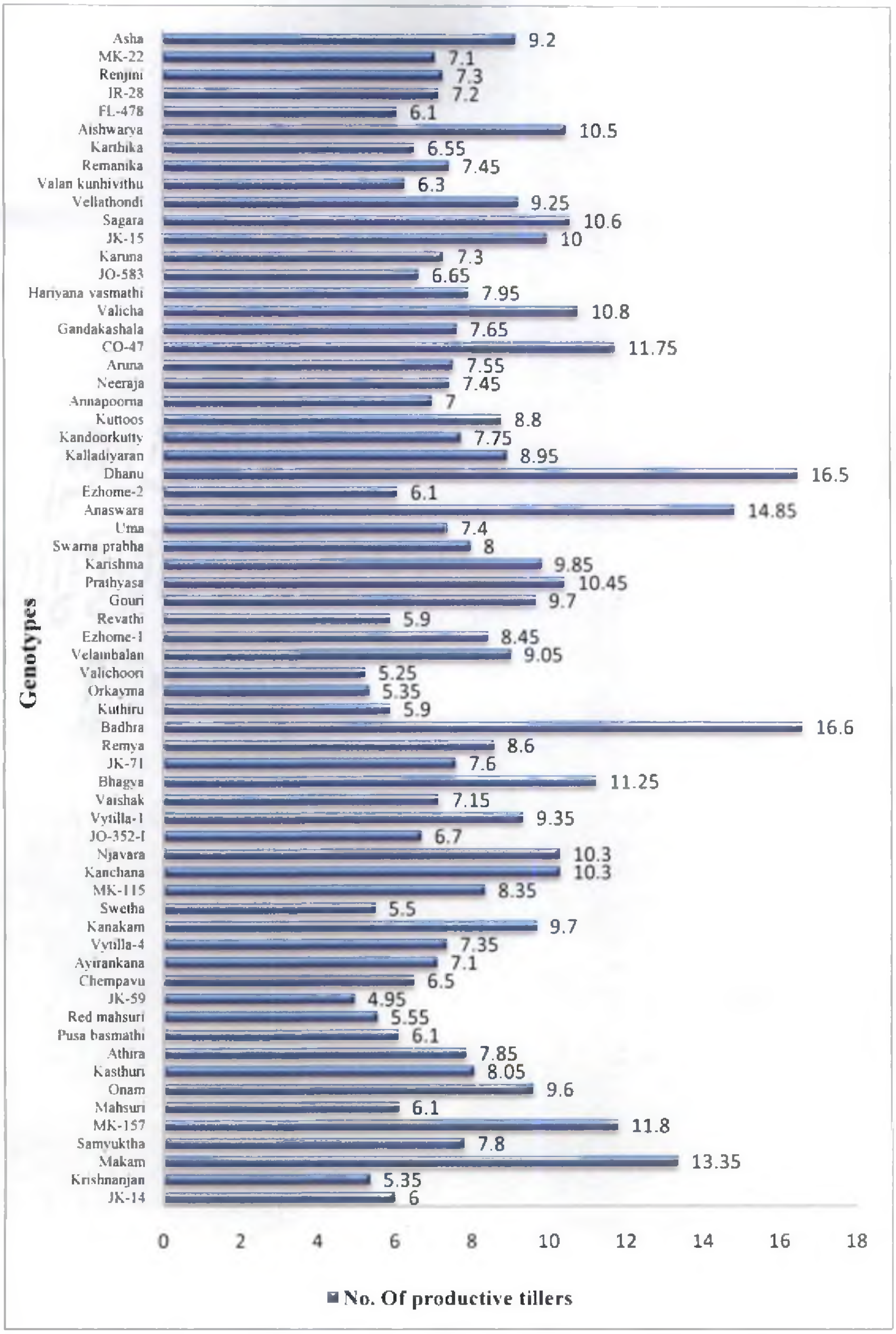


Fig.16. Variation in number of productive tillers plant^{-1} of 65 rice genotypes grown under organic management during Rabi season

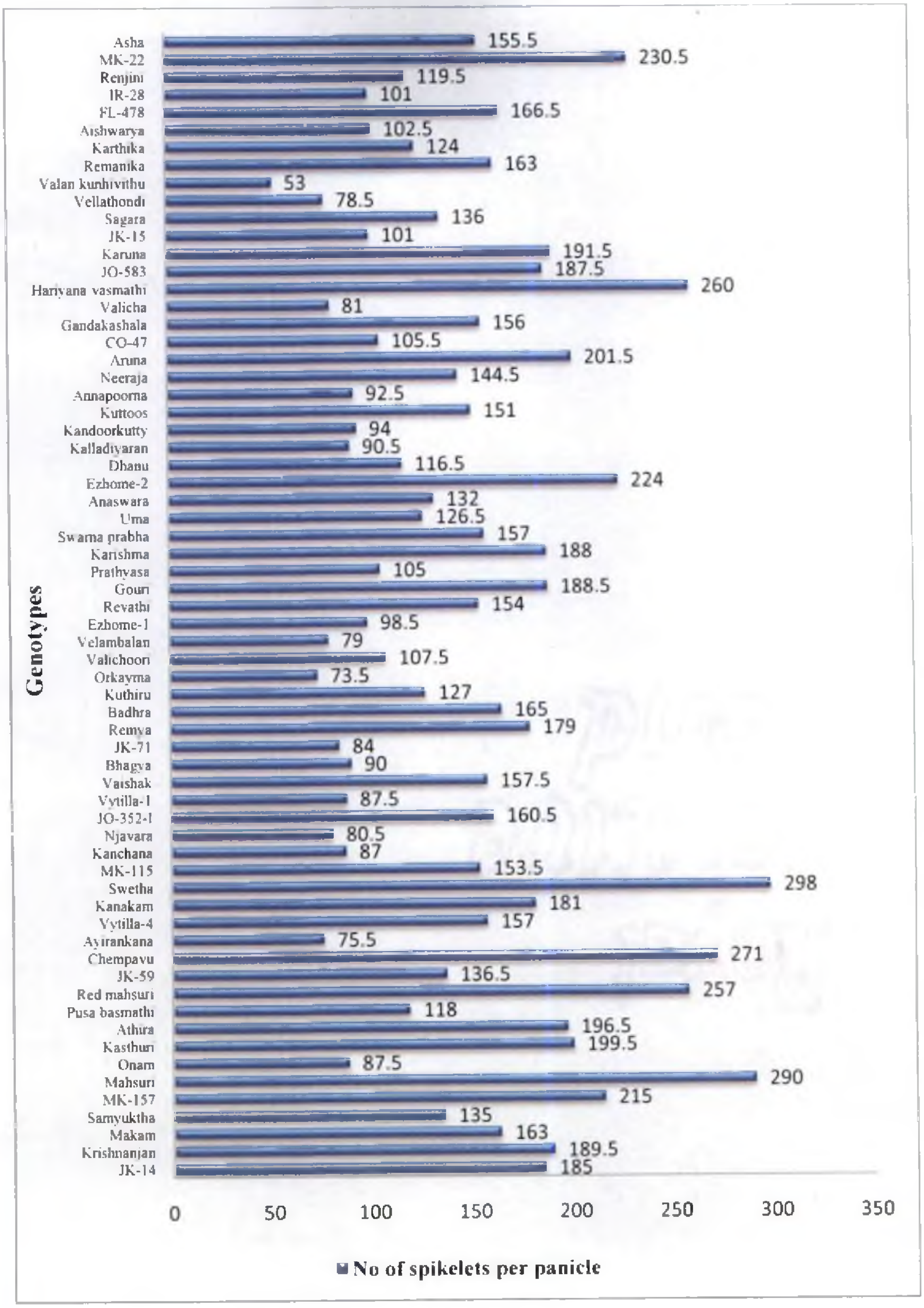


Fig.17. Variation in number of spikelets panicle^{-1} of 65 rice genotypes grown under organic management during Rabi season

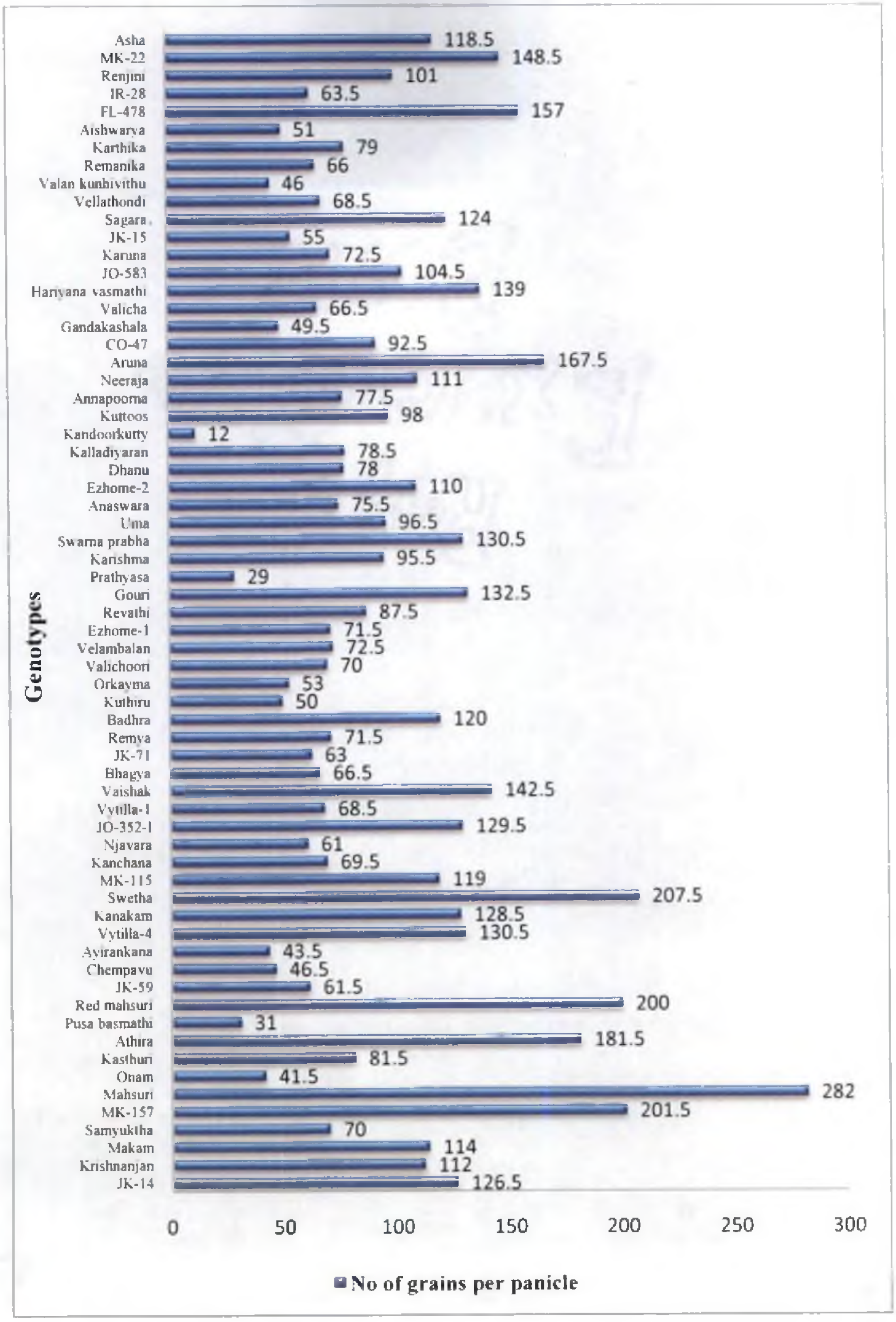


Fig.18. Variation in number of grains panicle^{-1} of 65 rice genotypes grown under organic management during Rabi season

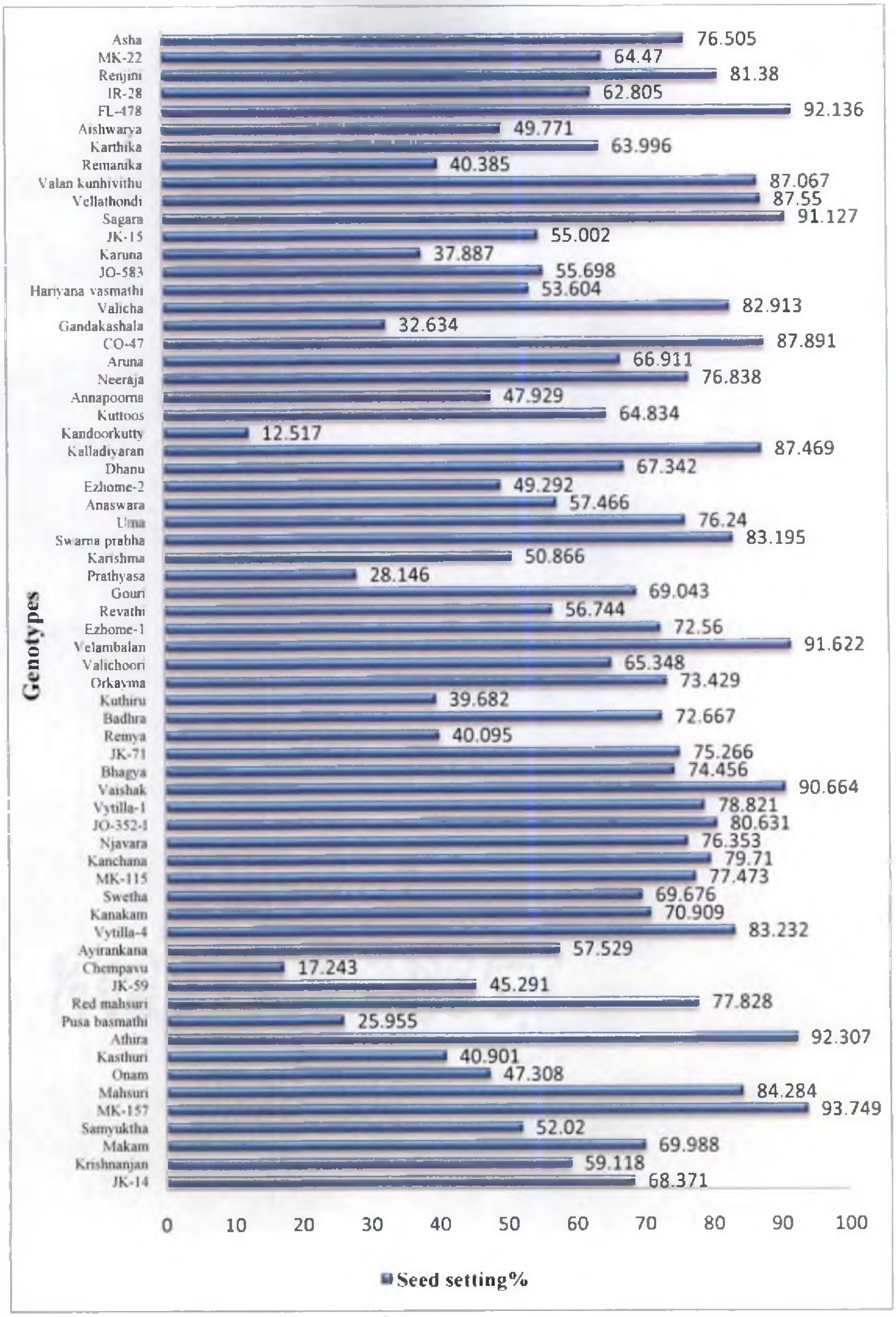


Fig.19. Variation indeed setting % of 65 rice genotypes grown under organic management during Rabi season

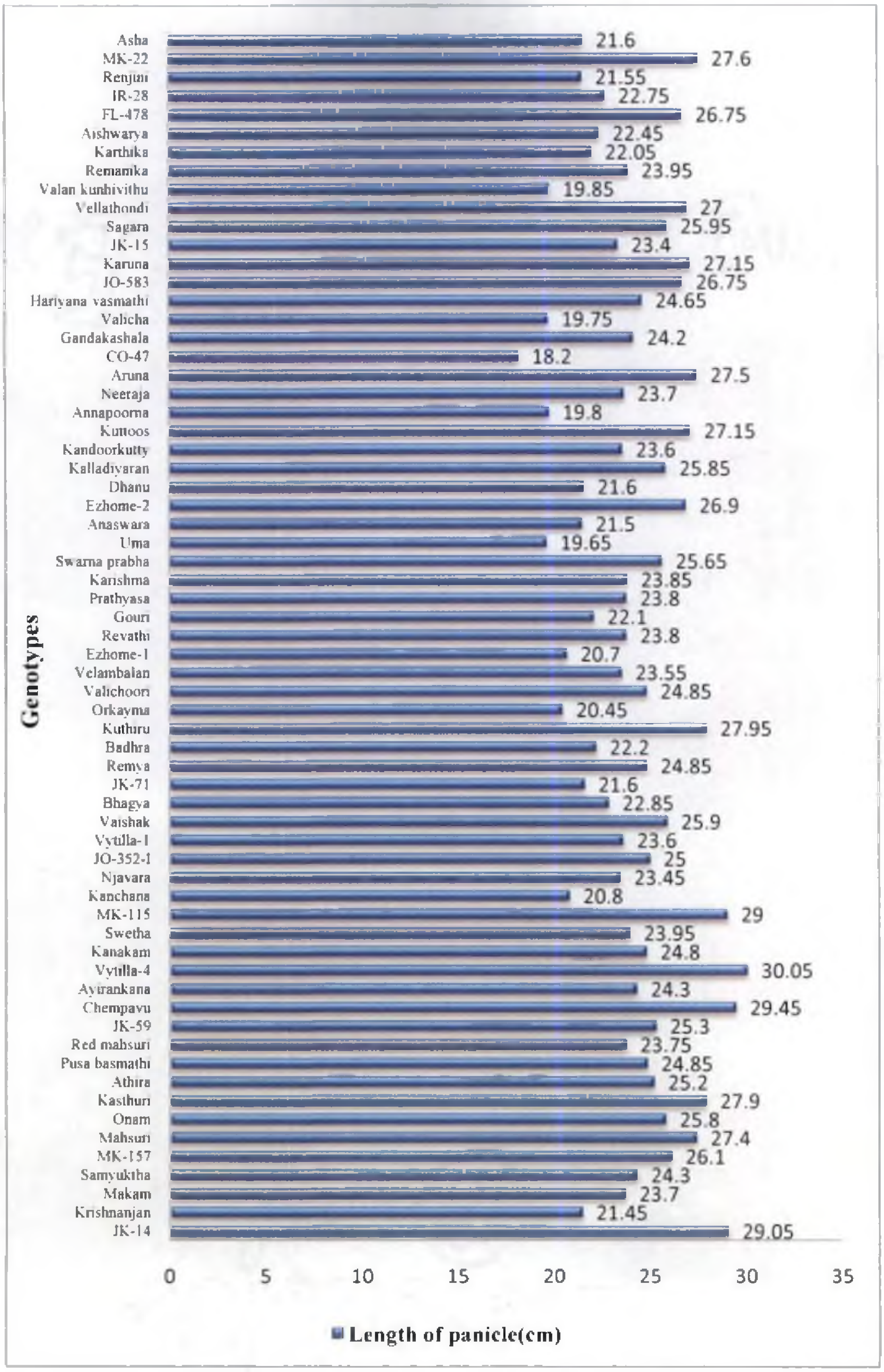


Fig.20. Variation in length of panicle (cm) of 65 rice genotypes grown under organic management during Rabi season

5.1.2.6. 1000 grains weight

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes for 1000 grains weight. It varies from 16.0gm to 35.8gm (Fig. 21). 1000 grain weight is an important plant trait which should be considered when any breeding program for higher paddy yield (Akhtar *et al.*, 2011). The genotype 'Valichoori', a traditional land race recorded significantly high and 'Mahsuri' recorded significantly low value for 1000 grain weight. Sarker *et al.* (2013) and Idris *et al.* (2012) recorded similar observations for 1000 grains weight and 100 grains weight respectively in different sets of genotypes.

5.1.2.7. Grain yield per plant

Grain yield showed significant differences at 5% level of significance for all the genotypes studied. It varies from 4.25gm to 26.6gm (Fig. 22). The genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice (Kusutani *et al.*, 2000; Dutta *et al.* 2002). In the current programme 'Anaswara' and Culture MK-157 (Jaiva) recorded significantly higher grain yield plant^{-1}, may be because of the higher number of productive tillers and number of grains panicle^{-1}.Similar results were reported by Ashrafuzzaman *et al.* (2009). The lowest grain yield recorded by 'Kandoorkutty', the tradition variety, may be due to its lowest number of grains and lowest seed setting % and also the reason can be it being a saline tolerant landrace popularly growing in saline prone tract may require salinity signal for showing enhanced expression (abiotic stress induced yield enhancement).

5.1.2.8. Straw yield per plant

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes studied for straw yield plant^{-1}. It varies from 9.56gm to 45.76gm (Fig. 23).The genotypes 'Kanakom', 'Dhanu', 'Anaswara', Culture MK-157 (Jaiva), Culture MK-115, 'Makam', 'Remanika' and 'Vytilla-4' recorded significantly higher straw yield plant^{-1}. The genotype 'Gouri' recorded

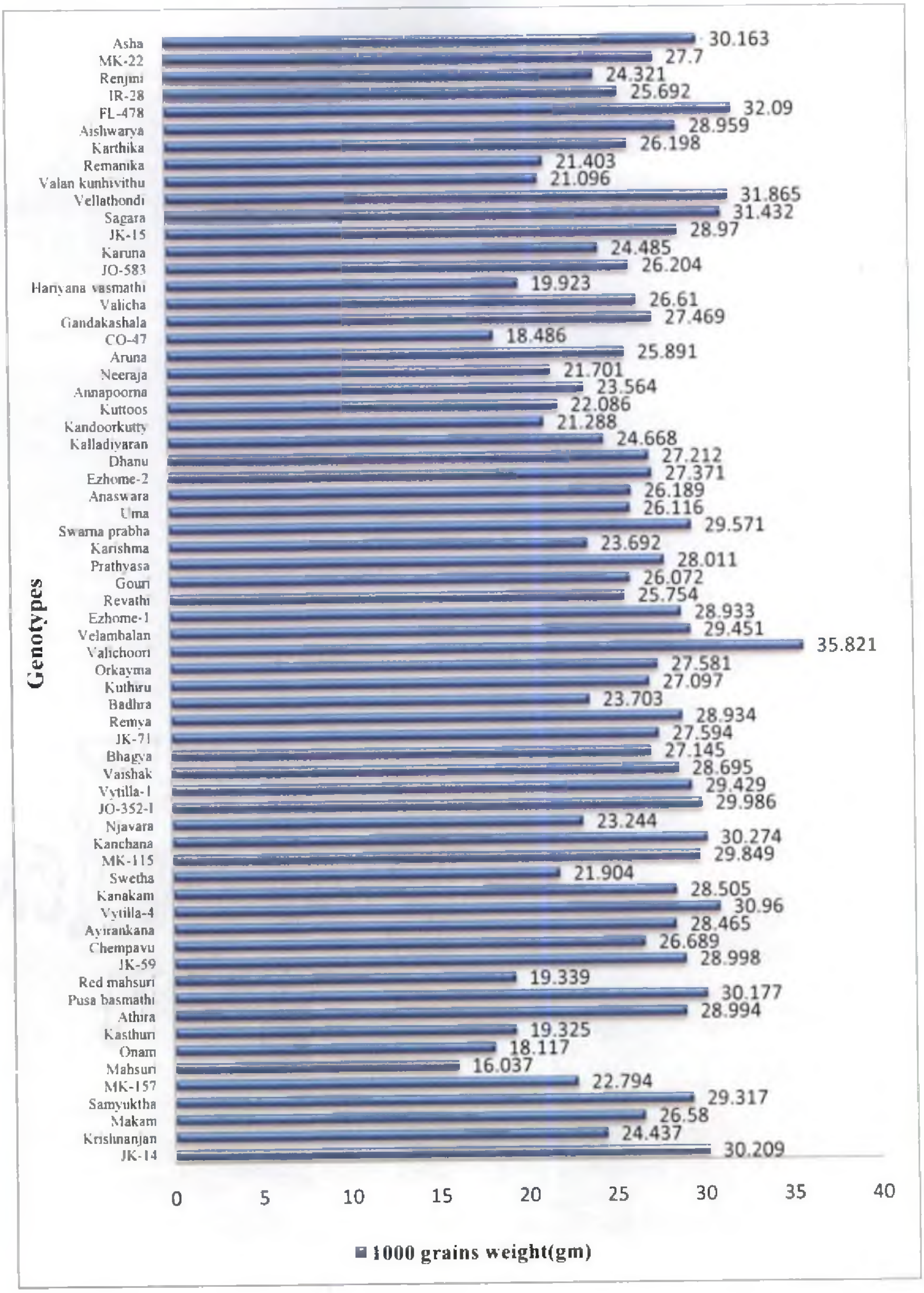


Fig.21. Variation in 1000 grains weight (gm) of 65 rice genotypes grown under organic management during Rabi season

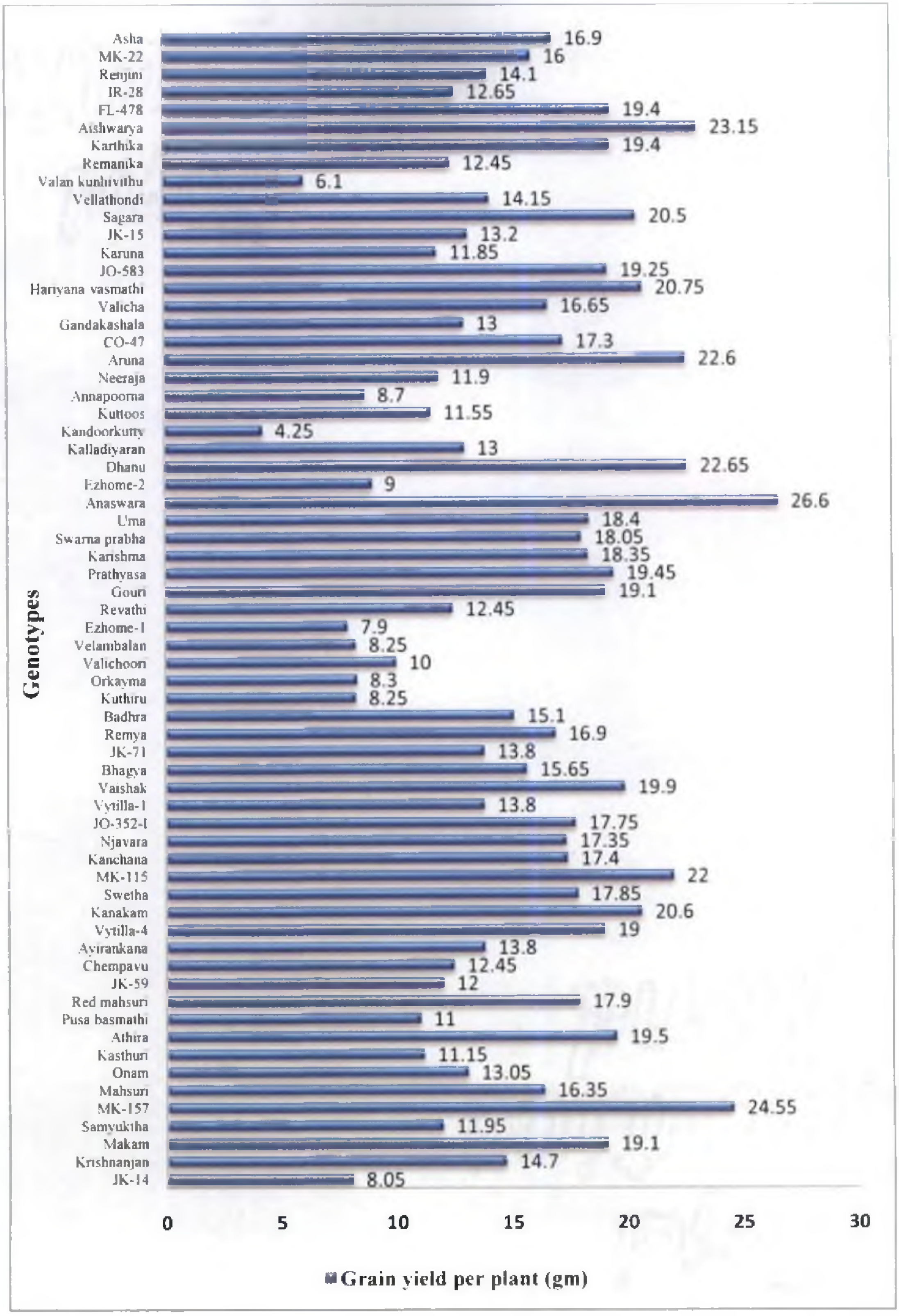


Fig.22. Variation in grain yield plant^{-1} (gm) of 65 rice genotypes grown under organic management during Rabi season

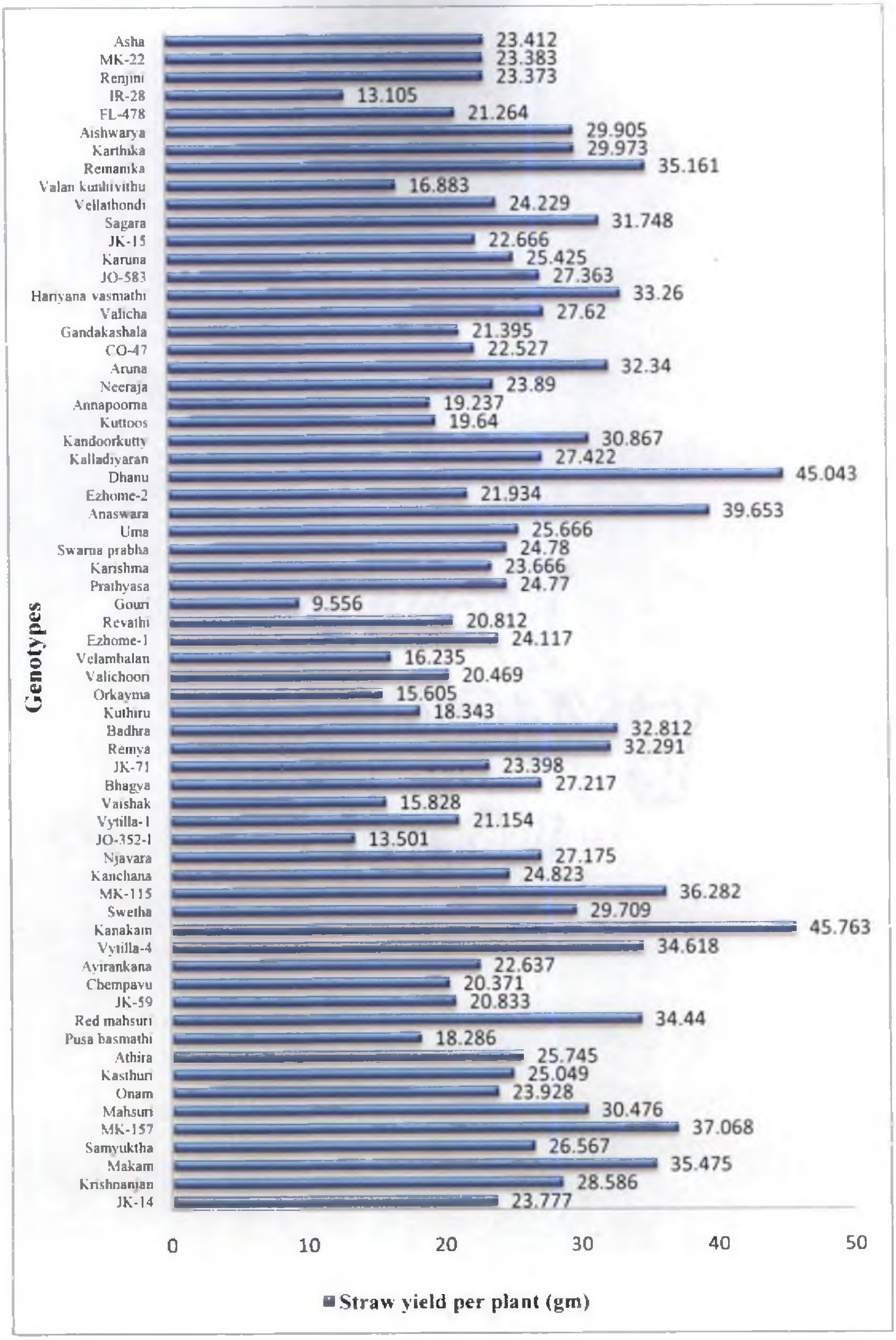


Fig.23. Variation instraw yield plant^{-1} (gm) of 65 rice genotypes grown under organic management

Significantly lower straw yield plant^{-1}. Similar observations were reported by Vanaja *et al.* (1998).

5.1.2.9. Harvest index

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes studied for harvest index. It varies from 0.11 to 0.65. 'IR-28' a long duration rice genotype recorded significantly higher harvest index, may be because of high grain yield and lowest straw yield. Among medium duration rice genotypes 'FL-478' recorded high Harvest Index and was found to be on par with 'Aishwarya', 'Prathyasha', 'CO-47' and 'Karishma'. Among short duration rice genotypes 'Anaswara' found to have highest. 'Kandoorkutty'· the long duration and traditional rice landrace recorded lowest harvest index. Harvest index of top yielding genotypes under organic management namely, 'Anaswara' and 'Jaiva' are 0.55 and 0.51. The standerd value for high yielding organic variety may be 0.51 to 0.55.

5.1.3. Physico-chemical and cooking quality parameters

5.1.3.1. L/B ratio of kernel

Elongation kernel is a preferable characteristic for certain groups of consumers like North India. There is 5% level of significance recorded between genotypes for L/B ratio of kernel. It varies from 1.8 to 4.79 (Fig. 24). The genotype 'PusaBasmathi' an aromatic rice variety recorded significantly higher L/B ratio of kernel, and 'Valankunhivithu' a traditional genotype recorded significantly lower L/B ratio of kernel indicating its smaller kernel size. Similar reports were recorded for different rice genotypes by Vanaja *et al.* (1998) and Umadevi *et al.* (2010) while working with various groups of rice genotypes.

5.1.3.2. Hulling percentage

Hulling % of a variety reveals the thickness and quantity of hull present on grains. Analysis of variance revealed significant differences at 5% level of significance for all the genotypes for hulling %. It varies from 66.25% to 80.94%

(Fig. 25). In the study the genotypes Culture JK-71,'Kanakom', 'Ezhome-1', 'Vytilla-1', Culture MK-115, 'Makam', Culture JO-532-1 (Ezhome-4), 'Gouri', 'Kuthiru', 'Ezhome-2', 'Aasha', 'Karthika', 'Anaswara', 'Remya', 'Uma', 'Sagara', 'Ezhome-3', Culture JK-59, Culture MK-157 (Jaiva), 'Kanchana', 'FL-478', 'Dhanu', Culture JK-15, 'Aishwarya', 'Badhra', 'Njavara', 'Orkayama', 'Vellathondi', 'Aruna', 'Samyuktha', 'Renjini' and 'Aathira' recorded significantly higher hulling % but still it is the modest value for a variety. 'Karuna' recorded significantly lower Hulling %. Similar results of variation in hulling % were also recorded by Umadevi *et al.* (2010) while working with 110 rice genotypes and Manonmani *et al.* (2010) while working with 20 rice hybrids.

5.1.3.3. Volume expansion ratio

The significance of the cooking quality trait volume expansion ratio with respect to consumers is that, it indicates how many people can be fed when one cup of raw rice is cooked. A 5% level of significance recorded between genotypes for volume expansion ratio. It varies from 1.97 to 4.07 (Fig. 26).The genotypes 'CO-47' a Coimbatore variety, Culture MK-157 (Jaiva) the organic variety of KAU and 'Valankunhivithu' a traditional land race recorded significantly higher volume expansion ratio. 'Kandoorkutty' a traditional land race which is saline tolerant recorded significantly lower volume expansion ratio indicating its poor quality characteristic in addition to its poor yield performance in non-saline wetlands. Umadevi *et al.* (2010) and Manonmani *et al.* (2010) also recorded similar results in different sets of rice genotypes.

5.1.3.4. Kernel elongation ratio

Analysis of variance revealed significant differences at 5% level of significance for all the genotypes for kernel elongation ratio. It varies from 1.12 to 1.66 (Fig. 27). The genotypes 'Valankunhivithu' whose grains are the smallest among 65 rice genotypes and has lowest number of grains per panicle, recorded the highest kernel elongation ratio which was on par with that of 'IR-28', Culture JO-532-1 (Ezhome-4)', 'Uma', 'Gandakasala' a traditional land race, 'Valicha', 'Renjini', 'FL-478', 'CO-47', 'Onam', 'Neeraja', 'Ezhome-3', 'Aasha', 'Annapurna', Culture JK-59, 'Swarnaprabha', Culture MK-157 (Jaiva), 'Mahsuri', Culture JO-583, 'Anaswara', 'Ezhome-1', 'Karthika', 'Velambalan',

Culture JK-15, 'Gouri', 'Orkayama', 'Badhra', 'Ayirankana', Culture JK-71, 'Sagara', 'Kasthuri', 'Karuna', 'Vellathondi', 'Bhagya', 'Aruna', 'Vytilla-4', 'Valichoori', 'Aishwarya', 'Chembav', 'Kuthiru', 'Dhanu', 'Revathy', 'Swetha', 'Makam' also recorded on par performance with 'Valankunhivithu' for kernel elongation ratio. 'Vaishakh' an upland rice variety recorded significantly lower kernel elongation ratio. Similar observations were made by Manonmani *et al.* (2010) while working with 20 rice hybrids.

5.1.3.5. Colour of kernel

Out of 65 genotypes studied, 55 genotypes recorded red kernel colour a trait much preferred by people of Kerala, and 20 genotypes recorded white kernel colour.

5.1.3.6. Alkali spreading value

Alkali spreading value which is normally measured to have an idea of the gelatinization temperature (GT), is inversely related to the alkali spreading value (ASV). When rice is treated with dilute alkali, the starch molecules present in rice get degraded resulting in disintegration of the grain (CRRI, 2011). Depending upon the variety, the changes in the grain shape may vary from no apparent effect to a completely dispersed grain. In this study out of 65 genotypes studied, the gelatinization temperature ranged from low (1) to high (5) (Fig. 28). Thirteen genotypes recorded low alkali spreading value, 21 genotypes recorded high alkali spreading value, and 31 genotypes recorded medium alkali spreading value. Rice genotypes with low GT have probably been selected for their cooking quality (Waters et al., 2005). Out of 65 genotypes, 21 genotypes namely, 'Samyuktha', Culture MK-157 (Jaiva), 'Mahsuri', 'Kasthuri', 'Chembav', 'Vytilla-4', 'Swetha', 'Njavara', 'Vytilla-1', 'Vaishakh', 'Orkayama', 'Velambalan', 'Ezhome-1', 'Swarnaprabha', 'Kandoorkutty', 'Aruna', 'CO-47', 'Vellathondi', 'Valankunhivithu', 'Aishwarya' and 'Aasha' recorded higher alkali spreading value, showing low GT which is a trait much preferred for cooking. Similar results were reported by Oko *et al.* (2012), Umadevi *et al.* (2010) and Manonmani *et al.* (2010) while working with different sets of rice genotypes.

5.1.3.6. Sensory evaluation

Sensory evaluation techniques have been used by several researchers to evaluate the effects of storage (Perez and Juliano, 1979), processing and variety on end-use quality of rice. In the current experiment out of 65 genotypes, variation in score ranged 8.6 to 5.3 (Fig. 29). The highest sensory evaluation score was recorded by 'Pusabasmathi' (8.6) an aromatic rice variety, followed by Culture MK-157 (Jaiva) (8.3) the first organic rice variety developed by KAU, 'FL-478' (8.3) a saline tolerant rice variety developed by IRRI from Pakkali variety, 'Ezhome-1' a saline tolerant variety of Kerala, 'Mahsuri' a variety of AndhraPradesh, 'Gouri', 'Swarnaprabha', 'Dhanu', 'IR-28', 'Aasha' and 'Aishwarya'. The genotype 'Makam' recorded lowest Sensory evaluation (5.4) score.

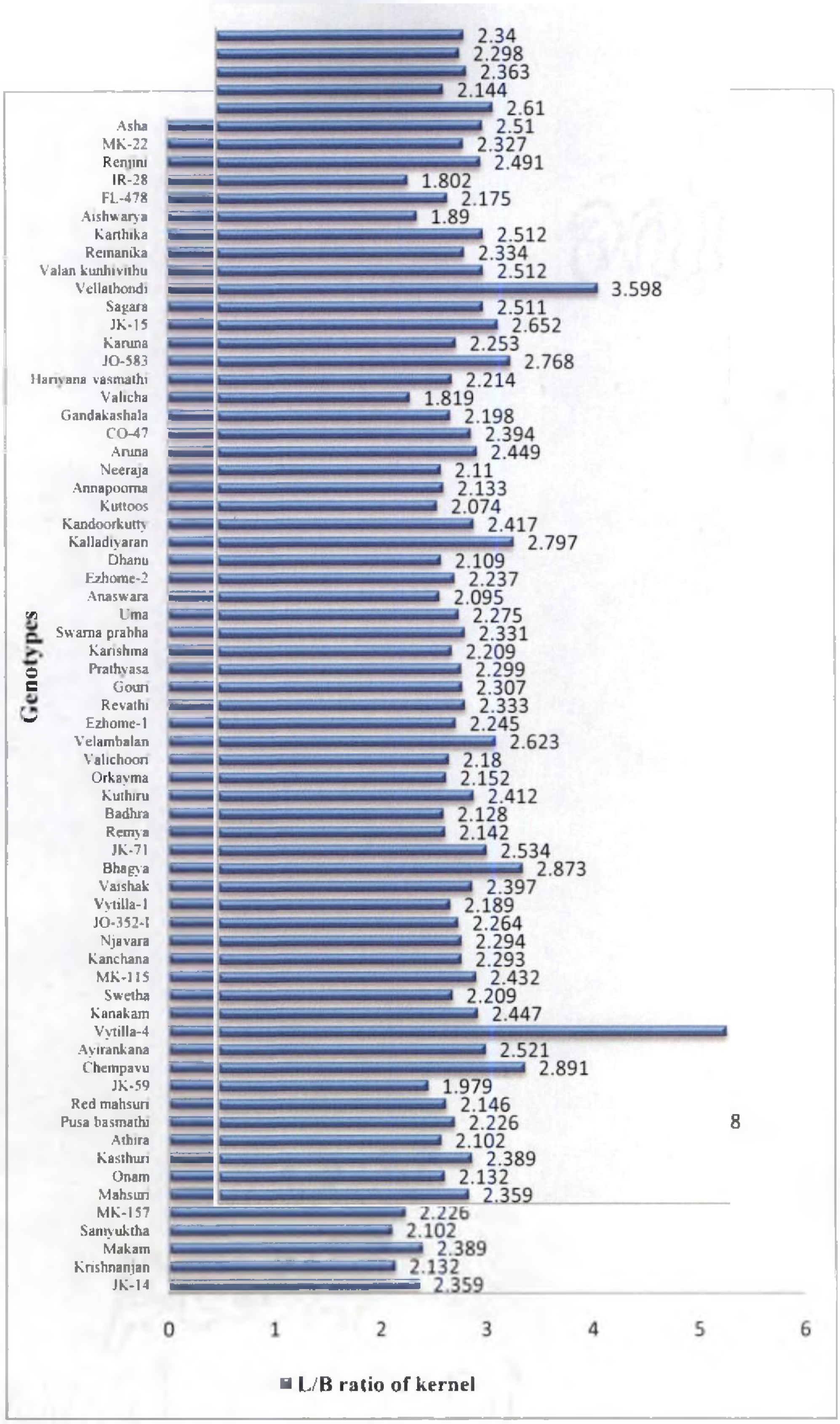


Fig.24. Variation in L/B ratio of kernel of 65 rice genotypes grown under organic management

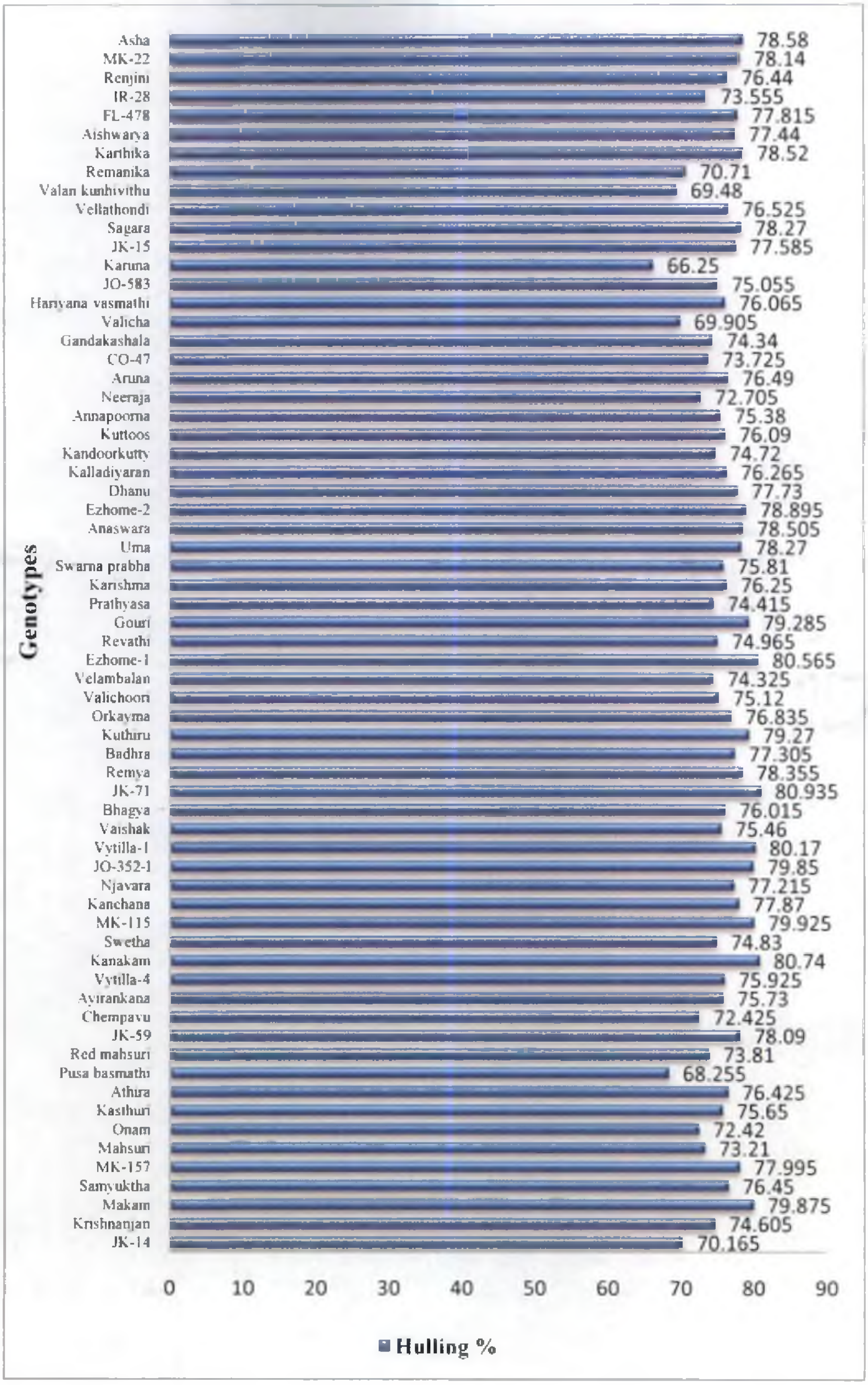


Fig.25. Variation in hulling % of 65 rice genotypes grown under organic management

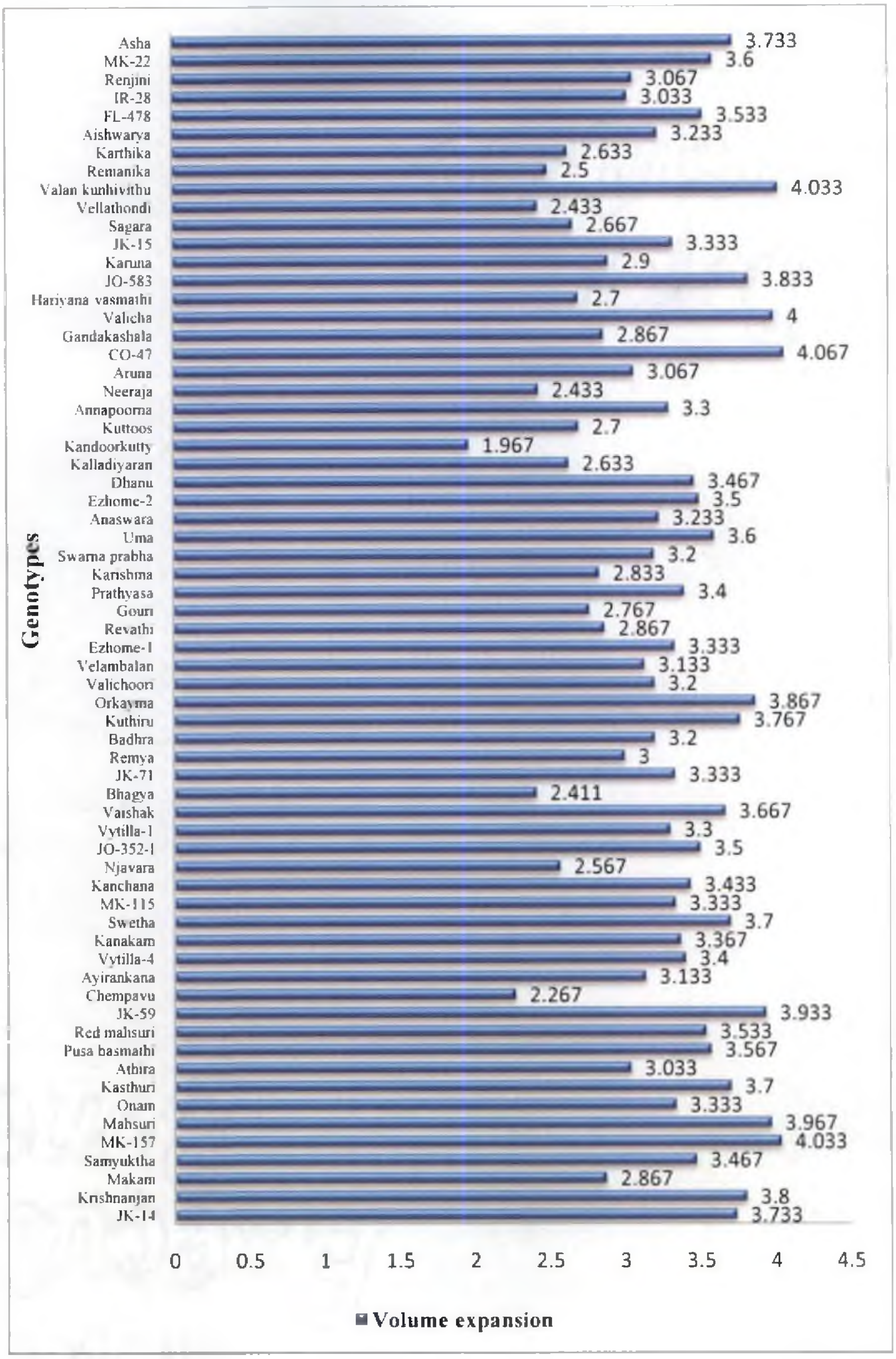


Fig.26. Variation in volume expansion of 65 rice genotypes grown under organic management

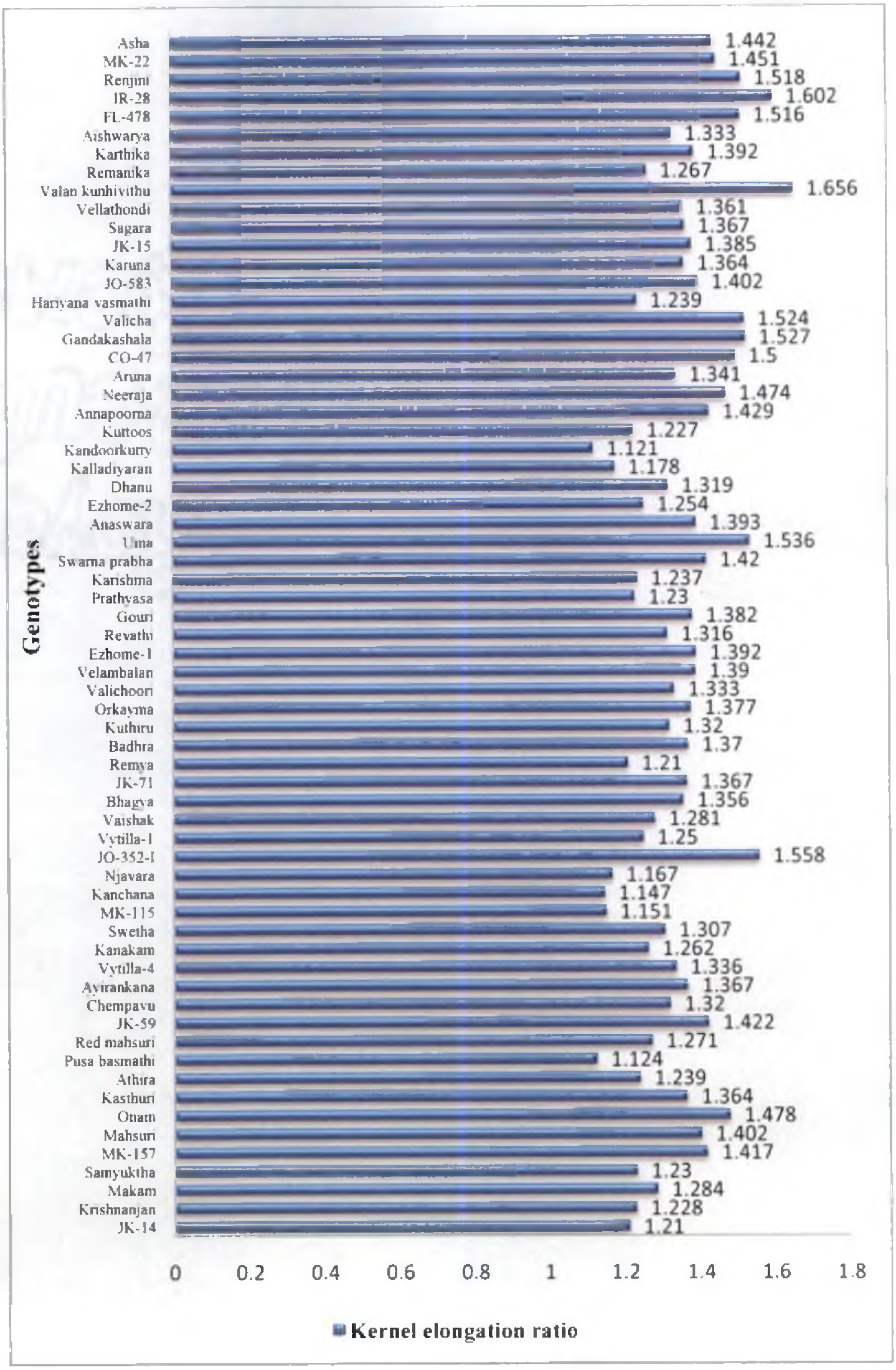


Fig.27. Variation in kernel elongation ratio of 65 rice genotypes grown under organic management

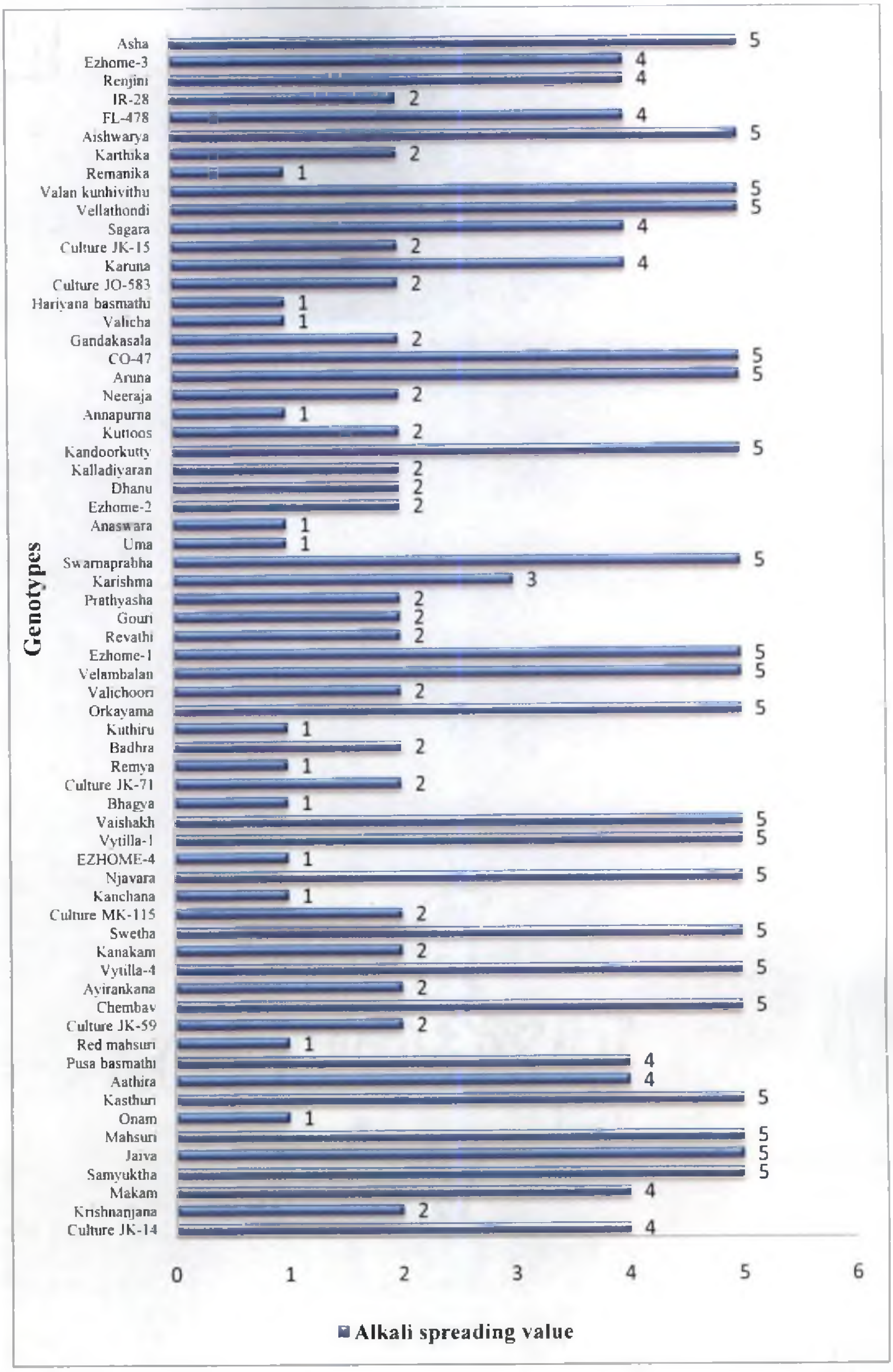


Fig.28.Variation in alkali spreading value of 65 rice genotypes grown under organic management

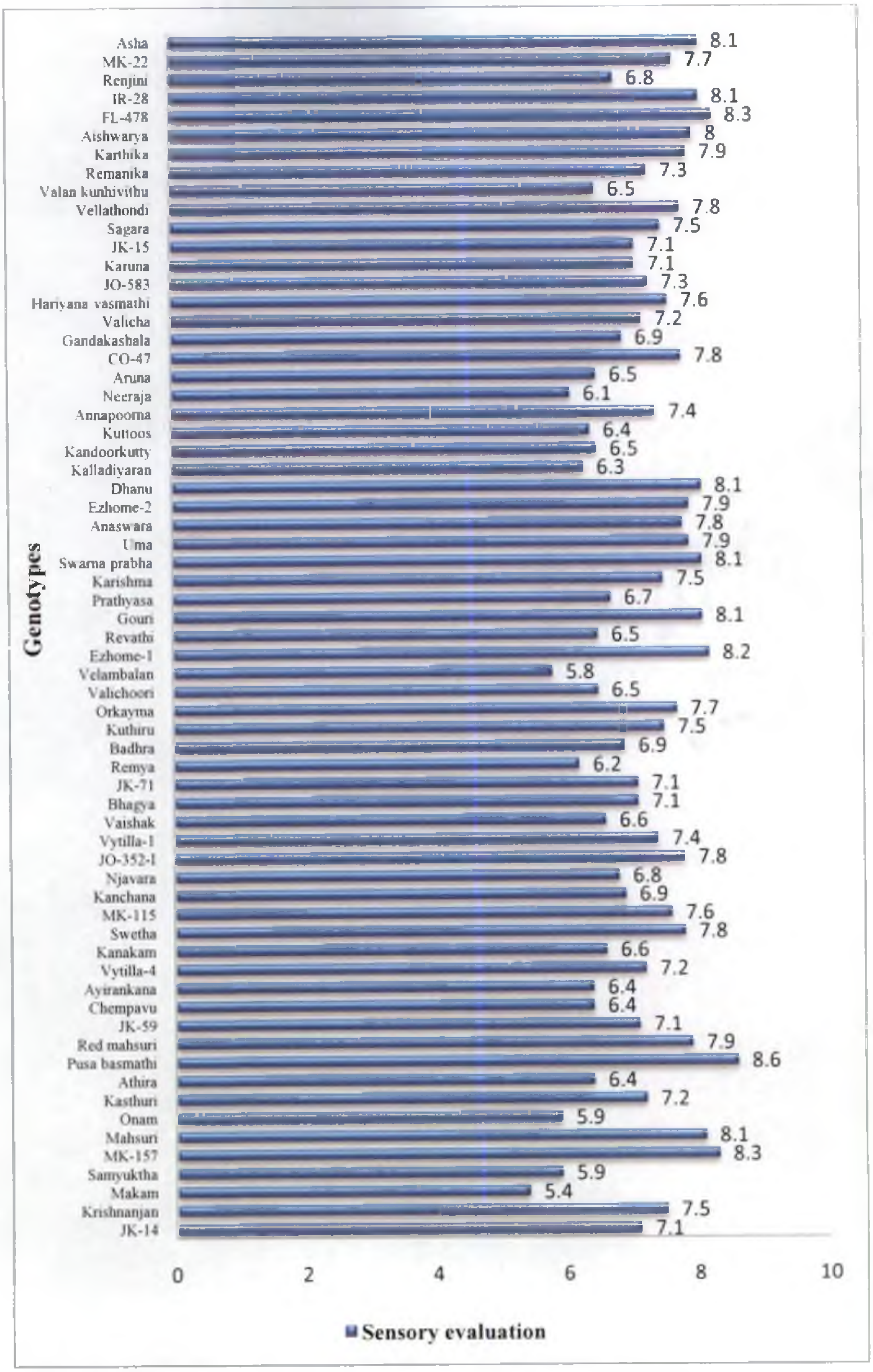


Fig.29. Variation in sensory evaluation of 65 rice genotypes grown under organic management

5.1.4. Incidence of pests and diseases

5.1.4.1. Incidence of pests

In the current study the genotypes namely, Culture JK-59, Culture MK-115, 'Remya', 'Badhra', 'Dhanu', 'Kalladiyaran', 'Aruna', 'Karuna', Culture JK-15, 'Sagara' and 'FL-478' recorded as free from BPH attack indicating that, these can be used as parental material while practicing selection aimed at improvement of BPH resistant variety. Similarly, 'Mahsuri', 'Aathira', 'Anashwara', Culture MK-115, 'Dhanu' and 'Karuna' for leaf roller/leaf folder resistance. 'Makom', 'Aathira', 'Jaiva', 'Pusabasmathi', 'Red mahsuri', Culture JK-59, 'Chembav', 'Ayirankana', 'Vytilla-4', 'Swetha', 'Njavara', Culture JO-532-1 (Ezhome-4),Culture JK-71, 'Remya', 'Revathy', 'Prathyasha', 'Anaswara', 'Neeraja', 'Aruna', 'CO-47', 'Valicha', 'Sagara' and 'Aishwarya' was free from rice bug/ear head bug indicating that, these can be used as parental material while practicing selection aimed at development of rice bug/ear head bug resistant variety as well as for organic rice variety development. The tolerance exhibited by these genotypes may be its genetic potential, which as to be conformed through artificial screening, or field tolerance due to organic cultural management.

5.1.4.2. Incidence of diseases

In the current investigation the genotypes namely, Culture MK-157 (Jaiva), 'Kasthuri', 'Pusabasmathi', 'Red mahsuri', 'Chembav', 'Ayirankana', 'Njavara', 'Kuthiru', 'Ezhome-1', 'Karishma', 'Anashwara', 'CO-47' and 'Valicha' showed tolerance to blast disease indicating that, these can be used as parental material while practicing selection aimed at developmentof rice blast resistant variety and organic rice variety.

5.1.5. Identification of conventional varieties for organic farming for short term and medium term period.

Out of 99 varieties of KAU developed for conventional farming in ordinary wetland using chemical fertilizers, 32 varieties were evaluated under organic management in this study. Out of these, 'Anaswara' variety followed by 'Dhanu' and 'Aishwarya' can be considered for organic farming for the time being as per the suggestion of IFOAM that, till enough organic varieties are developed adopting Organic Plant Breeding(OPB) strategies, those varieties developed for conventional farming using chemical fertilizers but performs well under organic management can be considered. The remaining 67 varieties of KAU developed for conventional farming has to be tested under organic management which may be the future line of work.

Out of 65 rice genotypes evaluated under organic management, 'Anaswara' the conventionally bred variety and Culture MK-157 the genotype developed based on strategies of Organic Plant Breeding (OPB) (it was released in the name 'Jaiva' in 2015 by KAU as the first organic rice variety) ranked first followed by the conventionally bred varieties namely, 'Aishwarya', 'Dhanu', 'Aruna', 'Hariyana Basmathi', 'Kanakom', 'Sagara' and the organic Culture MK-115.

Comparing the top ranked two varieties (i.e. Anaswara and Jaiva) with respect to the important yield and physico-chemical traits which are significant and positively correlated with grain yield, and those have significant and positive direct effect, the organic variety 'Jaiva' top ranked with respect to eight yield contributing characters namely, straw yield plant^{-1}, number of panicles plant^{-1}, total biomass plant^{-1}, number of grains panicle^{-1}, number of tillers at harvest, seed setting %, plant height at 60DAT and hulling%. 'Anaswara' the conventionally bred variety which also top ranked for grain yield under organic management for six yield contributing characters namely, straw yield plant^{-1}, number of grains panicle^{-1}, total biomass plant^{-1}, number of tillers at harvest, plant height at 60DAT and hulling %. Considering the cooking qualities evaluated in the current investigation namely, volume expansion, kernel elongation ratio, alkali spreading value and sensory evaluation, 'Jaiva' ranked best in all four categories and 'Anaswara' ranked only for kernel elongation ratio. With respect to pest and disease incidence, both 'Jaiva' and 'Anaswara' showed resistance to the major peats and diseases studied by visual observation.

Out of seven genotypes which ranked as second set with on par performance with respect to grain yield plant^{-1}, the conventionally bred varieties namely, 'Dhanu', 'Aishwarya' and the flood tolerant prerelease organic Culture MK-115 showed top performance for various yield component traits, few cooking qualities, and pest and disease tolerance. Hence these three genotypes can also be considered for organic farming after 'Jaiva' and 'Anaswara'.

5.2. Character association

5.2.1. Correlation

The present investigation indicated that, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients indicating that, the observed relationships among the various characteristics were due to genetic causes. This is in confirmation with the findings of Radhidevi *et al.* (2002), Najeeb and Wani (2004), Sarkar *et al.* (2007), Anbanandan *et al.* (2009) andSabesan *et al.* (2009). Correlation coefficients are discussed in detail.

Among the correlation coefficients of 25 characteristics with grain yield plant^{-1}, for the characteristics chlorophyll content of flag leaf, chlorophyll content of third leaf, number of tillers plant^{-1}at 30DAT, number of productive tillers plant^{-1}, number of spikelets panicle^{-1}, number of grains panicle^{-1}, seed setting %, straw yield plant^{-1} and hulling % , the genotypic correlation coefficients were higher than phenotypic correlation coefficients, indicating the less influence of environment on these characters. Similar results were reported by (Vanaja *et al.*, 1998; Ojo *et al.*, 2006). However, in the case of parameters namely, number of tillers plant^{-1}at 60DAT, number of tillers plant^{-1}at 90DAT and number of tillers plant^{-1}at harvest, the phenotypic correlation coefficients were higher than genotypic correlation coefficients, which indicates that the influence of environment on these characters is high.

The highest significant positive genotypic correlation of grain yield plant^{-1}with straw yield plant^{-1}followed by number of productive tillers plant^{-1}, number of grains panicle^{-1}, hulling %, seed setting %, number of tillers at 30DAT, number of spikelets panicle^{-1}, number of tillers plant^{-1}at 90DAT, number of tillers plant^{-1}at 60DAT, number of tillers plant^{-1}at harvest, and significant negative genotypic correlation of grain yield plant^{-1} with chlorophyll content of flag leaf and chlorophyll content of third leaf reveals that improvement in grain yield plant^{-1} could be achieved by exercising selection simultaneously for increased straw yield plant^{-1}, number of productive tillers plant^{-1}, number of grains panicle^{-1}, hulling %, seed setting %, number of tillers plant^{-1}at 30DAT, number of spikelets panicle^{-1}, number of tillers plant^{-1}at 90DAT, number of tillers plant^{-1}at 60DAT, number of tillers plant^{-1}at harvest and reduced chlorophyll content of flag leaf and third leaf. The above results were in agreement with the reports of Vanaja *et al.* (1998), Ramakrishnan *et al.* (2006), Chandra *et al.* (2009), Akhtar *et al.* (2011), Idris *et al.* (2012), Nagaraju *et al.* (2013), Kumar and Nilanjaya, (2014) for number of grains panicle^{-1}; Kole *et al.* (2008), Chandra *et al.* (2009),Babu *et al.* (2012), Nagaraju *et al.* (2013), Kumar and Nilanjaya, (2014), Karpagam *et al.* (2014), Allam *et al.* (2015), for number of productive tillers plant^{-1}; Ramakrishnan *et al.* (2006), Kumar and Nilanjaya, (2014) for seed setting %; Reddy *et al.* (2013), Allam *et al.* (2015) for number of spikelets panicle^{-1}.

The genotypic correlation coefficients of the characteristics namely, chlorophyll content of flag leaf, plant height at 60DAT, number of tillers plant^{-1}at 90DAT, chlorophyll content of third leaf, plant height at 30DAT, plant height at 90DAT, plant height at harvest, number of tillers plant^{-1}at 30DAT, number of tillers plant^{-1}at 60DAT, number of tillers plant^{-1}at harvest, number of productive tillers plant^{-1}, number of spikelets panicle-1, number of grains panicle^{-1}, seed setting %, 1000 grains weight and kernel elongation ratio with straw yield plant^{-1}were higher than phenotypic correlation coefficients, showing the less influence of environment on these characters. However, in the case of components namely, root spread and number of productive tillers plant^{-1}, the phenotypic correlation coefficients were higher than genotypic correlation coefficients, indicating the influence of environment on these characters.

The highest significant positive genotypic correlation of straw yield plant^{-1} was with number of tillers plant^{-1} at 60DAT followed by number of tillers plant^{-1} at 30DAT, number of tillers plant^{-1} at harvest, number of tillers plant^{-1} at 90DAT, number of productive tillers plant^{-1}, number of grains panicle^{-1}, number of spikelets panicle^{-1}, plant height at 90DAT, plant height at harvest, plant height at 30DAT, plant height at 60DAT, root spread and seed setting %, and highest significant negative genotypic correlations observed between straw yield plant^{-1} and chlorophyll content of flag leaf, kernel elongation ratio, chlorophyll content of third leaf and 1000 grains weight reveals that improvement in straw yield plant^{-1} could be achieved by increased number of tillers at 60DAT, number of tillers plant^{-1} at 30DAT, number of tillers plant^{-1} at harvest, number of tillers plant^{-1} at 90DAT, number of productive tillers plant^{-1}, number of grains panicle^{-1}, number of spikelets panicle^{-1}, plant height at 90DAT, plant height at harvest, plant height at 30DAT, plant height at 60DAT, root spread, seed setting % and reduced chlorophyll content of flag leaf and third leaf, kernel elongation ratio, chlorophyll content of third leaf and 1000 grains weight.

The high degree of significant positive association both at phenotypic and genotypic levels between straw yield plant^{-1} and grain yield plant^{-1} suggests that straw yield plant^{-1} is a highly reliable component of yield and can very well be utilized as an yield indicator, as it is an organic varietal trait. High degree of significant negative association both at phenotypic and genotypic levels of chlorophyll content of flag leaf at flowering stage and grain yield plant^{-1}indicates that while selecting parents we should go for a genotype having optimum chlorophyll content in flag leaf. High degree of significant positive association both at phenotypic and genotypic levels between number of tillers at all the growth stages and grain yield plant^{-1} suggests that number of tillers is an important yield contributing characteristics. Similar association was found between number of tillers plant^{-1} at all the growth stages and straw yield plant^{-1} suggesting that number of tillers is not only contribute high grain yield, it also major straw yield contributing characteristic and can be utilized as both grain yield and straw yield indicator at all the growth stages. The high degree of association found between number of grains panicle^{-1} and grain yield plant^{-1} compared to number of spikelets panicle^{-1} and grain yield plant^{-1} indicates that number of grains panicle^{-1} is a major yield contributing character than number spikelets panicle^{-1}, hence more importance has to be given to number of grains panicle^{-1} in yield improvement programmes. Similarly high degree of association found between number of productive tillers plant^{-1} and grain yield plant^{-1} compared to number of tillers and grain yield plant^{-1}indicates that productive tillers plant^{-1} is another major yield contributing characteristic than number of tillers plant^{-1}.

In the present study, absence of significant correlation of the important physico-chemical characters namely, L/B ratio of kernel, volume expansion, kernel elongation ratio with yield, suggests that these characters can be recombined as desired. The results were in agreement with the reports of Vanaja *et al.* (1998), Manonmani *et al.* (2010), Umadevi *et al.* (2010) for kernel elongation ratio. The negative association of L/B ratio of kernel with kernel elongation ratio and hulling% reveals that when the slenderness of grain increases the percentage of getting hulled grain as well as rate of expansion of kernel decreases.

The information on the inter-correlation among the yield components shows the nature and extent of relationship with each other. This will help in the simultaneous improvement of different characteristics along with grain yield in the breeding programmes (Umadevi *et al.*, 2010). Inter correlations among yield component characteristics revealed that heavy selection pressure on high straw yield plant^{-1} would bring forth correlation response of desirable characteristics such as more number of tillers at all growth stages, more number of productive tillers plant^{-1}, more number of spikelets panicle^{-1}, more number of grains panicle^{-1}, high Seed setting %, tall plant height at all growth stages, reduced chlorophyll content at flowering stage, low kernel elongation ratio and reduced 1000 grains weight. Similar inter correlations were earlier reported by Chandra *et al.* (2009)

between number of productive tillers per plant, panicle length, number of grains per panicle and 1000-grain weight; Nagaraju *et al.* (2013) between number of grains per panicle, total number of productive tillers per plant; Dhurai *et al.* (2014) between harvest index, number of grains per panicle, days to maturity.

It was evident from genotypic and phenotypic correlation coefficients that number of tillers plant^{-1}at 60 DAT plays a higher role compared to number of tillers at 30 DAT, at 90 DAT and at harvest to increase the straw yield plant^{-1}. Intercorrelations of panicle length with other yield components revealed that when panicle length increases number of spikelets panicle^{-1}, number of grains panicle^{-1} increases, which have positive significant correlation with yield. Hence, even though panicle length had no direct significant correlation with yield it has significant indirect influence on yield.

5.2.2. Path analysis

Though the correlation studies are helpful in measuring the association between yield and yield components; they do not provide the exact picture of the direct and indirect cause of such association which can be obtained through path analysis (Wright, 1923). Path analysis is very useful to pinpoint the important component which can be utilized for formulating selection parameters.

Low residual effect obtained in path analysis of current experiment indicates that the causative factor included in the analysis have been adequate to explain variability in yield. Path coefficient analysis revealed that the highest positive direct effect was exhibited by plant height at 90DAT. This may be due to the strong positive significant correlation between plant height at 90DAT and straw yield, where straw yield is highly correlated with grain yield plant^{-1}. It may also due do the combined effect of its positive indirect effect through plant height at harvest, or it may be due to organic farming, as it is an organic varietal trait. Positive direct effect of plant height on grain yield was earlier reported by Nagaraju *et al.* (2013), Dhurai *et al.* (2014). Second highest positive direct effect on grain yield plant^{-1} was contributed by the characteristic chlorophyll content of third leaf. High positive direct effect excerted by chlorophyll content of third leaf on grain yield plant^{-1} and at the same time its negative significant correlation with grain yield plant^{-1}indicates that there should be optimum chlorophyll content of third leaf at flowering stage for maximizing grain yield plant^{-1}. Highest positive direct effect of chlorophyll content was earlier reported by Kumar and Nilanjaya, (2014). Other characteristics namely, root weight, root spread, plant height at 30DAT, plant height at 60DAT, number of tillers plant^{-1}at 60DAT, number of productive tillers plant^{-1}, 1000 grains weight, straw yield plant^{-1}, number of grains panicle^{-1}, number of tillers plant^{-1}at harvest, L/B ratio of kernel and kernel elongation ratio also exhibited positive direct influence on grain yield plant^{-1}indicating their importance in determining this complex character and therefore, should be kept in mind while practicing selection aimed at the improvement of grain yield plant^{-1}. These results are in accordance with the findings of Vanaja *et al.* (1998), Ramakrishnan *et al.* (2006), Chandra *et al.* (2009), Nagaraju *et al.* (2013), Kumar and Nilanjaya, (2014), Allam *et al.* (2015) for number of productive tillers plant^{-1}; Prasad *et al.* (2001), Ramakrishnan *et al.* (2006), Chandra *et al.* (2009), Dhurai *et al.* (2014), Nagaraju *et al.* (2013), Kumar and Nilanjaya, (2014) for number of grains panicle^{-1}; Vanaja *et al.* (1998), Prasad *et al.* (2001), Chandra *et al.* (2009), Akhtar *et al.* (2011), Kumar and Nilanjaya, (2014) for 1000 grains weight; Ramakrishnan *et al.* (2006), Dhurai *et al.* (2014) for L/B ratio of kernel; Nagaraju *et al.* (2013), Dhurai *et al.* (2014) for kernel elongation ratio; Kumar and Nilanjaya, (2014) for number of tillers.

The highest negative direct effect was exhibited by plant height at harvest. This indicates that tallness in rice reduces the paddy yield due to high accumulation of photosynthates in vegetative parts as compared to reproductive parts (i.e. seed formation and grain filling) and lodging susceptibility (Tahir *et al.*, 1988 and Zahid *et al.*, 2006). Hence while selecting the genotypes, emphasis should be given to those becoming tall for up to reproductive stage for the improvement of grain yield plant^{-1}. Negative direct effect of plant height was earlier reported by Prasad *et al.* (2001), Ramakrishnan *et al.* (2006), Chandra *et al.*

(2009), Akhtar *et al.* (2011), Abarshahr *et al.* (2011), Kumar and Nilanjaya, (2014). Negative direct effect was also exhibited by the characteristics namely, Chlorophyll content of flag leaf, root length, number of tillers plant^{-1}at 30DAT, number of tillers plant^{-1}at 90DAT, total biomass plant^{-1}, number of spikelets panicle^{-1}, seed setting %, length of panicle, hulling % and volume expansion. These results are in accordance with the findings of Ramakrishnan *et al.* (2006), Chandra *et al.* (2009), Dhurai *et al.* (2014) for panicle length; Akhtar *et al.* (2011) for number of tillers; Kumar and Nilanjaya, (2014) for root length; Vanaja *et al.* (1998) for number of spikelets panicle^{-1}.

Correlation and path analysis studies conducted in the present investigation reveal that, in yield improvement programmes of organic rice, breeder should give emphasis for high plant height up to 90DAT, optimum plant height at harvest, high straw yield plant^{-1}, high chlorophyll content of third leaf with optimum chlorophyll content of flag leaf, high number of tillers at all the growth stages with high number of productive tillers plant^{-1}, high root weight and root spread with optimum root length, total biomass plant^{-1}, optimum length of panicle with optimum number of spikelets panicle^{-1}, with high number of grains panicle^{-1} and high seed setting %, high 1000 grains weight with optimum hulling %, high L/B ratio of kernel, high kernel elongation ratio and optimum volume expansion.

5.2.3. Identification of organic varietal traits

Out of eighteen growth and yield parameters studied under organic management, four parameters namely, number of tillers plant^{-1}at harvest, number of productive tillers plant^{-1}, number of grains panicle^{-1} and straw yield plant^{-1} showed both positive significant correlation and direct effect with grain yield plant^{-1}. Hence these four characteristics can be considered as organic varietal yield component traits. Similar results were reported by Kopke, 2005; Hoad *et al.*, 2006; Tann *et al.*, 2012; Siavoshi *et al.*, 2013 for number of tillers plant^{-1}, Nasser, 2010; Sangeetha *et al.*, 2013 for straw yield plant^{-1}, Babu *et al.*, 2012; Lakshmi *et* *al.*, 2014 for number of productive tillers plant^{-1}, Naseem *et al.*, 2014 for number of grains panicle^{-1}.

As mentioned by McClung *et al.* (2009) and Surekha *et al.* (2010) the quality characteristics namely, kernel elongation ratio, sensory evaluation (i.e. colour, taste, aroma, texture and flavor) are organic varietal traits which are also studied under this present investigation. The organic varietal traits namely, deep root system, number of crown roots indicated by Kopke, (2005) under stress conditions were not considered in this present investigation. Similarly, other organic varietal traits like weed smothering ability, ability for healthy relationship with micro-organisms, detailed pest and disease investigation was also not studied, which can be considered in the future continuous research programme.

5.2.4. Other organic varietal traits opined by organic farmers

Other organic varietal traits opined by organic farmers of Arayidam Padasekharam Samithy where the field experiment part of the current research programme was conducted are good germination % or crop establishment, tolerance to partial shade, good volume for cooked rice, good keeping quality of cooked rice, multipurpose suitability of rice, namely for regular food, breakfast, sweet gruel and temple prasadam and suitability for cooking of parboiled rice in rice cooker without foul smell.

5.2.5. Identification of parents for organic variety development through hybridization

Based on variation, correlation and path analysis studies, the genotypes which can be selected as parents for future breeding programmes of organic variety development are given below. Parents for the organic varietal trait straw yield plant^{-1} are 'Kanakom', 'Dhanu', 'Anaswara', 'Jaiva', Culture MK-115, 'Makam', 'Remanika', and 'Vytilla-4'. Parents for the organic varietal trait number of productive tillers plant^{-1} are 'Badhra', 'Dhanu', 'Anaswara' and 'Makam'. Parents for the organic varietal trait number of tillers at harvest are

'Dhanu', 'Badhra', 'Anaswara', 'Makam', 'Jaiva', and 'Remanika' and similarly, parents for number of grains panicle^{-1} is 'Mahsuri'.

Genotypes which can be selected as parents for important quality characteristics are 'CO-47', 'Jaiva' and 'Valankunhivithu' for volume expansion and 'Pusabasmathi', 'Jaiva', 'FL-478', 'Ezhome-1', 'Mahsuri', 'Gouri', 'Swarnaprabha', 'Dhanu', 'IR-28', 'Aasha' and 'Aishwarya' for sensory evaluation. The traditional genotypes which can be used as parents for less cooking time are 'Chambav', 'Njavara', 'Orkayama', 'Valambalan', 'Kandoorkutty', 'Vellathondi' and 'Valankunhivithu'.

On the basis of visual observation of pests and diseases, the genotypes that can be selected as parents for major pest and disease tolerance namely, stem borer, leaf roller, rice bug are Culture MK-115, 'Anaswara', 'Dhanu' and 'Mahsuri'. The parents that can be selected for tolerance to major diseases namely, blast and sheath blight are 'Jaiva', 'Kasthuri', 'Pusabasmathi', 'Anaswara', 'Ayirankana' and 'CO-47'.

5.2.6. Identification of parents for other yield component traits

Identification of parents for the yield component traits other than those mentioned above will help for the use of these genotypes in general yield improving variety development programme.

The traditional genotype 'Chambav' and the improved varieties 'Swetha' and 'Mahsuri' can be considered as parents for high number of spikelets panicle^{-1}, the organic variety 'Jaiva' can be considered for high seed setting % and the genotypes 'Chambav' and 'Vytilla-4' may be used as parents for long panicle.

The traditional variety 'Valichoori' which recorded the highest 1000 grain weight can be taken as parent for this characteristic in future breeding programme for yield enhancement. Parents for total biomass which is an another important trait determining the favorable performance of a variety can be 'Kanakom', 'Dhanu', 'Remanika', 'Jaiva' and 'Anaswara'.

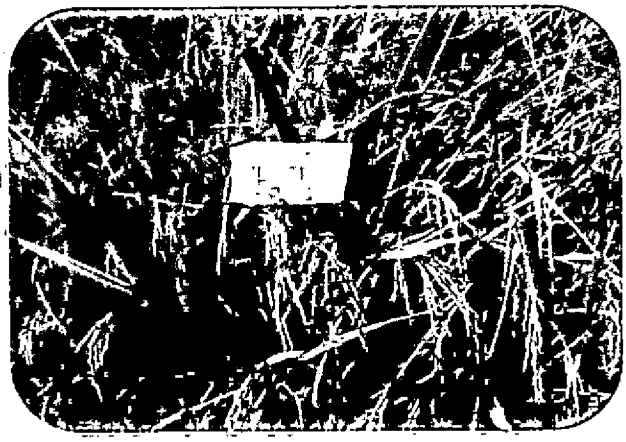
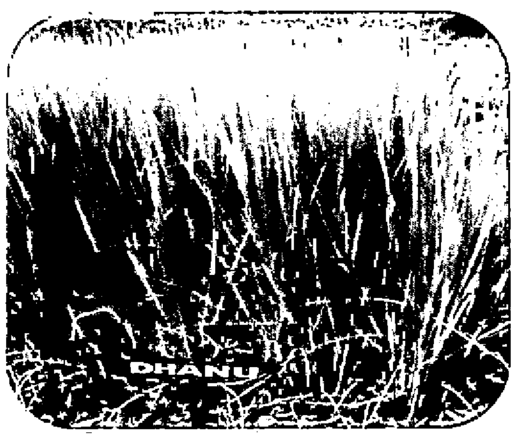


Plate 11. Jaiva (Cul. MK-157) the organic rice variety which top ranked for grain yield, straw yield, quality and biotic stress under organic management

(A)

(B)



(C)

Plate 12. (A) Anaswara, (B) Aishwarya, (C) Dhanu the conventional rice varieties of KAU which can be considered for organic farming for short and medium period

SUMMARY

6. SUMMARY

The present investigation of 'Evaluation of a Collection of *Indica* Rice Genotypes under Organic Management Adopting Farmer Participatory Evaluation Strategy' was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad, Kerala Agricultural University during 2013 - 2015. Field trials were laid out during Rabi season in the field of a progressive organic rice farming group (Arayidam padasekharam) in Mayyil Panchayath of Kannur district, Kerala.

The investigation was conducted for identification of rice genotypes suited for organic farming and the key varietal traits suited for organic farming.

The materials comprised of 65 genotypes of rice conserved in the Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad, which include14 traditional genotypes of Kerala, a collection of 41 improved varieties developed for conventional rice farming, out of which 32 varieties are of KAU and 10 rice varieties/ cultures developed by Kerala Agricultural University adopting strategies of Organic Plant Breeding (OPB).

Sixty five rice genotypes were raised in Arayidam Padasekharam during Rabi 2013 in a randomized block design with two replications. All cultural operations were carried out as per the organic cultural management practices followed by the farming group for the last five years. Observations on growth and yield parameters were recorded on ten randomly selected plants in each replication for each treatment after leaving the border rows.

Observations of growth parameters, yield parameters and physico-chemical parameters and major cooking quality parameters were taken as per the 'Standard Evaluation System for Rice' (IRRI, 1996). The cooking quality parameter, sensory evaluation were scored as per 'Nine Point Hedonic Scale'. Observations were recorded on 23 characteristics. The data were subjected to statistical analysis of variance, correlation and path analysis.

The salient findings of the study are:

1. The analysis of variance indicated highly significant variation for all the traits namely root length, root weight, root spread, chlorophyll content of flag leaf at flowering stage, chlorophyll content of third leaf at flowering stage, plant height at 30DAT, plant height at 60DAT, plant height at 90DAT, plant height at harvest stage, number of tillers plant^{-1}at 30DAT, number of tillers plant^{-1}at 60DAT, number of tillers plant^{-1}at 90DAT, number of tillers plant^{-1}at harvest stage, total biomass plant^{-1}, number of productive tillers plant^{-1}, number of spikelets panicle^{-1}, number of grains panicle^{-1}, seed setting %, length of panicle, 1000 grains weight, straw yield plant^{-1}, L/B ratio of kernel, hulling %, volume expansion and kernel elongation ratio.

2. Out of eighteen growth and yield parameters studied under organic management, four parameters namely, number of tillers plant^{-1}at harvest, number of productive tillers plant^{-1}, number of grains panicle^{-1} and straw yield plant^{-1} showed both positive significant correlation and direct effect with grain yield plant^{-1}. Hence these four characters can be considered as organic varietal yield component traits.

3. Out of 65 rice genotypes evaluated under organic management, 'Anaswara', the variety developed by KAU for conventional farming and Culture MK-157, the genotype developed based on strategies of Organic Plant Breeding (OPB) (it was released in the name 'Jaiva' in 2015 by KAU as the first organic rice variety) ranked first and also showed tolerance to the major pests and diseases on visual observations. But in quality analysis the variety 'Jaiva' ranked best for all the four quality parameters evaluated namely, volume expansion, kernel elongation ratio, alkali spreading value and sensory evaluation. Whereas 'Anaswara' variety ranked only for kernel elongation ratio. Hence considering

yield, quality and biotic stress tolerance together 'Jaiva' variety can be ranked first.

4. Comparing the top ranked two varieties (i.e. Anaswara and Jaiva) with respect to the important yield and physico-chemical traits which are significant and positively correlated with grain yield, and those have significant and positive direct effect, the organic variety 'Jaiva' (Culture MK-157) top ranked with respect to eight yield contributing characters namely, straw yield plant^{-1}, number of panicles plant^{-1}, total biomass plant^{-1}, number of grains panicle^{-1}, number of tillers at harvest, seed setting %, plant height at 60DAT and hulling%. 'Anaswara' the variety developed for conventional farming also on par with 'Jaiva' for grain yield under organic management top ranked for six yield contributing characters namely, straw yield plant^{-1}, number of grains panicle^{-1}, total biomass plant^{-1}, number of tillers plant^{-1}at harvest, plant height at 60DAT and hulling %.

5. Considering the cooking qualities evaluated in the current investigation namely, volume expansion ratio, kernel elongation ratio, alkali spreading value and sensory evaluation, the variety 'Jaiva' ranked best in all four categories, and the variety 'Anaswara' ranked only for kernel elongation ratio. However both 'Jaiva' and 'Anaswara' showed resistance to the major pests and diseases studied by visual observations.

6. Out of seven genotypes namely, 'Aishwarya', 'Dhanu', 'Aruna', 'Hariyana Basmathi', 'Kanakom', 'Sagara' and Culture MK-115, which ranked as second set with on par performance with respect to grain yield plant^{-1}, the genotypes 'Dhanu', 'Aishwarya' and the flood tolerant pre release organic Culture MK-115 showed top performance for various yield component traits, few cooking qualities, and pest and disease tolerance. Hence these three genotypes can also be considered for organic farming after 'Jaiva' and 'Anaswara'.

7. Other organic varietal traits opined by organic farmers of Arayidam Padasekharam Samithy where the field experiment of the current research

programme was conducted are tolerance to weeds, good germination % / crop establishment, tolerance to partial shade, good root system to cope up with adverse soil condition, good volume for cooked rice, excellent taste, aroma and texture, good keeping quality of cooked rice, multipurpose suitability of rice, namely for regular food, breakfast, sweet gruel and temple prasadam and suitability for cooking of parboiled rice in rice cooker without foul smell.

8. Out of99 varieties of KAU developed for conventional farming in ordinary wetland using chemical fertilizers, 32 varieties were evaluated under organic management in this study. Out of these, 'Anaswara' variety followed by 'Dhanu' and 'Aishwarya' can be considered for organic farming for the time being as per the suggestion of IFOAM until enough organic varieties are developed adopting Organic Plant Breeding(OPB) strategies, those varieties developed for conventional farming using chemical fertilizers but performs well under organic management can be considered. The remaining 67 varieties of KAU developed for conventional farming has to be tested under organic management which may be the future line of work.

9. Based on variation, correlation and path analysis studies, the genotypes which can be selected as parents for future breeding programmes of organic variety development are given below. Parents for the organic varietal trait straw yield plant^{-1} are 'Kanakom', 'Dhanu', 'Anaswara', 'Jaiva', Culture MK-115, 'Makam', 'Remanika', and 'Vytilla-4'. Parents for the organic varietal trait number of productive tillers plant^{-1} are 'Badhra', 'Dhanu', 'Anaswara' and 'Makam'. Parents for the organic varietal trait number of tillers at harvest are 'Dhanu', 'Badhra', 'Anaswara', 'Makam', 'Jaiva', and 'Remanika' and parents for number of grains panicle^{-1} is 'Mahsuri'.

10. Genotypes which can be selected as parents for important quality characteristics are 'CO-47', 'Jaiva' and 'Valankunhivithu' for volume expansion and 'Pusabasmathi', 'Jaiva', 'FL-478', 'Ezhome-1', 'Mahsuri',

'Gouri', 'Swarnaprabha', 'Dhanu', 'IR-28', 'Aasha' and 'Aishwarya' for sensory evaluation.

11. On the basis of visual observation of pests and diseases, the genotypes that can be selected as parents for major pests namely, stem borer, leaf roller, rice bug are Culture MK-115, 'Anaswara', 'Dhanu' and 'Mahsuri'. The parents that can be selected for tolerance to major diseases namely, blast and sheath blight are 'Jaiva', 'Kasthuri', 'Pusabasmathi', 'Anaswara', 'Ayirankana' and 'CO-47'. Validation through artificial screening is necessary.

12. The absence of significant correlation between the important quality characters, namely, volume expansion and kernel elongation ratio with grain yield plant^{-1} suggest that yield and quality characteristics can be recombined as desired.

13. The highest degree of significant positive association both at phenotypic and genotypic levels between straw yield plant^{-1} and grain yield plant^{-1} suggest that straw yield plant^{-1} is a highly reliable component of yield and can very well be utilized as an yield indicator, as it is an organic varietal trait.

REFERENCE

7. REFERENCES

Abarshahr, M., Rabiei, B. and Lahigi, H.S. 2011. Genetic variability, correlation and path analysis in rice under optimum and stress irrigation regimes. *Nott. Sci. Biol.* 3(4):134-142.

Akhtar, N., Nazir, M.F., Rabnawaz, A., Mahmood, T., Safdar, M.E., Asif, M. and Rehman, A., 2011. Estimation of heritability, correlation and path coefficient analysis in fine grain rice. *The J. Anim. Pl. Sci.* **21**(4):660-664.

Allam, C.R., Jaiswal, H.K. and Qamar, A. 2015. Character association and path analysis studies of yield and quality parameters in basmati rice (*Oryza sativa* L.). *The bioscan.* **9**(4): 1733-1737.

Almekinder, C. and Hardon, J. 2006. Bringing farmers back into breeding. Experiences with participatory plant breeding and challenges for institutionalisation. Agromisa Special 5, Agromisa, Wageningen. 140p.

Anbanandan, V., Saravanan, K. and Sabesan, T. 2009. Variability, heritability and genetic advance in rice (*Oryza sativa* L.). *Int. J. Plant Sci.* 4(1): 61-63.

Anonymous, 1985. Root development of winter wheat. In: Verslag over 1983. OBS-publikatic No 4. Proefatationvoor de Akkerbouwen de Groentcteelt in de VolleGrond (PAV), Lelystad. pp.53-58. (In Dutch)

APEDA, 2011. Agricultural and Processed Food Products Export Development (APEDA).(http://www.apeda.gov.in/apedawebsite/organic/Organic_Products.htm)

Araus, J.I., Bort, J., CecCadelli, S. and Grando, S. 1997. Relationship between leaf structure and Carbon isotope discrimination in field grown barley. Plant Physiol. *Biochem.* **35**: 533-541.

Asish, K., Binodh, R., Kalaiyarasi and Thiyagarajan. K. 2007. Genetic parameter studies on quality traits in rice. *Madras Agric. J.* 94 (16):109-113.

Ashrafuzzaman, M., Rafiqul Islam, M.D., Razi Ismail, M., Shahidullah, S .M. and Hanafi, M. M. 2009. Evaluation of six aromatic rice varieties for yield and yield contributing characters. *Int. J. Agric. Biol.* 11(5):616-620.

Atanu, P.K. and Sabesan, T. 2010. Studies on genetic variability for lodging related traits in rice (*Oryza sativa* L.). *Electron. J. Plant Breed.* 1(3): 301-304.

Azeez, M.A. and Shafi, M. 1966. Quality in Rice. Department of agriculture, West Pakistan *Technology Bulletin.* pp.13: 50.

Babu, V.R., Shreya, K., Dangi, K.S., Usharani, G. and Shankar, A.S. 2012. Correlation and path analysis studies in popular rice hybrids of India. *Int. J. Scient. Res. Publs.* 2(3): 1-5.

Bajpai, A., Singh, Y. and Singh, U.S. 2012. Evaluation of Grain Quality of Kalanamak varieties/lines cultivated in Uttar Pradesh. *Int. J. Scient. Res. Publs.* 2(10):1-8.

BAashar, M.D.K. 1987. Genetic studies of rice root xylem vessels and related to characters in relation to drought avoidance mechanisms. M.Sc. Thesis, Agron. Dept., Fac. of the Graduate school, Los Banos, Philippines.

Batey, I.L. and Curtin, B.M. 2000. Effects on pasting viscosity of starch and flour from different operating conditions for the Rapid Visco-Analyzer. *Cereal Chem.* 77: 754-760.

Berg, T. 1995. Revolution of plant breeding. In: Sperling, L. and Loevinsohn, M. (Eds.), Proceedings of the workshop using diversity: enhancing and maintaining genetic resources on- farm, International Development Research Centre (IDRC), New Delhi, pp. 116-126.

Binodh, A.K., Kalaiyarasi, R. and Thiyagarajan, K. 2007. Genetic parameter studies on quality traits in rice. *Madras Agric. J.* **94** (1-6): 109-113.

Bishaw, Z. and Turner, M. 2007. Linking participatory plant breeding to the seed supply system.*Euphytica.* **163**:31-44.

Bonifacio, A. 2003. Liberaci´on de la variedadJach'agrano de quinua con Resistencia al mildiuen Bolivia. In: Danial, D. L. (eds) Agro-biodiversidad y producci´on de semillacon el sector informal a trav´es del mejoramientoparticipativoen la zona Andina, Lima, Per´u, 22–26 de. pp. 56-63. (In Dutch

Brockea, K., Trouchea, G., Weltzienb, E., Clarisse, P., Kondomboc, B., Gozed, E. and Chantereau, J. 2010. Participatory variety development for sorghum in Burkina Faso: Farmers' selection and farmers' criteria. *Fld. Crops Res.* **119**: 183-194.

Brouwer, R. 1983. Functional equilibrium; sence or nonsence?.*Neth. J. Agric. Sci.* **31**: 335-348.

Bueren, L.E.T. 2003. Challenging new concepts and strategies for organic plant breeding and propagation.*Eucarpia Leafy Vegetables.*pp.17-21.

Bueren, L.E.T. and Osman, A. 2002. Organic plant breeding and seed production: the case study of spring wheat, Neth. pp. 133-187.

Bueren, L.E.T., Struik, P.C. and Jacobsen, E. 2002. Ecological concepts in organic farming and their consequences for an organic crop ideotype. *Neth. J. Agric. Sci.* **50**: 1-26.

Bueren, L.E.T., Jones, L., Tamm, K.M., Murphy, J.R., Myers, C. and Leifert, M.M. 2011. The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: A review. Wageningen, *J. Life Sci.* **58**: 193-205.

Ceccarelli, S. and Grando, S. 1997. Increasing the efficiency of breeding through farmer participation. In Ethics and Equity in conservation and use of genetic resources for sustainable food security. pp. 116-121.

Ceccarelli, S., Gando, S., Tutwiler, R., Baha, J., Martini, A.M., Salahieh, H., Goodchild, A. and Michael, M. 2000. A methodological study on participatory barley breeding I. Selection phase. *Euphytica.* **111**: 91-104.

Ceccarelli, S., Gando, S., Bailey, E., Amri, A., El-Felah, M., Nassif, F., Rezgui, S. and Yahyaoui, A. 2001. Farmer participation in barley breeding in Syria, Morocco and Tunisia. *Euphytica.* **122**: 521-536.

Ceccarelli, S., Gando, S., Singh,M., Michael, M., Shikho, A., Al Issa, M., Al Saleh, M., Kaleonjy, G., Al Ghanem, S.M., Al Hasan, A. L., Dalla, H., BAasha, S. and BAasha, T. 2003. A methodological study on participatory barley breeding II. Response to selection. *Euphytica.* **133**: 185-200.

Ceccarelli, S. and Grando, S. 2009. Participatory plant breeding. *Cereals Handb. pl. Breed.* 3(2):395-414.

Chandra, B.S., Reddy, T.D., Ansari, N.A. and Kumar, S.S. 2009. Correlation and path analysis for yield and yield components in rice (*Oryza Sativa* L.). *Agric. Sci. Digest.* **29**(1):45-47.

Chordhuym, D. and Ghosh, A.K. 1978. Evaluation of agronomic and physicochemical characteristics of fine and scented rice varieties. *Indian J. Agri. Sci.* **48**:573-578.

Claure, T.I. 2003. Liberaci´on de la variedad de ma´ızsint´etico 2- Preduza con Resistencia a pudrici´on de mazorcaen Bolivia. In: Danial, D. L. (eds) Agro-biodiversidad y producci´on de semilla con el sector informal a trav´es del mejoramientoparticipativoen la zona Andina, Lima, Per´u, 22–26 de. pp. 18–22. (In Dutch)

CRRI. 2011. Grain quality parameters. Rice knowledge management portal. (http://www.rkmp.co.in/content/alkali-spreading-value-asv).

Danial, D., Parlevliet, J., Almekinders., C. and Thiele. G. 2007. Farmers' participation and breeding for durable disease resistance in the Andean region. *Euphytica.* **153**: 385-396.

Deshpande, H.H. and Devasenapathy, P. 2010. Effect of green manuring and organic manures on yield, quality and economics of rice (*Oryza sativa* L.) under lowland condition. *KarnatakaJ. Agric. Sci.* **23**(2): 235-238.

Desclaux, D. 2005. Participatory plant breeding methods for organic cereals: review andPerspectives. Driebergen, *Int. Congr. on Org. Plant Breed.* pp. 17-19.

Devi, C.R., Reddy, D.M., Reddy, K.H.P. and Sudhakar, P. 2013. Selection strategy through genetic association studies for improvement of yield and quality under organic fertilizer management in rice (*Oryza sativa* L.). *Crop Res.* **45**:79-83.

Devi, R.K., Sankar, S.A. and Sudhakar, P. 2013. Identification of rice genotypes for drought tolerance based on root characters. *Int. J appl. Biol. pharmaceutical technol.* **4**(4): 186-193.

Dhurai, S.Y., Reddy, D.M. and Bhati, B.K. 2014. Correlation and path coefficient analysis for yield and quality traits under organic fertilizer management in rice (*Oryza sativa* L.).*Electronic J. Pl. Breed.* 5(3): 581-587.

Dutta, R.K., Baset-Mia, M.A. and Khanam, S. 2002. Plant architecture and growth characteristics of fine grain and aromatic rice and their relation with grain yield. *IRC Newslett.* **51**: 51-56.

El-Hissewy, A.A., El-Kady, A.A. and Lasztity, R. 1992. A study on the cooking and eating quality characteristics of some egyptian rice varieties. *PeriodicaPolytechnica Ser. Chem. Engng.* **36**(1):3-11.

Ezeaku, I.E. and Mohammed, S.G. 2006. Character association and path analysis in grain sorghum. *Afr. J. Biotech.* 5(14):1337-1340.

FAI. 2000. Fertilizer Statistics 1999-2000. The Fertilizer Association of India, New Delhi.

Fernandez, M.G., Becraft, P.W., Yin, Y. and Lubbersted, T. 2009. From dwarves to giants? Plant height manipulation for biomass yield. *Trends Plant Sci.* 14(8): 454-461.

Gastelo, M., Roncal, E.S. and Landeo. J. 1991. Canchán-INIAA, unanuevavariedad de papa para el Perú con resistencia de campo al tizóntardío. Lima, Perú. 69 p. (In Dutch)

Ganesan, K. 1995. Genetic studies in extra early rice (Oryza sativa L.). Ph.D. Thesis. TNAU, Coimbatore, India.

George, S.P., Bastian, N.V., Radhakrishan and Aipe, K.C. 2005. Evaluation of aromatic rice varieties in Wayanad, *KeralaJ. of Trop. Agric.* 43 (1-2): 67-69.

Ge, G.K., Shi, C.H., Wu, J.G. and Ye, Z.H. 2008. Analysis of the genetic relationships from different genetic systems between the amylose content and the appearance quality of indica rice across environments. *Genets. Mol. Biol.* 31(3): 711-716.

Halewood, M., Deupmann, P., Sthapit, B R., Vernooy, R. and Ceccarelli, S. 2007. Participatory Breeding to Promote Farmer's rights. *Biodiversity Int.* 7p.

Hegde, S., Yenagi, N., Itagi, S., Babalad, H.B. and PrAashanthi, S.K. 2013. Evaluation of red rice varieties for nutritional and cooking quality cultivated under organic and conventional farming systems. *Karnataka J. Agric. Sci.* 26(2): 288-294.

Hoad, S.P., Davies, H.D.K. and Topp, C.F.E. 2006. How to select varieties for organic farming: science and practice. *Aspects Appl. Biol.* 79: 115-120.

Hossaina, S., Singh, A.S. and Zamanb, F. 2009. Cooking and eating characteristics of some newly identified inter sub-specific (indica/japonica) rice hybrids. *Sci. Asia*. **35**: 320-325.

Hussain, A.A., Muarya, D.M. and Vaish, C.P. 1987. Studies on quality status of indigenous upland rice *(Oryza saliva).Indian J. Genet*. **47**: 145-152.

Idris, E., Justin, F.J., Dagash, Y.M.I. and Abuali, A.I. 2012. Genetic variability and inter relationship between yield and yield components in some rice genotypes. *Am. J. Exp. Agric*. **2**(2): 233-239.

IRRI, 1996. Standard Evaluation System for Rice (3rdEd.). *International Rice Testing Programme*. Los Banos, Laguna, Philippines, pp. 43.

Jagadeeshwar, R., Varma, R.G.N., Reddy, G.B., Reddy, N.P., Raju, S.C.H. and Vanisree. S. 2012. Evaluation of different organic nutrient sources and varieties for organic rice (*Oryza sativa* L.) production. *J.Res.* ANGRAU. **40**(3):6-8.

Jonaliza, C., Lanceras, P., Pantuwan, G., Boonrat, J. and Theerayut, T. 2004. Quantitative trait loci associated with drought tolerance at reproductive stage in rice. *Plant Physiol*. **135**: 1-16.

Joshi, A. and Witcombe, J.R. 1996. Farmer participatory crop improvement II. Participatory varietal selection, a case of India. *Expl. Agric*. **32**: 461-477.

Juliano, B.O. and Duff, B. 1991. Rice grain quality as an emerging priority in national breeding programs. In rice grain marketing and quality issues, International Rice Research Institute, Los Banos, Philippines, pp. 55-64.

Juliano, B.O. and Villareal, C.P. 1993. Grain quality evaluation of world rices. International Rice Research Institute, Los Banos, Philippines. pp. 22-31.

Karad, S.R. and Pol, K.M. 2008. Character association, genetic variability and path-coefficient analysis in rice (*Oryza sativa* L.). *Int. J. Agric. Sci.* **4**(2): 663-666.

Karpagam, V., Jebaraj, S., Rajeswari, S. and Vanniarajan, C. 2014.Role of root and yield characters under drought stress in rice (*Oryza sativa L.*). *Electronic J. Pl. Breed.* 5(4): 760-764.

Kato, Y., Kamoshita, A. and Yamagishi, J. 2008. Pre flowering abortion reduces spikelet number in upland rice (*Oryza sativa* L.) under water stress. *Crop Sci.* **48**: 2389-2395.

Kennedy, V. J. F. and Rangasamy, P. 1998. Correlation studies in rice hybrids under low temperature condition. *Madras Agric. J.* **85**: 130-131.

Kerr, J. and Kolavalli, S. 1999. Impact of agricultural research in poverty alleviation: conceptual framework with illustrations from literature. EPTD discussion paper, IFPRI, Washington, 195 pp.

Kimani, J.M., Tongoona, P., Derera, J. and Nyende, A.B. 2011. Upland rice varieties development through participatory plant breeding. *J. Agric. Biol. Sci.* **6**(9):19-27.

Kole, P.C., Chakraborty, N.R. and Bhat, J.S. 2008. Analasis of variability, correlation and path coefficients in induced mutants of aromatic non-basmati rice. *Trop. Agric. Res. Ext.* **11**: 60-64.

Kopke, U. 2005. Crop ideotypes for organic cereal cropping systems. Proceedings of the COST SUSVAR/ECO-PB work shop on organic plant breeding strategies and the use of molecular markers. Louis Bolk Institute, Driebergen, *The Neth.* 103 pp.

Kornegay, J., Beltran, J.A. and Ashby, J. 1996. Farmer selections within segregating populations of common bean in Colombia. In: Eyzaguirre, P. and Iwanaga, M. (Eds.), Participatory Plant Breeding: Proceedings of a Workshop on Participatory Plant Breeding, International Plant Genetic Resource Institute (IPGRI), Rome, Italy, pp. 151–159.

Kumar, C. and Nilanjaya. 2014. Correlation and path coefficient analysis of yield components in aerobic rice (*Oryza sativa* L.). *The Bioscan.* **9**(2): 907-913.

Kumar, A., Verulkar, S. Dixit, S., Chauhan, B., Bernier, J., Venuprasad, R., Zhao, D. and Shrivastava, M.N. 2009. Yield and yield-attributing traits of rice (*Oryza sativa* L.) under lowland drought and suitability of early vigor as a selection criterion. *Fld. Crops Res*. **114**: 99-107.

Kusutani, A., Tovata, M., Asanuma, K. and Cui, J. 2000. Studies on the varietal differences of harvest index and morphological characteristics of rice. *Jpn. J. Crop Sci*. **69**: 359-364.

Lakshmi, M.V., Suneetha, Y., Yugandhar, G. and Lakshmi, N.V. 2014. Correlation Studies in Rice (Oryza sativa L.). *Int. J. Genet. Engng. Biotech.* 5(2):121-126.

Lipton, M. and Longhurst, R. 1989. New seeds and poor people. Unwin Hyman, London, 473p.

Lodh, S.B. 2002. Quality evaluation of rice for domestic and international consumers. In: Genetic evaluation and utilization (GEU) in rice improvement. *CRRI*, Cuttack, pp. 135-140.

Madhavilatha, L. 2002 Studies on genetic divergence and isozyme analysis on rice *(Oryza sativa* L). M.Sc. (Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

Malandrin, V. and Dvortsin, L. 2013. Participatory processes of agroecological innovation in organic cereal breeding: a case study from Italy. 4^{th}*Int. Symp. Agrosym*. pp. 719-725.

Mandal, U.K., Singh, G., Victor, U.S. and Sharma, K.L., 2003. Green manuring: its effect on soil properties and crop growth under rice–wheat cropping system. *Eur. J. Agron*. **19**:225-237.

Manickavelu, A., Gnanamalar, R.P., Nadarajan, N. and Ganesh, S.K. 2006. Identification of important traits in rice (*Oryza sativa* L.) For lowland drought situation by association analysis. *J.of Agric.* 1(6): 509-521.

Manonmani, S., Malarvizhi, D., Robin, S., Umadevi, M., Ameenal, M., Pushpam, M., Sundaram, M.K. and Thiyagarajan, K. 2010. Breeding three line rice hybrids with good grain quality. *Electronic J. Plant Breed.* 1(4): 1265-1269.

McClung, A.M., Bett Garber, K.L., Bergman, C.J., Grimm, C.C., Chen, M. and Champagne, E.T. 2009. Organic rice production systems and their impact on grain quality. *Cereal Foods Wld.* 54p.

Morris, M.L. and Bellon, M.R. 2004. Participatory plant breeding research: Opportunitiesand challenges for the international crop improvement system. *Euphytica.* **136**: 21-35.

Murphy, K., Campbell, K.G., Lyon, S. and Jones, S.S. 2007. Evidence for varietal adaptationto organic farming systems. *Fld. Crops Res.* **102**: 172-177.

Muthuramu, S., Jebaraj, S. and Gnanasekaran, M. 2010. Combining ability and heterosis for drought tolerance in different locations in rice (*Oryza sativa* L.). *Res. J. Agric. Sci.* 1(3): 266-270.

Nagaraju, C., Sekhar, R.M., Reddy, H.K. and Sudhakar, P. 2013. Correlation between traits and path analysis coefficient for grain yield and other components in rice (*Oryza sativa* L.) genotypes. *Int. J. Appl. Biol. Pharmaceutical Technol.* 4(3):137-142.

Najeeb, S. and Wani, S.A. 2004. Correlation and path analysis studies in barley. *Nath. J. PlantImprov.* 6(2): 124-125.

Naik, K.R., Reddy, S.P., Ramana, J.V. and Rao, V. 2005. Correlation and path co-efficient analysis in rice (*Oryza sativa* L.). *Andhra Agrl. J.* 52(1-2): 52-55.

Nasser, S. and Ghumaiz, A. 2010. Yield performance quality of eight wheat genotypes under organic and conventional farming systems in Saudi Arabia. *J. Int. Scient. Publs: Agric. Food.* 2:20-24.

Naseem, M., Khan, A.S. and Akhter, M. 2014. Correlation and path coefficient studies of some yield related traits in rice (Oryza sativa L.). *Int. J. Scient. Res. Publs.* 4(4): 1-5.

Nayak, A.R., Chaudary, D. and Reddy, J.N. 2001.Correlation and path analysis in scented rice (*Oryza sativa* L.). *Indian J. Agric. Res.* 35(3):186-189.

Nayak, A.R and Reddy, J.N. 2005. Seasonal influence on quality characters in scented rice. *Indian J. Genets. Plant Breed.* 65(2): 127-128.

Ojo, D.K., Omikunle, O.A., Ajala, M.O. and Ogunbayo, S.A. 2006. Heritability, character correlation and path coefficient analysis among six-linked of maize. *Wld. J. Agri. Sci.* 2: 352-358.

Oko, A.O., Ubi, B.E. and Dambaba, N. 2012. Rice cooking quality and physico-chemical characteristics: a comparative analysis of selected local and newly introduced rice varieties in Ebonyi State, Nigeria. *Fd. Public Health.* 2(1): 43-49.

Oosterom, E.J., Whitaker, M.L. and Weltzien, E. 1996. Integrating genotype by environment interaction analysis, characterization of drought patterns and farmer preferences to identify adaptive plant traits for pearl millet. In: Cooper, M. and Hammer, G. L. (Eds.), Plant Adaptation and Crop Improvement, *CABI*, Wallingford, UK. pp. 383–402.

Pan, R. Z. and Dong, Y. D. 1995. Plant physiology. *Higher Educ. Press*, Beijing.

Pantuwan, G., Fukai, S., Cooper, M., Rajatasereekul, S. and O'Toole, J.C. 2002. Yield response of rice (*Oryza sativa* L.) genotypes to different types of drought under rainfed lowlands: Part grain yield and yield components. *Fld. Crops Res.* 73:153-168.

Pandit, D.B., Islam, M.M., Rashid, H.M. and Sufian, M.A. 2007. Participatory variety selection in wheat and its impact on scaling-up seed dissemination and varietal diversity. *Bangladesh J. Agric. Res.* **32**(3):473-486.

Paul, C.R. and Nanda, J.S. 1994. Path analysis of yield and yield components and construction of selection indices of direct seeded rice: first season. Annual review conference proceedings. National Agriculture Research Institute, Caribbean Agricultural Research and Development Institute, Guyana, pp. 63-71.

Perez, C.M. and Juliano, B.O. 1979. Indicators of eating quality for non-waxy rices. *Food Chem.* **4**: 185-195.

Prasert, S. 1997. Application of rice straw compost to lowland rice and its effects on root morphology in Tai paddy field. In: Proceeding of the fourth JSSRR SYMPOSIUM, pp. 32–33.

Prasad, B., Patwary, A.K. and Biswas, P.S. 2001. Genetic variability and selection criteria in fine rice (*Oryza sativa* L.). *Pakistan J. Biol. Sci.* **4**: 1188-1190.

Priya, A.A. and Joel, A.J. 2009. Grain yield response of rice cultivars under upland condition. *Electr. J. Pl. Breed.* **1**: 6-11.

Qualset, C.O., Damania, A.B., Zanatta, A.C.A. and Brush, S.B. 1997. Locally based crop plant conservation. In: Maxted, N., Ford-Lloyd, B.V. and Hawkers, J.G. (Eds.), Plant Genetic Conservation: The *in situ* Approach, London, UK, pp. 160-175.

Quyena, N.V. and Sharma, S.N. 2003. Relative effect of organic and conventional farming on growth, yield and grain quality of scented rice and soilfertility. *Arch. Agron. Soil Sci.* 49: 623-629.

Radhidevi, R.P., Nagarajan, P., Shanmugasundram, P., Chandrababu, R., Jayanthi, S. and Subramani, S. 2002. Combining ability analysis in three line and two line rice hybrids. *Plant Arch.* **2**: 99-102.

Rakesh, B., Bajpai, R.K. and Banwasi, R. 2001. Effect of integrated nutrient management on root growth of wheat in a rice–wheat cropping system. *Agric. Sci. Digest.* **21**: 1-4.

Ramakrishnan, S.H., Anandakumar, C.R., Saravanan, S. and Malini, N. 2006. Association analysis of some yield traits in rice (*Oryza sativa L.*). *J. Appl. Sci. Res.* **2**(7): 402-404.

Reddy, G.E., Suresh, B.G., Sravan, T. and Reddy, P.A. 2013. Interrelationship and cause effect analysis of rice genotypes in northeast plane zone. *The Bioscan.* 8(4): 1141-1144.

Rivadeneira, M., Ponce, L. and Abad, S. 2003. Liberaci´on de nuevasvariedades de cebada y trigo para ´areas marginalesen Ecuador, como lo hicimos ? In: Danial, D. L. (eds) Agrobiodiversidad y producci´on de semilla con el sector informal a trav´es del mejoramientoparticipativoen la zona Andina, Lima, Per´u, 22–26 de, pp. 23–32. (In Dutch)

Rodel, G., Maghirang, Gloria, S., Podulfo, Madrid, Elmer ferry, Cruz, C. D., Vilbar, L., and Jocelyn, S. 2014. Participatory breeding on organic vegetables. Building Organic Bridges, at the Organic World Congress. Istanbul, Turkey. pp. 909-912.

Roy, D.K. and Singh, B.P. 2006. Effect of level and time of nitrogen application with and without vermicompost on yield, yield attributes and quality of malt barley (*Hordeumvulgare*). *Indian J. Agron.* **51**: 40-42.

Sabesan, T., Saravànan, K. and Anandan, A. 2009. Genetic divergence analysis for certain yield and quality traits in rice (*Oryza sativa* L.) grown in irrigated saline low land of Annamalainagar, South India. *J. Cent. Eur. Agric.* 10(4):405-410.

Sangeetha, S.P., Balakrishnan, A. and Devasenapathy, P. 2013. Influence of organic manures on yield and quality of rice (*Oryza sativa* L.) and blackgram (*Vigna mungo* L.) in rice-blackgram cropping sequence. *Am. J. plant Sci.* 4:1151-1157.

Sandhya, G. R., Lavanya, G., Babu, S., Kumar, K., Rai, S. K., and Devi, B. 2014. Study of genetic variability and D^2 analysis in elite rice genotypes. Int. J. of Fd. Agric. and Vet. Scis. 4(2): 12-16.

Sankar, D.P., Sheeba, A. and Anbumalarmathi, J. 2006. Variability and character association studies in rice. *Agric. Sci. Digest*. 26(3): 182-184.

Sarker, S.K., Ray, B.P., Sarker, M. and Saha, S. 2013. Genetic variability, correlation and path coefficient analysis in aman rice (*Oryza sativa* L.). *J. Biol. Chem. Res.* 30(2):466-484.

Sarkar, K.K., Bhutia, K.S., Senapati, B.K. and Roy, S.K. 2007. Genetic variability and character association of quality traits in rice *(Oryza sativa* L.). *Oryza.* 44(1): 64-67.

Selvaraj, I.C., Nagarajan, P.K., Thiyagarajan, M., Bharathi and Rabindran, R. 2011. Genetic parameters of variability, correlation and path-coefficient studies for grain yield and other yield attributes among rice blast disease resistant genotypes of rice (*Oryza sativa* L.). *Afr. J. Biotech.* 10(17): 3322-3334.

Sharma, N. 2002. Quality characteristics of non-aromatic and aromatic rice (*Oryza sativa* L.) varieties of Punjab. *Indian J. Agric. Sci.* 72: 408–410.

Shashidhar, H.E., Pasha, F., Manjunath, J., Vinod, M.S. and Adnan, K. 2005. Correlation and path co-efficient analysis in traditional cultivars and doubled haploid lines of rainfed lowland rice (*Oryza sativa* L.). *Oryza.* 42(2): 156-159.

Sheeba, A. 2005. Genetic studies on drought tolerance and stability of Temperature Sensitive Genic Male Sterility (TGMS) based rice hybrids. Ph.D. Thesis, TNAU, Coimbatore.

Shelton, A., Zyskowski, J., Diffley, M., Navazio, J., Perkins, D. and William, F.T. 2010. Participatory plant breeding to improve sweet corn for organic farmers. Breeding for resilience: a strategy for organic and low-input farming systems? EUCARPIA 2nd Conference of the "Organic and Low-Input Agriculture" Section 1-3, Paris.

Shrirame, M.D. and Muley, M.D. 2003. Variability and correlation studies rice (*Oryza sativa* L.). *J. Soil Crop.* **13**: 165-167.

Siavoshi, M., Dastan, S., Yassari, E., Shankar, L. and Laware. 2013. Role of organic fertilizers on morphological and yield parameters in rice (Oryza sativa L.). *Int. J. Agron. Plant Prod.* 4(6):1220-1225.

Sidiras, N., Bilalis, D. and Vavoulidou, E. 2001. Effects of tillage and fertilization on some selected physical properties of soil 0–30(cm depth) and on the root growth dynamic of winter barley (*Hordeumvulgare L.*). *J. Agron. Crop Sci.* **187**: 167-176.

Singh, B., Singh, Y. and Sekhon, G.S. 1995. Fertilizer nitrogen use efficiency and nitrate pollution of groundwater in developing countries. *J. Contam. Hydrol.* **20**:167–174.

Sinha, P.K., Prasad, K. and Mishra, G.N. 2000. Studies on root characters related to drought resistance and their association in selected upland rice genotypes. *Oryza.* 37(1): 29-31.

Sperling, L., Loevinsohn, M. and Ntambovura, B. 1993. Rethinking the farmer's role in plant breeding: Local bean experts and on-station selection in Rwanda. *Exp. Agric.* **29**: 509-519.

Stockdale, E.A., Lampkin, N.H., Hovi, M., Keatinge, R., Lennartsson, E.K.M., MacDonald, D.W., Padel, S., Tattersall, F.H., Wolfe, M.S. and Watson, C.A. 2001. Agronomic and environmental implications of organic farming systems. *Adv. Agron.* **70**: 261-327.

Surek, H. and Beser, N. 2003. Correlation and path analysis for some yield related traits under rainfed condition. *Turkish J. Agric. For.* **27**: 77-83.

Surekha, K., Rao, K.V., Rani, S.N., Latha, P.C. and Kumar, R.M. 2013. Evaluation of organic and conventional rice production systems for their productivity, profitability, grain quality and soil health. *Agric. Technol.* **11**(6): 1-6.

Tahir, H., Jillani, G. and Iqbal, M.Z. 1988. Integrated use of organic and inorganic N fertilizers in rice-wheat cropping system. *Pakistan J. Soil Sci.* **3**: 19-23.

Tandekar, K., Rastogi, N.K., Tirkey, P. and Sahu, L. 2008. Correlation and path analysis of yield and its components in rice germplasm resources. *Plant Arch.* **8**(2): 887-889.

Tann, H., Makhonpas, C., Utthajadee, A. and Soytong, K. 2012. Effect of good agricultural practice and organic methods on rice cultivation under the system of rice intensification in Cambodia. *J. Agric. Technol.* **8**(1): 289-303.

Thirumeni, S. and Subramanian, M. 1999. Character association and path analysis in saline rice. *Vistas of Rice Res.* pp. 192-196.

Thomas, J.A., Jeffrey, A.C., Atsuko, K. and David, M.K. 2005. Regulating the proton budget of higher plant photosynthesis. *Proc. Natl. Acad. Sci.* USA **102**: 9709–9713.

Tomar, J.B. and Nanda, J.S. 1981. Correlation between quality traits in rice. *Oryza.* **79**:13-16.

Ullah, M.Z., BAashar, M.K., Bhuiyan, M.S.R., Khalequzzaman, M. and Hasan, M.J. 2011. Interrelationship and cause-effect analysis among morpho-physiological traits in birouin rice of Bangladesh. *Int. J. Plant Breed. Genet.* **5**: 246-254.

Umadevi, M.P., Veerabadhiran, S., Manonmani and Shanmugasundaram, P. 2010. Physico-chemical and cooking characteristics of rice genotypes. *Electronic J. Plant Breed.* **1**(2): 114-123.

Usha, R., Lakshmi, M., Gomathy, G., Parimala, C. and Rajeshwari, R. 2012. Quality analysis of indigenous organic Asian Indian rice variety- Salem Samba. *Indian J. of Traditional Klowledge.* **11**(1): 114-122.

Vanaja, T. 1998. Genetic analysis of high yielding rice genotypes of diverse origin. Phd thesis, Kerala Agricultural University, Thrissur.

Vanaja, T. and Babu, L.C. 2006. Variability in grain quality attributes of high yielding rice varieties (*Oryza sativa* L.) of diverse origin. *J. Trop. Agric.* **44**(1): 61-63.

Vanaja, T., Neema, V.P., Mammootty, K.P., Rajeshkumar, R., Balakrishnan, P.C., Naik, J. and Raji, P. 2009. Development of first non-lodging and high yielding rice cultures for saline *Kaipad* paddy tracts of Kerala, India. *Curr. Sci.* **96**(8): 1024-1028.

Vanaja, T., Mammootty, K.P. and Govindan, M. 2013. Development of organic indica rice cultivar (*Oryza sativa* L.) for the wetlands of Kerala, India through new concepts and strategies of crop improvement. *J. of Org. syst.* 8(2):18-28.

Virk, D.S., Chakraborty, M., Ghosh, J., Prasad, S.C. and Witcombe, J.R. 2005. Increasing the client orientation of maize breeding using farmer participation in Eastern India. *Expl. Agric.* **41**:413-426.

Walker, T.S.2006. Participatory varietal selection, participatory plant breeding and varietal change. Background paper for the world development report.

Wang, F.H., Wang, G.X., Li, X.Y., Huang, J.L. and Zheng, J.K. 2008. Heredity, physiology and mapping of a chlorophyll content gene of rice (*Oryza sativa* L.). *J. Plant Physiol.* **165**: 324 -330.

Waters, D.L., Henry, R.J., Reinke, R.F. and Fitzgerald, M.A. 2005. Gelatinization temperature of rice explained by polymorphisms in starch synthase. *Plant Biotech. J.* 4(1): 115-122.

Witcombe, J.R., Joshi, K.D., Rana, R.B. and Virk, D.S. 2001. Increasing genetic diversity by participatory varietal selection in high potential production systems in Nepal and India. *Euphytica*. **122**: 575-588.

Witcombe, J.R., Joshi, A. and Goyal, S.N. 2003. Participatory plant breeding in maize: a case study from Gujurat, India. *Euphytica*. **130**: 413-422.

Wolfe, M.S. 2008. Developments in breeding cereals for organic agriculture. *Euphytica.* **163**:323-346.

Wright, S.1923. The theory of path coefficients. *Genet.* **8**: 239-355.

Yadav, A.K. 2007. Status of organic farming in India and world, ICAR Winter School on organic farming in rainfed agriculture. *CRIDA*. 1-21.

Yadav, R.L., Yadav, D.S., Singh, R.M. and Kumar, A. 1998. Long-term effects of inorganic fertilizer inputs on crop productivity in rice-wheat cropping system. *Nutr. Cyc. Agroecosys*. **51**: 193-200.

Yadav, R.S. and Bhushan, C. 2001. Effect of moisture stress on growth and yield in rice genotypes. *Ind. J. Agric. Res*. **2**:104-107.

Yang, C., Yang, L., Yang, Y. and Ouyang, Z. 2004. Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. *Agric. Water Mgnt*. **70**: 67–81.

Yogameenakshi, P., Nadarajan, N. and Anbumalarmathi, J. 2004. Correlation and path analysis on yield and drought tolerant attributes in rice (*Oryza sativa* L.) under drought stress. *Oryza*. **41**(4): 68-70.

Yogameenakshi, P. and Vivekanandan, P. 2010. Association analysis in F1 and F2 generations of rice under reproductive stage drought stress. *Electron. J. Pl. Breed.* 1(4):890-898.

Yolanda, J.L. and Das, L.D.V. 1995. Correlation and path analysis in rice (*Oryza sativa* L.). *Madras Agric. J.* 11:576-578.

Yuan, J.S., Tiller, K.A., Al-Hamad, H., Stewart, N.R. and Stewart, C. 2008. Plants to power: Bioenergy to fuel the future. *Trends Plant Sci.* 13(8): 421-429.

Zahid, M.A., Akhtar, M., Sabir, M., Manzoor, Z. and Awan, T.H. 2006. Correlation and path analysis studies of yield and economic traits in Basmati rice (*Oryza sativa* L.). *Asian J. Plant Sci.* 5: 643-645.

Zhao, X., Qin, Y. and Sohn, J.K. 2010. Identification of main effects, epistatic effects and their environmental interactions of QTLs for yield traits in rice. *Genes and Genomics.* **32**: 37-45.

Zheng, J.G., Ren, G.J., Lu, X.J. and Jiang, X.L. 2003. Effect of water stress on rice grain yield and quality after heading stage. *Chin. J. Rice Sci.* 3:239-243.

Zhou, Y. and Luo, A.C. 1997. Effect of organic manure on phosphorus absorption and root activity of wheat. *Pl. Nutr. Fertil. Sci.* 3: 243-248.

EVALUATION OF A COLLECTION OF *INDICA* RICE GENOTYPES UNDER ORGANIC MANAGEMENT ADOPTING FARMER PARTICIPATORY EVALUATION STRATEGY

by

MANJUNATHA, G. A

(2013 - 11 - 176)

ABSTRACT

Submitted in partial fulfillment of therequirement for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANT BREEDING AND GENETICS

COLLEGE OF AGRICULTURE

PADANNAKKAD, KASARAGOD – 671314

KERALA, INDIA

2015

ABSTRACT

The experiment entitled 'Evaluation of a Collection of *Indica* Rice Genotypes under Organic Management Adopting Farmer Participatory Evaluation Strategy' was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad, Kerala Agricultural University during 2013 - 2015. Field trials were laid out during rabi season in the field of a progressive organic rice farming group (Arayidam padasekharam) in Mayyil Panchayath of Kannur district, Kerala. The main objectives of the study were identification of rice genotypes suited for organic farming and the key organic varietal traits.

The materials comprised of 65 genotypes of rice conserved in the Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad, which include 14 traditional genotypes of Kerala, a collection of 41 improved varieties developed for conventional rice farming, out of which 32 are of KAU, and 10 rice varieties/ cultures developed by Kerala Agricultural University adopting strategies of Organic Plant Breeding (OPB).

Out of 65 rice genotypes evaluated under organic management, 'Anaswara', the variety developed by KAU for conventional farming and Culture MK-157, the genotype developed based on strategies of Organic Plant Breeding (OPB) (it was released in the name 'Jaiva' in 2015 by KAU as the first organic rice variety) ranked first for grain yield and also showed tolerance to the major pests and diseases on visual observation. But in quality analysis, the variety 'Jaiva' ranked best for all the four quality parameters evaluated namely, volume expansion, kernel elongation ratio, alkali spreading value and sensory evaluation, whereas 'Anaswara' variety ranked only for kernel elongation ratio. Hence considering yield, quality and biotic stress tolerance together, 'Jaiva' variety can be ranked first.

Out of seven genotypes namely, 'Aishwarya', 'Dhanu', 'Aruna', 'HariyanaBasmathi', 'Kanakom', 'Sagara' and Culture MK-115, which ranked as second set with on par performance with respect to grain yield, the genotypes 'Dhanu', 'Aishwarya' and the flood tolerant pre-release organic Culture MK-115 showed top performance for various yield component traits, few cooking qualities, and pest and disease tolerance. Hence these three genotypes can also be considered for organic farming after 'Jaiva' and 'Anaswara'.

Out of 99 varieties of KAU developed for conventional farming in ordinary wetland using chemical fertilizers, 32 varieties were evaluated under organic management in this study. Out of these, 'Anaswara' variety followed by 'Dhanu' and 'Aishwarya' can be considered for organic farming for the time being as per the suggestion of IFOAM that, till enough organic varieties are developed adopting Organic Plant Breeding(OPB) strategies, those varieties developed for conventional farming using chemical fertilizers but performs well under organic management can be considered. The remaining 67 varieties of KAU developed for conventional farming has to be tested under organic management which may be the future line of work.

Out of eighteen growth and yield parameters studied under organic management, four parameters namely, number of tillers plant^{-1} at harvest, number of productive tillers plant^{-1}, number of grains panicle^{-1} and straw yield plant^{-1} showed both positive significant correlation and direct effect with grain yield plant^{-1}. Hence these four characters can be considered as organic varietal yield component traits.

Based on variation, correlation and path analysis studies, the genotypes which can be selected as parents for various organic varietal yield component traits for future breeding programmes of organic variety development are given below. Parents for the straw yield plant^{-1} are 'Kanakom', 'Dhanu', 'Anaswara', 'Jaiva', Culture MK-115, 'Makam', 'Remanika', and 'Vytilla-4'. Parents for the number of productive tillers plant^{-1} are 'Badhra', 'Dhanu', 'Anaswara' and 'Makam'.

Parents for the number of tillers plant^{-1}at harvest are 'Dhanu', 'Badhra', 'Anaswara', 'Makam', 'Jaiva', and 'Remanika' and parent for number of grains panicle^{-1} is 'Mahsuri'.

Genotypes which can be selected as parents for important cooking quality characters which are considered as organic varietal traits are 'CO-47', 'Jaiva' and 'Valankunhivithu' for volume expansion and 'Pusabasmathi', 'Jaiva', 'FL-478', 'Ezhome-1', 'Mahsuri', 'Gouri', 'Swarnaprabha', 'Dhanu', 'IR-28', 'Aasha' and 'Aishwarya' for sensory evaluation like taste, texture, colour, aroma etc.

On the basis of visual observation of pests and diseases, the genotypes that can be selected as parents for tolerance to major pests, namely, stem borer, leaf roller and rice bug are Culture MK-115, 'Anaswara', 'Dhanu' and 'Mahsuri'. The parents that can be selected for tolerance to major diseases namely, blast and sheath blight are 'Jaiva', 'Kasthuri', 'Pusabasmathi', 'Anaswara', 'Ayirankana' and 'CO-47'.Validation through scientific screening is necessary.